ORIGINAL RESEARCH

Comparative Evaluation of the Efficiency of Four Ceramic Finishing Systems

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ABSTRACT

Aim: To compare the effect of four different finishing systems and diamond paste on ceramic roughness with the objectives of evaluating the roughness of ceramic surface of prepared specimens after abrasion, finishing and polishing.

Materials & Methods: A total of 50 test specimens were fabricated in the form of discs of diameter 13mm and 0.6mm thickness. Test specimens were then randomly distributed into five groups of 10 and coded. All the test specimens were then abraded with 125µm diamond in unidirectional motion to create surface roughness that will simulate occlusal or incisal correction. The values were recorded and the specimens were then finished using the various finishing systems. multiple range tests by Duncan's procedure. One way Anova was used to calculate the p-value

Results:After fini shing, the Ra,Rq,Rz and Rt values showed a tendency to decline to levels much inferior to the values obtained after the preparation of the specimens. Ra values of group III specimens were slightly higher and the increase was significant. The highest Rt value [5.29] obtained after polishing is below the lowest roughness values [7.42] obtained after finishing the specimens.

Conclusions: Finishing and polishing procedures have a significant role in reducing the roughness of ceramics.Following abrasion with diamond point to simulate clinical adjustment the roughness values doubled when compared to the initial reading.Ra, Rq,Rz and Rt values suggest that Sof lex is the most efficient of all the systems tested followed by auto glazing.After the final diamond paste polishing, sof lex group specimens showed the best finish and auto glazed specimens showed a value almost as equal to the so flex group.

Key Words: Ceramic, Finishing Systems, Randomized Clinical Trial.

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Introduction

Ideally ceramic restorations should retain their intact surface glaze and it has been shown that a final glaze presented the most acceptable surface.[1] However, occasions will arise when ceramic restorations require adjustment in circumstances that preclude reglazing.[2] In such situations the surface tends to become rough. Rough surfaces of ceramic abrade opposing teeth or restorations and the abrasiveness is correlated more with the ceramic roughness rather than its hardness.[3] Roughness of intra oral hard surfaces is a major cause for adhesion and retention of oral microorganisms and thereby increasing the risk of dental caries and periodontal disease.[4,5] Unglazed or trimmed porcelain

may also lead to inflammation of the soft tissues it contacts.[6] Trimming of porcelain may cause some reduction in the strength of a ceramic restoration.[7]

It has been shown that the polished surface was characterized by a glossy, reflective surface and the unpolished surfaces showed striations, pits and a dull non glossy surface.[8] It has been agreed that re-glazing was necessary after porcelain adjustment in the clinical setting.[9] Many dentists therefore, prefer the porcelain surface of a restoration to be glazed (or re-glazed) prior to cementation.[10] 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.[11]

Thus, it has become imperative to consider the various available ceramic finishing systems to recreate the lost smoothness of the abraded surfaces. The ultimate goal of surface finishing is the attainment of a well polished surface which can substitute for glazed porcelain. Therefore, an in vitro study was carried out to compare the effect of four different finishing systems and diamond paste on ceramic roughness with the objectives of evaluating the roughness of ceramic surface of prepared specimens after abrasion, finishing and polishing and to compare the effect of auto glazing with various finishing systems.

Table 1: Ceramic Specimen Firing Parameters

Preheat	Predry	Preheat	Vacuum	Temperature rise	Vacuum	Firing
650*	4min	3min	1min	60*/min	50hpa	920*

Table 2: Glaze Firing Parameters

Preheat	Predry	Preheat	Vacuum	Temperature rise	Vacuum	Firing
650*	4min	3min	0min	60*/min	0hpa	830*

Materials & Methods

A total of 50 test specimens were fabricated in the form of discs of diameter 13mm and 0.6mm thickness. The metallic die used to prepare the specimens had a diameter of 15mm and weighed 575 gms.0.6mg of the ivoclar classic ceramic preweighed in an electronic balance and 0.1 ml of distilled water was used to make each sample. The ceramic was mixed with distilled water and placed in a metallic mould and was compacted.

The discs were then fired in a multimat vacuum furnace according to the manufacturer's instructions. 40 of the 50 specimens were prepared according to the parameters shown in Table 1. The remaining 10 specimens were prepared according to the glaze firing parameters shown in Table 2. Test specimens were then randomly distributed into five groups of 10 and coded. All the test specimens were then abraded with 125µm diamond in unidirectional motion to create surface roughness that will simulate occlusal or incisal correction. The values were recorded and the specimens were then finished using the various finishing systems. Group I samples were finished using sof lex disc, Group II samples were finished using white silicon and grey rubber, Group III samples were finished with sintered diamond, Group IV samples were finished using sintered diamond followed by white silicon and grey rubber and Group V Samples were auto glazed.

The finished specimens were then cleaned in an ultrasonic bath for 30 minutes and the surfaces were measured again. Finally yeti diamond polishing paste was used for polishing the specimens of the first four groups and the final recordings were measured. The parameters for the different finishing systems is given in Table 3. The evaluation of surface roughness was recorded with Ra being the average roughness of the samples, and Rq the Root of mean square roughness. The Rq value is proportional to Rs; it is about 1.1 times larger than Ra.Rz is the average of the ten highest and lowest points. Rt is peak roughness, Rp is the height peak in the roughness profile over the evaluation length. Similarly, Rv is the depth of the deepest valley in the roughness profile over the valuation length; total roughness Rt is the sum of these two or the vertical

Table 3: Parameters for the use of different finishing systems				
S.No.	**Systems**	**Materials**	**Time (sec)each**	**Speed and dry/wet**
1	Sof-lex disc	Coarse Medium Fine Extra fine	30 30 30 30	Moderate dry
2	White-silicon	Universal Polishing Grey Polishing	30 30	Moderate dry
3	Sintered Diamond	5023 HP 807.104.023	30 30	High wet

distance from the deepest valley to the highest peak.

The surface roughness was measured using veeco surface profiler which works on the principle of optical interferometry. This is a standard procedure employed in many studies.[12] The efficiency of each system was calculated by subtracting the values obtained after finishing and after polishing from the values obtained after abrasion.

Statistical Analysis

The roughness values of specimens were tabulated and statistically analyzed using multiple range tests by Duncan's procedure. One way Anova was used to calculate the p-value. SPSS (statistical package for social sciences) version 11 was used for the calculations.

Results

In Group I the Ra values of the samples after abrasion increased from 1.94 to 4.69 (mean), from 1.83 to 4.60 in Group II, 1.85 to 4.89 in Group III, 2.02 to 4.63 in Group IV and 1.93 to 4.62 in Group V. After finishing with so flex the values were reduced to 0.49 in Group I, and after polishing with yeti diamond polishing paste the values got further reduced to 0.3.In Group II after finishing with White Silicon and grey rubber the values were reduced to 1.07 and after polishing with yeti diamond polishing paste the values got further reduced to 0.67.In Group III, after finishing with Sintered diamond the values were reduced to 1.51 and after polishing with yeti diamond polishing paste the values got further reduced to 0.79.In Group IV, after finishing with Sintered diamond followed by white silicon and grey rubber the values were reduced to 1.25 and after polishing with yeti diamond polishing paste the values got further reduced to 0.68.In Group V, after self glazing the values were reduced to 0.37.

The mean Rq values of the samples of in Group I after abrasion increased from 2.13 to 5.17, from 2.01 to 5.06 in Group II, from 2.04 to 5.38 in Group III, 2.22 to 5.09 in Group IV, from 2.12 to 5.08 in Group V.In Group I, after finishing with sof lex the values were reduced to 0.54 and after polishing with yeti diamond polishing paste the values got further reduced to 0.32.In Group II, after finishing with white silicon and grey rubber the values were reduced to 1.17 and after polishing with yeti diamond polishing paste the values got further reduced to 0.73.In Group III, after finishing with Sintered diamond the values were reduced to 1.65 and after polishing with yeti diamond polishing paste the values got further reduced to 0.86. In Group IV, after finishing with Sintered diamond followed by white silicon and grey rubber the values were reduced to 1.37 and after polishing with yeti diamond polishing paste the values got further reduced to 0.75.In Group V, after self glazing values reduced to 0.40.

The Rz values of the samples of Group I after abrasion increased from 9.80 to 20.47, in Group II from 8.88 to 19.38, from 9.17 to 19.66 in Group III, from 9.24 to 20.13 in Group IV and from 9.18 to 20.25 in Group V. In Group I, after finishing with so flex the values were reduced to 1.96 and after polishing with yeti diamond polishing paste the values got further reduced to 0.39. After finishing with white silicon and grey rubber in Group II the values were reduced to 4.45 and after

polishing with yeti diamond polishing paste the values got further reduced to 3.05.In Group III, after finishing with Sintered diamond the values were reduced to 5.52 and after polishing with yeti diamond polishing paste the values got further reduced to 4.39. In Group IV, after finishing with Sintered diamond followed by white silicon and grey rubber the values were reduced to 4.66 and after polishing with yeti diamond polishing paste the values got further reduced to 3.37.In Group V after auto glazing the values were reduced to 1.55.

The Rt values of the samples of Group I were increased to 9.75 after abrasion, in Group II 24.61 to 33.01, in Group III from 23.96 to 32.62, in Group IV from 24.45 to 33.70 and Group V from 25.52 to 34.53. In Group I, after polishing with yeti diamond polishing paste the values got further reduced to 4.19,whereas in Group II, after finishing with White Sintered and grey rubber the values reduced to 7.42 and after polishing with yeti diamond polishing paste the values got further reduced to 4.45. In Group III, after finishing with Sintered diamond the values were reduced to 8.37 and after polishing with yeti diamond polishing paste the values got further reduced to 5.29. In Group IV, after finishing with Sintered diamond followed by white

Table 4: Mean and Standard deviation of the different roughness values of samples initially recorded

	Ra	Rq	Rz	Rt
Group I	1.94 ± 0.17	2.13 ± 0.19	9.80 ± 0.16	23.3 ± 1.47
Group II	1.83 ± 0.14	2.01 ± 0.16	8.88 ± 0.33	24.61 ± 0.78
Group III	1.85 ± 0.05	2.04 ± 0.06	9.17 ± 0.49	23.96 ± 1.17
Group IV	2.02 ± 0.08	2.22 ± 0.09	9.24 ± 0.18	24.45 ± 0.95
Group V	1.93 ± 0.11	2.12 ± 0.12	9.18 ± 0.12	25.52 ± 0.59

Table 5: Mean and Standard deviation of the different roughness values of samples recorded after abrasion

	Ra	Rq	Rz	Rt
Group I	4.69 ± 0.18	5.17 ± 0.20	20.47 ± 0.62	31.27 ± 2.0
Group II	4.60 ± 0.16	5.06 ± 0.18	19.38 ± 0.79	33.01 ± 1.0
Group III	4.89 ± 0.06	5.38 ± 0.06	19.66 ± 0.73	32.62 ± 1.44
Group IV	4.63 ± 0.16	5.09 ± 0.17	20.13 ± 0.84	33.70 ± 0.71
Group V	4.62 ± 0.23	5.08 ± 0.25	20.25 ± 0.64	34.53 ± 0.58

Table 6: Mean and Standard deviation of the different roughness values of samples after finishing

	Ra	Rq	Rz	Rt
Group I	0.49 ± 0.06	0.54 ± 0.06	1.96 ± 0.10	9.75 ± 0.67
Group II	1.07 ± 0.07	1.17 ± 0.07	4.45 ± 0.16	7.42 ± 0.33
Group III	1.51 ± 0.05	1.65 ± 0.05	5.52 ± 0.26	8.37 ± 0.52
Group IV	1.25 ± 0.09	1.37 ± 0.10	4.66 ± 0.16	7.84 ± 0.16

Table 7: Mean and Standard deviation of the different roughness values of samples after polishing

	Ra	Rq	Rz	Rt
Group I	0.30 ± 0.03	0.32 ± 0.04	1.39 ± 0.06	4.19 ± 0.17
Group II	0.67 ± 0.07	0.73 ± 0.07	3.05 ± 0.11	4.45 ± 0.21
Group III	0.79 ± 0.04	0.86 ± 0.04	4.39 ± 0.15	5.29 ± 0.16
Group IV	0.68 ± 0.11	0.75 ± 0.12	3.37 ± 0.16	4.76 ± 0.25
Group V	0.37 ± 0.06	0.40 ± 0.07	1.55 ± 0.08	4.61 ± 0.22

silicon and grey rubber the values were reduced to 7.84 and after polishing with yeti diamond polishing paste the values got further reduced to 4.76. In Group V, after self glazing the values were reduced to 4.61.

In Table 4 it was found that the specimens are of uniform nature excepting for Ra values of Group IV. The mean Ra, Rq, Rz and Rt values obtained after abrasion are shown in Table 5. Ra values of group III specimens were slightly higher and the increase was significant ($p<0.005$).

The mean Ra, Rq, Rz and Rt values of group I to IV specimens after finishing are presented in Table 6. Mean Ra in Group III (1.51 ± 0.05) is significantly higher when compared to other groups and the values are significant ($p<0.05$). The mean Ra, Rq, Rz and Rt values of all groups reduced after polishing with yeti diamond polishing paste (Table 7).

Discussion

The superiority of ceramic restorations is that they possess a glossy surface which is impervious to oral fluids. When the restorations are brought from the laboratory they will have a glazed surface, which on many occasions are subjected to modifications. Many studies[1,12,13,14] have been conducted to find out the efficiency of different finishing and polishing systems but a comparative evaluation is not well documented.

The Ra values really indicate an average roughness of the surface, whereas Rz and Rt values indicate the highest peaks and deepest valleys together. After roughening with diamond point the roughness values predictably increased. The maximum Ra value before abrasion was 2.02 and which got enhanced to 4.89 after abrasion while considering all the groups. Similarly the Rq values got enhanced from 2.22 to 3.58, the Rz values from 9.8 to 20.47 and Rt values from 25.52 to 34.53.

The average roughness almost doubled by grinding with diamond. The increase in Rz and Rt values indicate that roughening can produce both peaks and valleys, but predominantly peaks; that is why while the Rz values doubled, the Rt values increased only to a lesser extent.

After finishing, the Ra, Rq, Rz and Rt values showed a tendency to decline to levels much inferior to the values obtained after the preparation of the specimens. The lowest Ra value of the specimen [1.83] obtained soon after the preparation got declined to 0.49 after finishing.the results are similar to the results of Edward RS et al[13]. The lowest Rz value of the specimen [8.88] soon after the preparation got declined to 1.96 after finishing.

The highest Rz value was 9.80 after preparation of the samples whereas the highest Rz value obtained after finishing was 5.52 which well below the lowest roughness values obtained after preparing the specimens.these findings are similar to the findings of David AN et al[14]. The lowest Rt value of the specimens [23.3] soon after the preparation got declined to 7.42 after finishing. The highest Rt value was 25.52 after preparation whereas the highest Rt value obtained after finishing was 9.75 which was well below the lowest roughness values obtained after preparing the specimens.

After polishing of the samples the roughness values reduced considerably. The lowest Ra value of the specimens after finishing [0.49] got declined to 0.30 after polishing. The highest Ra value observed after finishing was 1.51 whereas the highest Ra value observed after polishing was 0.79. It may be noticed that the highest Ra value obtained after polishing is below the lowest roughness values obtained after finishing the specimens except in Group I.

The lowest Rq value of the specimen soon after finishing got declined to 0.32 after polishing. The highest Rq value observed after finishing was 1.65 whereas the highest Rq value observed after polishing was 0.86, the findings are similar to the findings obtained by David AN et al.[14] It may be noticed that the highest Rq value obtained after polishing is below the lowest roughness values obtained after finishing the specimens except in Group I.

The lowest Rt value of the specimen soon after finishing got declined to 4.19 after polishing. The highest Rt value observed after finishing was 9.75 whereas the highest Rt value observed after polishing was 5.29. It may be noticed that the highest Rt value [5.29] obtained after polishing is below the lowest roughness values [7.42] obtained after finishing the specimens. From this it can be observed that polishing process provides a more regular surface than that obtained after the finishing. Similar to the findings in the present study, Patterson CJ et al[15] compared the

surface finishes attained with a commercial porcelain refinishing kit when applied to porcelain that has been adjusted using two grades of high speed diamond burs and found that after grinding with a diamond bur, use of a refinishing kit produced a clearly visible improvement in smoothness of the porcelain surfaces.[15]

Conclusions

Finishing and polishing procedures have a significant role in reducing the roughness of ceramics. Following abrasion with diamond point to simulate clinical adjustment the roughness values doubled when compared to the initial reading. Ra, Rq, Rz and Rt values suggest that Sof lex is the most efficient of all the systems tested followed by auto glazing. After the final diamond paste polishing, sof lex group specimens showed the best finish and auto glazed specimens showed a value almost as equal to the so flex group. Any adjusted porcelain restoration should be reglazed or subjected to a finishing sequence. Care should be taken clinically to avoid over-reduction of an aluminous porcelain surface, that will give rise to a more abrasive surface in the finished restoration.

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