Original Article

Effect of two different finishing systems on surface roughness of feldspathic and fluorapatite porcelains in ceramo-metal restorations: Comparative *in vitro* study

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Abstract

Objective: The objective of present study was to qualitatively and quantitatively evaluate and compare the effect of two ceramic finishing systems and diamond polishing paste on surface texture of two ceramic materials. **Methodology**: The 40 test specimens were randomly divided into two main groups (Group I and Group II). Which were subsequently veneered with feldspathic porcelain and fluorapatite leucite porcelain systems respectively. The samples in Test group I and Test group II were subjected to different abrasion and finishing systems (Soft Lex and White silicon and grey rubber respectively). The surface roughness of all the four groups was assessed qualitatively using the scanning Electron Microscope and profilometer. **Results:** The surface roughness of Feldspathic and fluorapetite porcelain increased after abrasion and finishing as compared to auto-glazed porcelin. The surface roughness was more in grey rubber disc group (Gp Ib) as compared to the soft lex disc groups. After polishing with the diamond paste, there was reduction in the surface roughness of both the disc groups. The Mean Ra values of the Feldspathic porcelain at three intervals were 0.52 ± 0.06, 0.54 ± 0.06, 0.32 ± 0.06 and 0.50 ± 0.04, 1.25 ± 0.10, 0.45 ± 0.6 respectively for grey rubber disc and soft lex groups. The Mean Ra values of Fluorapetite porcelain at three intervals were 0.40 ± 0.06, 0.52 ± 0.06, 0.30 ± 0.03 and 0.41 ± 0.04, 1.17 ± 0.09, 0.39 ± 0.07 respectively for grey rubber disc and soft lex groups. **Discussion and Conclusion:** The surface roughness was less in the polished samples as compared to the auto-glazed porcelain. The findings were more reinforcing in the soft lex group as compared to the white/grey rubber disc group. Between the two porcelain systems, the Fluorapatite leucite porcelain specimens exhibited better surface smoothness than feldspathic porcelain.

Key words: *Ceramo metal restoration, feldspathic, fluorapatite, surface roughness*

INTRODUCTION

Dental ceramics are widely used in dental practice as material of choice for porcelain-fused-to-metal or all-ceramic restorations in crown and bridge prosthodontics and as laminate veneers in cosmetic dentistry, because of their natural appearance.[1,2]

Porcelain fused to metal restorations account for more than 80% of the restorations made world-wide.[3] These are popularly used in prosthodontics because of their refractive nature, hardness, biocompatibility and chemical inertness.[1] These have metal substructures supporting a ceramic veneer that is mechanically and chemically bonded. Among the various types of veneering porcelain available for metal ceramic restorations, the traditional feldspathic porcelain is still widely used despite numerous scientific reports of their harmful behavior regarding increased wear of the

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opposing dentition. The fluorapatite leucite porcelain claims to have smoother surface topography, lower abrasiveness toward the enamel and improved color which accounts for its increased use in recent times.[4]

The strong life-like appearance of the completed metal ceramic restoration results from a surface glaze, formed on additional firing of the restoration.[2-5] However very often the chair side adjustment of ceramic for shape, contour and occlusion results in the surface roughness of these restoration.[6-8] In the clinical set up it is not possible to reglaze the restorations due to practical constraints. In such situations the surfaces tends to become The rough ceramic surfaces abrade opposing teeth and/or restorations.[9-16] Rough porcelain surfaces also significantly reduce the strength of ceramic restorations and make them prone to fracture.[2,12] 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.[3,17] 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.[13-15,18,19] 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.[20-23]

The adjusting, contouring and finishing procedures for metal 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.[5,24-27] Others, however, favor mechanical polishing and concluded that intraoral polishing of porcelain can equal or surpass the smoothness of glazed porcelain.[6,8,28-30] Today, it is recognized that improved esthetic results are obtained by polishing.[28,31-33] The ultimate goal of mechanical finishing and polishing is the attainment of a well-polished surface which can substitute for glazed porcelain.

The studies comparing the efficacy of various smoothening and polishing systems for metal ceramic restorations are carried out either qualitatively or quantitatively. Most studies have focused on the qualitative analysis of the ceramic surface.[5,8,27,34-38] Very few studies have examined the surface quantitatively.[30,39,40]

Some studies have both qualitative and quantitative assessment following different finishing procedures.[25,29,31,41-45] The analysis of the surface both qualitatively and quantitatively can aid in obtaining better inferences.

In light of the above, the present *in vitro* study was designed to qualitatively and quantitatively evaluate and compare the effect of two ceramic finishing systems and diamond polishing paste had on the surface texture of two ceramic materials used for ceramo-metal restorations.

METHODOLOGY

The present study was the comparative *in vitro* study, carried out to evaluate the qualitative and quantitative effect of two different finishing systems on the surface roughness of two different type of porcelain systems.

The totals of forty test patterns were fabricated using the custom made metal mold to standardize the specimen shape and dimensions. The dimensions of the patterns were 10 mm width and 2 mm thickness. The test specimens were then air abraded and subsequently steam cleaned to remove surface impurities.

The test specimens were randomly divided into two main groups (Group I and Group II) with twenty samples in each group. The Group I and Group II were subsequently veneered with feldspathic porcelain (Ivoclar-IPS Classic, Ivoclar Vivadent AG, Liechtenstein, Germany) and fluorapatite leucite porcelain systems (Ivoclar-d sign, Ivoclar Vivadent kG, Liechtenstein, Germany) respectively. All specimens were subjected to auto-glazing according to the manufacturer's guidelines to simulate the surface conditions after intraoral adjustments.

Following the autoglazing, the samples in test Group I (Feldspathic) and test Group II (fluorapatite) were further divided into two subgroups (Ia, Ib and IIa, IIb) and subjected to different abrasion and finishing systems as underlined in Table 1.

The finished test samples (Gp Ia, Ib, IIa, IIb) were polished with the Yeti diamond paste (Yeti diamond products) along with rubber prophy cup for 30 s.

The surface roughness of all the four groups was assessed qualitatively using the scanning electron microscope (SEM) (JEOL, ASM 6360, Japan) and quantitative evaluation was made using profilometer (*R*a values). The assessment was made at three intervals-after autoglazing, after abrasion and finishing, after polishing with diamond paste.

Statistical analysis

The data was entered in the Microsoft Excel and analyzed using the SPSS version 19.0 (SPSS Inc, Chicago, USA). The descriptive statistics included mean, standard deviation and the difference of the mean "*R*a" values for the average surface roughness of the ceramic materials between the two different abrasion systems was analyzed using the unpaired *t*-test. The level of significance was fixed at 0.05.

RESULTS

The qualitative assessment (SEM) of the surface roughness of the feldspathic porcelain group at three intervals has been depicted in Figures 1-3 respectively. The surface roughness of feldspathic porcelain increased after abrasion and finishing when compared with the initial assessment done after auto-glazing. The surface roughness was more in the white and grey rubber disc group (Gp Ib) when compared with the soft-lex disc groups (Gp Ia). After polishing with the diamond paste, there was reduction in the surface roughness of both the groups. However the surface roughness was more in white rubber group when compared with soft-lex group.

The qualitative assessment of the fluorapetite porcelain showed similar findings as the feldspathic porcelain after autoglazing, finishing with different type of systems (IIa and IIb) and polishing with diamond paste. However, the surface roughness was less in the fluorapetite porcelain when compared with feldspathic porcelain [Figures 4-6].

Table 1: Description of surface finishing systems

Subgroups	Surface abrasion and finishing system
Gp Ia	Abraded and finished with Sof-Lex discs (coarse, medium, fine, extra fine)
Gp Ib	Abraded and finished with white silicon and grey rubber
Gp IIa	Abraded and finished with Sof-Lex discs (coarse, medium, fine, extra fine)
Gp IIb	Abraded and finished with white silicon and grey rubber

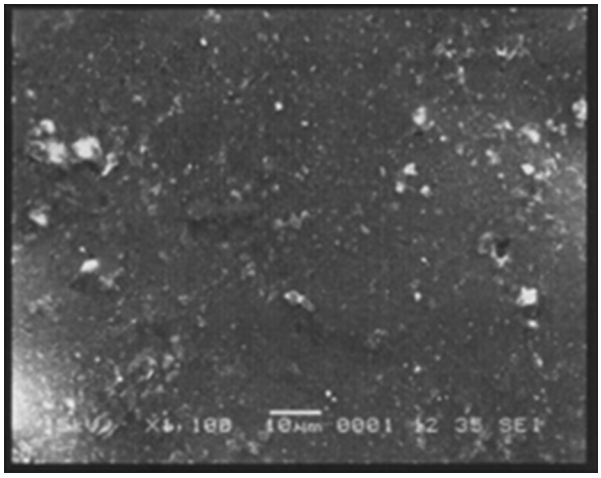

Figure 1: Surface roughness of feldspathic porcelain (Gp I) following the autoglazing

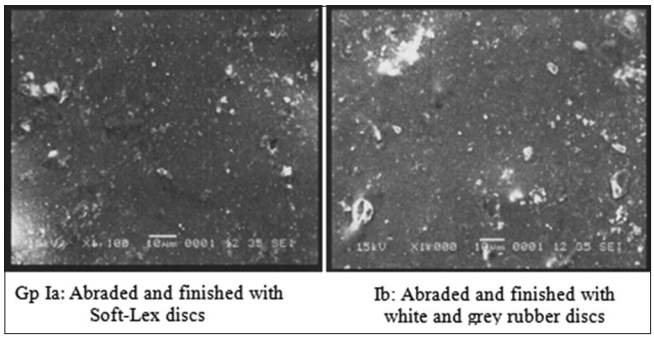

Figure 2: Surface roughness of feldspathic porcelain following the abrasion and finishing with different systems

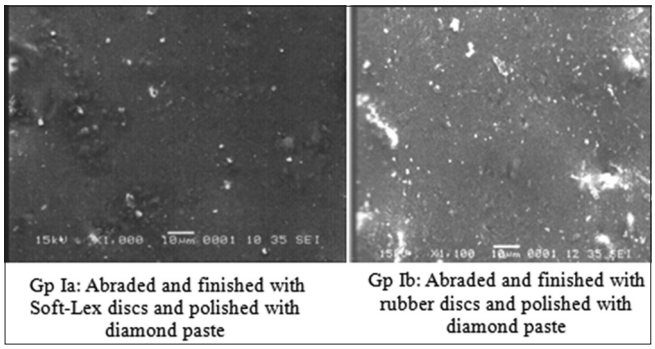

Figure 3: Surface roughness of feldspathic porcelain following the polishing

The quantitative assessment of the surface roughness at three intervals for the feldspathic and fluorapetite porcelains were carried out using the profilometer and recorded as *R*a mean values. The mean *R*a values of the two different subgroups of feldspathic porcelain (Gp Ia and Gp Ib) at three intervals - after auto-glazing, after abrasion, finishing and after polishing are shown in Table 2.

The mean *R*a values of the two different subgroups

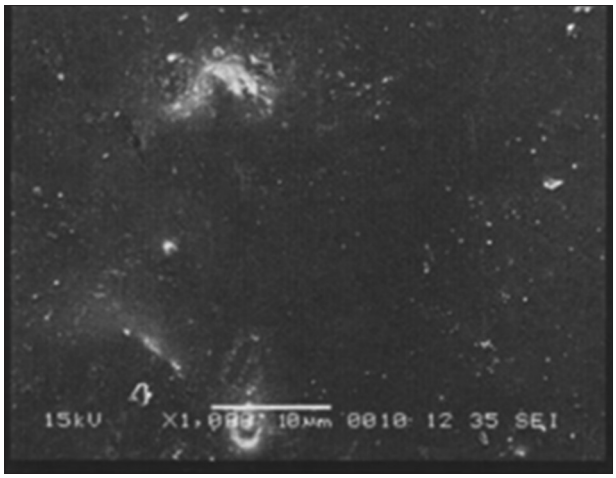

Figure 4: Surface roughness of fluorapetite porcelain (Gp II) following the autoglazing

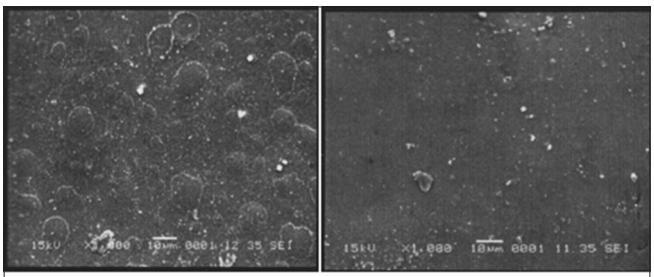

Figure 5: Surface roughness of fluorapetite porcelain following the abrasion and finishing with different systems

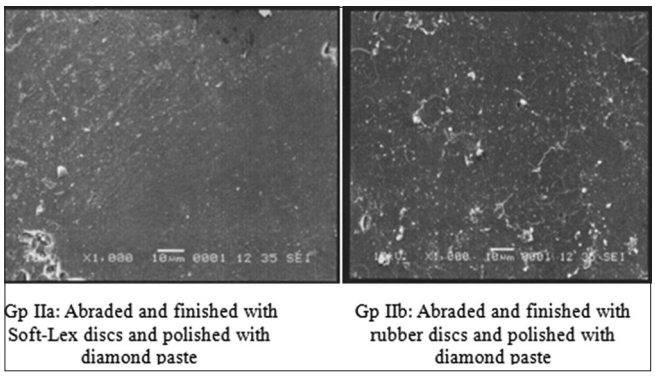

Figure 6: Surface roughness of fluor apetite porcelain following the polishing with diamond paste

of fluorapetite porcelain (Gp IIa and Gp IIb) at three intervals - after auto-glazing, after abrasion, finishing and after polishing are shown in Table 3.

The difference of the mean "Ra" values for the average surface roughness of the ceramic materials between the two different abrasion systems (soft-lex and grey rubber disc) was significant for feldspathic (Gp Ia, Ib) and fluorapetite porcelains (Gp IIa, IIb).

Table 2: Mean *Ra* values of the two different subgroups of feldspathic porcelain (Gp Ia and Gp Ib) at three intervals

Intervals	Soft-lex group (Gp Ia)	Rubber disc group (Gp Ib)	*P* value
Autoglazing	0.52±0.06	0.50±0.04	>0.26
After abrasion and finishing	0.54±0.06	1.25±0.10	0.02
After polishing	0.32±0.6	0.45±0.6	0.04

Table 3: Mean *Ra* values of the two different subgroups of fluorapetite porcelain (Gp IIa and Gp IIb) at three intervals

Intervals	Soft-lex group (Gp IIa)	Rubber disc group (Gp IIb)	*P* value
Autoglazing	0.40±0.06	0.41±0.04	0.51
After abrasion and finishing	0.52±0.06	1.17±0.09	0.001
After polishing	0.30±0.03	0.39±0.07	0.05

The difference between the two porcelain systems (feldspathic and fluorapatite leucite) when finished with similar finishing systems, i.e. either with soft-lex or with White silicon and grey rubber followed by diamond polishing was non-significant. The test of significance between Ia and IIa showed $P = 0.151$ and between Ib and IIb showed $P = 0.628$ denoting non-significant difference between the subgroups.

DISCUSSION

Dental ceramic technology is one of the fastest growing areas of dental material research and development due to its ability to closely match natural tooth color, biocompatibility, high resistance to wear and chemical inertness. The esthetic appearance of ceramic restorations is attributable to surface texture of the restoration, which is determined by the autoglazing process. However, the chair side adjustment of ceramic restorations for shape, contour, occlusion and surface finish often result in loss of the auto glaze layer and create a rough surface.[31,35,46-48] 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.[47-49] Hence, it has been recommended by many authors that the roughened surface must be either reglazed or polished to produce the smoothest surface possible.[8,28-30,48,50]

A number of mechanical polishing techniques are described in the literature and were compared with

the gold standard given by the original glaze. Studies comparing the efficacy of various smoothening and polishing systems for metal ceramic restorations are carried out either qualitatively or qualitatively. In the present study, the parameter of surface texture was evaluated qualitatively and quantitatively, in two different porcelain systems (feldspathic [Group I] and fluorapatite leucite [Group II]) using SEM and profilometer respectively.

Among the various types of porcelain available for porcelain fused to metal systems traditional feldspathic porcelain allowed systematic control of sintering temperature and thermal expansion co-efficient in harmony with the substructure alloy used. Fluorapatite leucite porcelain claims to have lower abrasiveness toward the enamel because of the structural arrangement of the fluorapatite crystals similar to the hydroxyl apatite crystals of the tooth enamel, better color quality and smooth surface topography.

In the present study, the thickness of the metal substructure was 2 mm in contrast to the thickness used in most clinical situations. This was to facilitate the better handling of the test specimens as required by the testing equipment employed in this study namely the SEM and profilometer. To ensure uniform thickness of the veneered porcelain, each sample was measured at multiple points using an Iwanson's Gauge.

In the present study, SEM studies were used to visualize and compare the surface profile at initial recording (Autoglazing), after abrasion and finishing and after polishing in the two porcelain test systems employed. The SEM investigation provided minor details such as voids and air bubbles, undetectable by visual inspection. The two groups of auto glazed porcelain test samples were subjected to surface texture analysis quantitatively by employing a profilometer (Taylor Hobson, Talysurf, UK) for obtaining first sets of values. Profilometer is a contact stylus instrument used to measure surface profiles and roughness. A mean roughness profile (Ra) was determined of each specimen to describe the overall roughness of the surface.

The qualitative and quantitative analysis showed that within the conditions of the study, surface texture of the Feldspathic porcelain and fluorapatite leucite porcelain samples after finishing with different abrasive systems and polishing with diamond polishing paste was superior to auto glazed porcelain samples. The results of this study are in agreement with the work of Raimondo *et al*.,[36] who in an *in vitro* investigation found that two of the polishing paste systems produce a surface equal to or better than oven glazing. Klausner *et al*.,[6] had similar findings in favor of polishing porcelain. Further the soft-lex discs produced smoother surface when compared with the white and grey rubber disc for both Feldspathic and fluorapetite porcelain. The findings are in agreement with the findings of works of Monasky and Taylor[11] and Wiley.[16]

Between the two porcelain systems tested, the surface texture of the fluorapatite leucite porcelain samples when compared with feldspathic porcelain samples using SEM photomicrographs was superior. Fluorapatite leucite porcelain being ultra-low fusing porcelain is composed of fine leucite crystals dispersed in a glass matrix. It has a smaller particle size and produces a smoother surface topography when compared with the traditional feldspathic porcelain.[4] The superior surface texture of the fluorapatite leucite porcelain samples when compared with feldspathic porcelain samples can thus be attributed.

The study has the inherent limitation in the sense that only two porcelain systems were taken into consideration in the present investigation, however recently, hydrothermal low fusing porcelain system with a single glass phase and no crystal phase has been introduced to overcome the damaging wear of enamel. Further in the present study the effect of only two finishing systems (soft-lex discs and white silicon and grey rubber) and one polishing paste (Diamond polishing paste) were observed. There is a need for further research with inclusion of recently introduced new porcelain systems and surface evaluation using other finishing systems and polishing pastes such as Brasseler, Shofu-kit etc., The findings of this study can form a basis for future studies incorporating the above considerations

CONCLUSION

Within the limitations of the present study, it can be concluded that the surface roughness was less in the polished samples when compared with the auto-glazed porcelain. The findings were more reinforcing in the soft-lex group when compared with the white/grey rubber disc group. Between the two porcelain systems tested in this study, the fluorapatite leucite porcelain specimens exhibited better surface smoothness than feldspathic porcelain.

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