Original Article

Evaluation of surface roughness of glazed and polished ceramic surface on exposure to fluoride gel, bleaching agent and aerated drink: An *in vitro* study

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STATEMENT OF PROBLEM: The effect of acidic solutions on the surface roughness of ceramic material is not well documented. **PURPOSE:** Evaluate the surface roughness of three acidic solutions on exposure to two ceramic materials. **MATERIALS AND METHODS:** About 40 discs (10 mm diameter, 2 mm thick) were made from the following ceramic: low-fusing ceramic (Ivoclar classic) Group A and all ceramic (Ivoclar IPS empress 2) Group B. Each disc abraded with medium-grit diamond on one half of disc and polished with diamond paste while other half retains the glaze. The discs (10 specimens/group) immersed in 1.23% APF Gel, 16% carbamide peroxide, Coca-cola and distilled water (control). The surface roughness evaluated with surface profiler, before and after exposure to acidic solutions followed by SEM analysis. The data analyzed using Student's *t*-test and Student's independent *t*-test. Increase in surface roughness was calculated in percentage change. **RESULTS:** For Group A, Ra values for glazed surface were significantly higher than Ra values before exposure to acidic solutions (1.07 ± 0.17 µm, 1.090.33 µm, 1.29 ± 0.33 µm and $P<0.05$). For Group B, glazed surface showed higher values after exposure, not at significant level. Polished surfaces had no effect on exposure to acidic solutions. Coca-cola showed higher percentage changes in surface roughness among acidic solutions. SEM showed acidic solutions etched the ceramic surfaces of both materials. **CONCLUSION:** Polishing ceramic with diamond paste provides smoother surface than glazed surface. Roughening of porcelain may occur following application of fluoride gel, bleaching agent and on exposure to Coca-cola.

Key words: Acidic solutions, glazed/polished surface, surface roughness

Fixed restorations have become an integral part of prosthodontic treatment. Ceramics have become a popular restorative material and used extensively in fixed restorations due to its natural, life – like appearance. It fulfills the esthetic and functional demands of the patients by its superior properties than other restorative materials like metals, acrylic and composites.

Caries control is necessary for the long-term success of the restorations. Patients with ceramic restorations may hence be treated with fluoride preparations. It is routinely prescribed for children's, adults and for who treated with radiation therapy to the head and neck.[1] The highly glazed surfaces of porcelain restorations can be etched and roughened by repeated application of fluoride solution or gels.

Pressing esthetic demands of good looking make people to undergo bleaching frequently. Tooth bleaching was reported in the literature as an esthetic treatment option as early as 1900s. Carbamide peroxide is very unstable, which dissociates immediately on contact with tissues or saliva. Since these agents whiten the teeth are basically acidic in nature its effect on the surface properties of esthetic dental restorative materials is incomplete.[2]

Many beverages people consume as part of changing life style. The potential erosive effect of these carbonated beverages on enamel occurs primarily by dissolution of apatite crystals.[3] The effect of these acidic solutions has been documented but there effect on the surface alterations of porcelain surfaces was not well-documented.

Hence the present *in vitro* study was designed with the following objectives as to:

1. Evaluate the surface roughness of glazed and polished surfaces of two ceramic materials before exposure to the acidic solutions viz. fluoride gel, Bleaching agent and Coca-cola.
2. Evaluate the effect of fluoride gel, bleaching agent and aerated drink on the surface roughness of low-fusing and all ceramic.

3. Determine, which acidic solution causing rougher surface on glazed and polished surfaces.

MATERIALS AND METHODS

About 80 test specimens were fabricated in the form of discs of diameter 10 and 2 mm thickness [Figure 1]. About 0.6 mg of ceramic powder pre-weighed in an electronic balance and 0.1 ml of distilled water was used to make each sample. The ceramic powder mixed with distilled water placed in the metallic mold [Figure 2] and compacted. The discs were fired in the Programat P 80 ceramic furnace according to the manufacturer's instructions.

The prepared specimens were abraded on one half of the glazed surface with medium grit diamond points and polished with polishing discs namely with white pre polisher followed by pink polisher. Finally the specimens were polished with diamond paste on the polished surface only.

The specimens were divided into two groups of 40 specimens each i.e., Group A (ceramic material for metal ceramic restorations) and Group B (ceramic material for all ceramic restorations) material of ceramic used. The surface roughness reading of all test specimens before exposing to the acidic solutions [Figure 3] were noted using the surface profiler.

Test specimens of each group were then randomly distributed into four groups. Each group contains 10 specimens. They are: [Figure 4]

- Sub Group (i) - immersed in 1.23% APF solution for 2 days.
- Sub Group (ii) - immersed in 16% carbamide peroxide solution for 50 min.
- Sub Group (iii) - immersed in Coca-cola for 60 hrs.
- Sub Group (iv) - immersed in distilled water.

The specimens were then washed and dried. The surface roughness of the test specimens were again recorded for the glazed and polished surface of both the groups followed by SEM analysis.

Results were analyzed using Student's paired *t*-test and Student's independent *t*-test. Increase in surface roughness for both the ceramic materials was calculated in percentage.

RESULTS

For low-fusing ceramic specimens, the mean Ra values for glazed surface were significantly higher than the mean Ra values before exposure to the acidic solutions (APF Gel, bleaching agent and Coca-cola 1.07 ± 0.17 µm, 1.09 ± 0.33 µm, 1.29 ± 0.33 µm, respectively and P<0.05). For all ceramic, glazed surface showed higher means values after exposure but not at significant level. Polished surfaces of both the ceramic material had no effect on exposure to acidic solutions that were tested. Coca-cola showed comparatively higher percentage changes in the surface roughness on glazed and polished surface for both ceramic materials than the other acidic solutions.

DISCUSSION

Ceramics have become very popular because of their known impervious nature. Dental porcelain when compared to other esthetic dental materials has a smooth and glossy surface finish, which is attained by glazing. Ideally ceramic restorations should retain their surface glaze even under function in the oral environment, where they are exposed to various food substances and acidic solutions. Etching of ceramic surfaces can occur on exposure to these acidic solutions, resulting in a rough surface, which is undesirable for maintaining esthetics.[4] Rough surfaces are susceptible to stain, abrade opposing teeth and accumulate plaque.[5] So, polishing of rough surface becomes mandatory for ceramic restorations in course of time. Reports claim that glazed surfaces are not always the smoothest. Polishing with a fine-size abrasive obtains even a smoother surface finish.[6] Fluoride treatment was proved to be beneficial to natural teeth structure by inhibiting dental caries, but at the same time it causes adverse effects on dental porcelain.[7] By design dental porcelain contain large glass component that can easily be etched and pitted by presence of fluoride ions. The low pH of the fluoride gel can result in the formation of hydrofluoric acid, which can lead to the etching of restorations that contain silica such as porcelain. Many studies have evaluated the effects of acidic solutions such as topical fluoride gel and bleaching agent on dental materials and ceramics. But not many studies have been conducted on the effect of aerated drinks on the surface texture of dental porcelain.

The surface roughness was measured using Veeco surface profiler, which made use of the principle of optical interferometry and average surface roughness Ra values were used in the evaluation [Figure 5]. Use of this procedure has been employed in many documented studies.

The roughness data was obtained at two stages namely:

- Ra values measured and recorded on glazed and polished surfaces before exposure to the acidic solutions.
- Ra values measured and recorded on glazed and polished surfaces after exposure to the acidic solutions.

Followed by the surface roughness evaluation the ceramic samples where subjected to gold sputtering for SEM analysis.

Within Group A (low-fusing ceramic) before exposure, glazed surfaces in general appear much rougher than

Figure 1: Ceramic specimens

Figure 2: Metallic mold

Figure 3: 1.23% APF Gel, 16% carbamide peroxide, Coca-cola

the polished surface, based on the mean Ra values [Table 1]. However, polished surfaces were not affected by immersion in any of the three acidic solutions. But

Figure 4: Ceramic specimens immersed in 1.23% APF Gel, 16% Carbamide peroxide, Coca-cola and distilled water

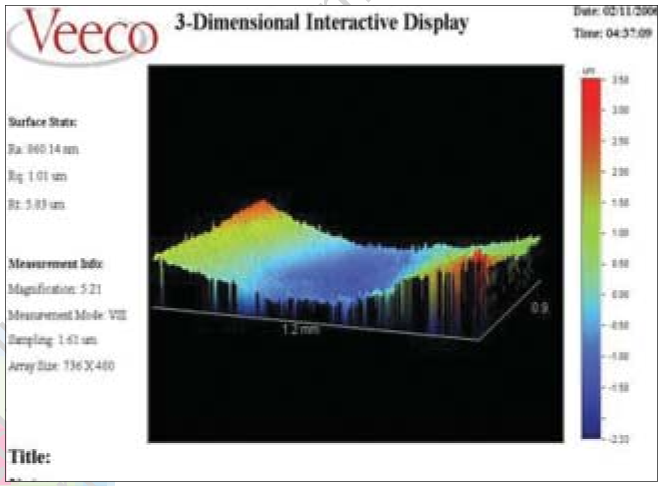

Figure 5: 3-D view of ceramic specimen after exposure to acidic solution

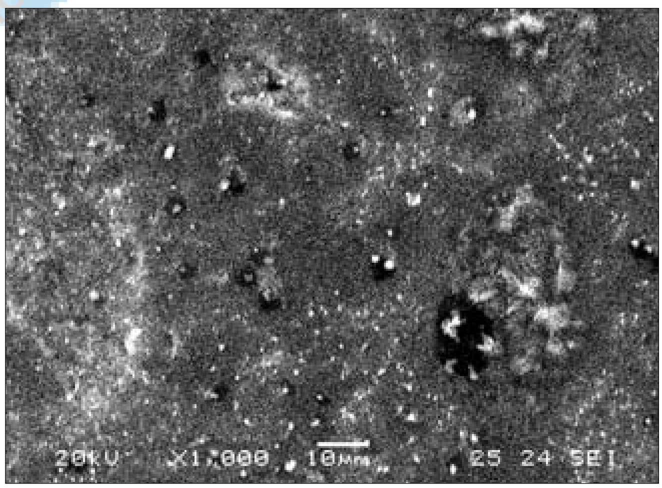

Figure 6: SEM view of ceramic specimen after exposure to acidic solution

the average surface roughness values for glazed surface after exposure to acidic solutions showed increase in Ra values (1.07 ± 0.17 μm, 1.09 ± 0.33 μm, 1.29 ± 0.33 μm for APF Gel, bleaching agent and Coca-cola, respectively) than the Ra values (0.98 ± 0.17 μm, 0.91 ± 0.21 μm, 0.93 ± 0.20 μm for APF Gel, bleaching agent and Coca-cola, respectively) before exposure, at significant level [Table 2]. The percentage increase in surface roughness values showed Coca-cola causing rougher surface on glazed (35.4%) and polished (34.4%) surfaces of low-fusing ceramic when compared to other agents that were tested [Table 3]. SEM analysis of glazed and polished surfaces exposed to acidic solutions showed etching of ceramic surfaces in the form of pits [Figure 6].

Within Group B (all ceramic) before exposure, glazed surface in general appear much rougher than the polished surface. However, glazed and polished surfaces were not affected by immersion in any of three acidic solutions. But the average surface roughness values for glazed surface on surface treatment showed increase in Ra values after exposure (to APF Gel, Bleaching agent and Coca-cola values 0.82 ± 0.20 μm, 0.94 ± 0.33 μm, 0.79 ± 0.20 μm, respectively) than before exposure, but not at significant level. The percentage increase in surface roughness values showed Coca-cola causing rougher surface on glazed (5.4%) and polished (8.9%) surfaces of all ceramic when compared to other agents that were tested [Table 3]. SEM analysis of the glazed and polished surfaces after exposure to acidic solutions showed etching of ceramic surface in the form of pits.

CONCLUSIONS

Within the limitations of the study, following conclusions are drawn:

1. The polished surface appears smoother than the glazed surface for both the ceramic material viz. low-fusing ceramic and all ceramic.
2. For low-fusing ceramic, the glazed surfaces are significantly affected after exposure to the acidic solutions viz. APF Gel, Bleaching agent and Coca-cola while polished surfaces were not affected at significant level.
3. For all ceramic, the glazed and polished surfaces are not affected after exposure to acidic solutions at significant level.
4. Coca-cola shows comparatively higher percentage changes in surface roughness when compared to other acidic solutions tested on glazed as well as polished surfaces of low-fusing ceramic and all ceramic material.

Table 1: Mean, standard deviation and test of significance of mean values between glazed and polished surface of ceramic before exposure to acidic solutions (μm)

Sr. No.	Groups	No. of samples (*n*)	Mean Ra values	SD	**P* value (2 tailed)
Group A	Before glazing	40	0.958	± 0.173	0.000 (Sig)
	Before polishing	40	0.609	± 0.154	
Group B	Before glazing	40	0.749	0.225	0.000 (Sig)
	Before polishing	40	0.517	± 0.160	

*Student's independent t test was used to calculate the *P* value, Sig - Significant

Table 2: Mean (Ra) values of ceramic surfaces obtained before exposure and after exposure to acidic solutions (μm) and its test of significance (*P* value)

	A						B					
	Glazed			Polished			Glazed			Polished		
Acidic solutions	Before exposure mean values	After exposure mean values	*P*-value	Before exposure mean values	After exposure mean values	*P*-value	Before exposure mean values	After exposure mean values	*P*-value	Before exposure mean values	After exposure mean values	*P*-value
APF gel	0.983	1.076	0.002 (sig)	0.646	0.731	0.293 (NS)	0.788	0.828	0.548 (NS)	0.594	0.618	0.656 (NS)
Bleaching agent	0.914	1.091	0.019 (sig)	0.541	0.604	0.315 (NS)	0.850	0.895	0.508 (NS)	0.539	0.584	0.374 (NS)
Coco-cola	0.953	1.291	0.008 (sig)	0.589	0.792	0.137 (NS)	0.751	0.792	0.629 (NS)	0.504	0.549	0.649 (NS)

Student's paired t-test was used to calculate the *P* value. Sig - Significant. NS - Not significant

Table 3: Mean (Ra) values of ceramic surfaces obtained before exposure and after exposure to acidic solutions (μm) and its percentage changes (%)

	A						B					
	Glazed			Polished			Glazed			Polished		
Acidic solutions	Before exposure mean values	After exposure mean values	*P*-value %	Before exposure mean values	After exposure mean values	*P*-value %	Before exposure mean values	After exposure mean values	*P*-value %	Before exposure mean values	After exposure mean values	*P*-value %
APF gel	0.983	1.076	9.9	0.646	0.731	13.1	0.788	0.828	5.0	0.594	0.618	4.0
Bleaching agent	0.914	1.091	19.3	0.541	0.604	11.4	0.850	0.895	5.3	0.539	0.584	8.3
Coco-cola	0.953	1.291	35.4	0.589	0.792	34.4	0.751	0.792	5.4	0.504	0.549	8.9

Student's paired t-test was used to calculate the *P* value. Sig - Significant. NS - Not significant

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