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Comparative Evaluation of Surface Roughness Induced by Topical Fluorides on Porcelain Fused to Metal Surface at Different Intervals of time: An In-Vitro Study

Devika Gangavne[1*] Charushila S. Sardar[2] Gaurang Mistry[3] Omkar Shetty[4]

[1]PG Student, Department of Prosthodontics, DY Patil University, School of Dentistry, Navi Mumbai, Maharashtra, India.
[2]Professor and PG Guide, Department of Prosthodontics, DY Patil University, School of Dentistry, Navi Mumbai, Maharashtra, India.
[3]Professor and Head, Department of Prosthodontics, DY Patil University, School of Dentistry, Navi Mumbai, Maharashtra, India.
[4]Professor and Dean, Department of Prosthodontics, DY Patil University, School of Dentistry, Navi Mumbai, Maharashtra, India.

ABSTRACT

Aim: To evaluate and compare the surface roughness (Ra) induced by topical fluorides on porcelain fused to metal surface at different intervals of time.

Materials and Method: An in vitro study was undertaken to evaluate the surface roughness of porcelain fused to metal samples induced by different topical fluorides Sodium Fluoride (2%) Stable Stannous Fluoride (0.4%), Sodium Fluoride (4.4 mg) and Sodium Fluoride (1.23%) at different time intervals of 16 minutes, 32 minutes, 6 hours and 12 hours. For this study, total 64 samples were fabricated. The samples measuring 10 mm×10 mm×1.5mm. The 64 samples were then divided into four groups. These samples were then evaluated for surface roughness with the help of Zeta 20 optical profiler.

Results: The readings of all the procedures were noted, tabulated and analyzed statistically using Tukey's and Anova test. The results of this study showed least surface roughness with Sodium Fluoride (2%) (Colgate® Total toothpaste), Stable Stannous Fluoride (0.4%) (Colgate® Gel.kam toothpaste), Sodium Fluoride (4.4 mg) (Colgate® Phos-flur mouthrinse) as compared to Sodium Fluoride (1.23%) (Topical Fluorovil Thixotropic Gel).

Conclusion: Sodium Fluoride (1.23%) (Topical Fluorovil Thixotropic Gel) induced greater amount of surface roughness on porcelain fused to metal samples as compared to that of Sodium Fluoride (2%) (Colgate® Total toothpaste), Stable Stannous Fluoride (0.4%) (Colgate® Gel.kam toothpaste) and Sodium Fluoride (4.4 mg) (Colgate® Phos-flur mouthrinse).

Keywords: Topical Fluoride, porcelain, surface roughness.

INTRODUCTION

Porcelain fused to metal systems were introduced in the 1950s. A development in 1962 greatly improved these systems; that is, the incorporation of a high proportion of leucite crystals into the feldspathic porcelain composition which veneered the cast gold alloy substructure. The leucite crystals serve to increase the thermal expansion of the porcelain to bring it closer to that of the metal substrate. The leucite prevents stresses occurring, due to a thermal mismatch, which could lower the strength.[1] Metal ceramic systems combine both the exceptional esthetic properties of ceramics and the extraordinary mechanical properties of metals.[2] The specialty of ceramic is the ability to mimic the natural tooth in color and translucency along with strength. Ceramics have excellent intraoral stability and wear resistance adding to their durability.[3]

The degradation of dental ceramics generally occurs because of mechanical forces or chemical attack.

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*__Correspondence Dr. Devika Gangavne.__
Department of Prosthodontics, DY Patil University, School of Dentistry, Navi Mumbai, Maharashtra, India.
Email: Not Disclosed

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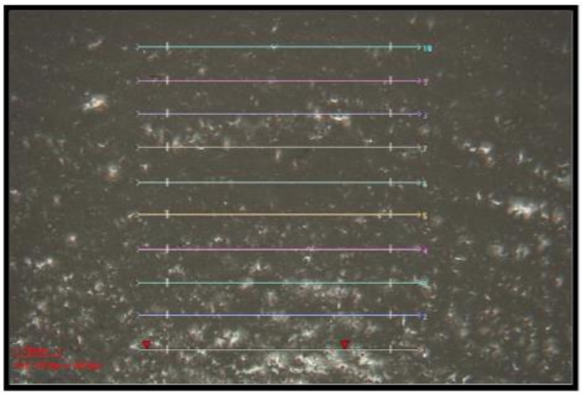

Fig 1: Showing SEM photograph of Group I porcelain fused to metal samples.

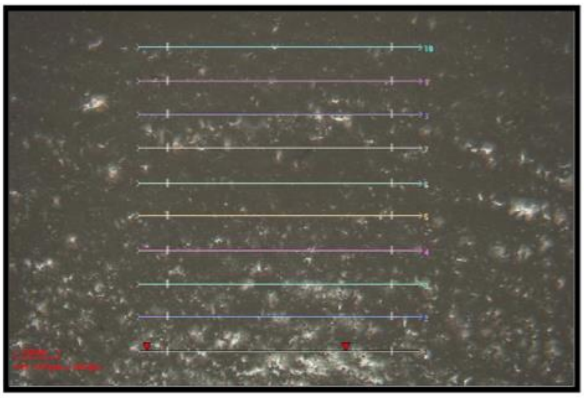

Fig 2: Showing SEM photograph of Group II porcelain fused to metal samples.

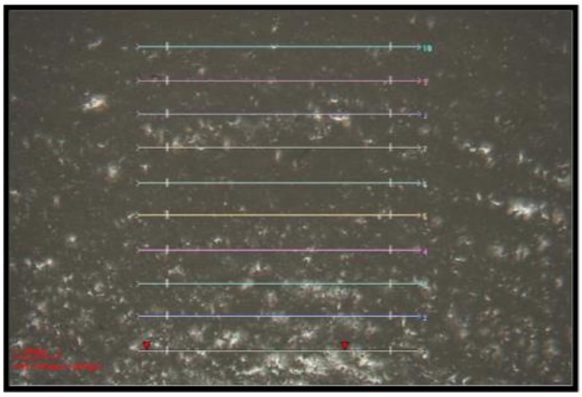

Fig 3: Showing SEM photograph of Group III porcelain fused to metal samples

The chemical durability of the ceramics is excellent, with the exception of the exposure to acidulated fluoride or hydrofluoric acid. Porcelain surface stains are also lost occasionally when abraded by prophylactic pasts and \ or acidulated fluoride.[4] Many authors have studied the effect of acids on the surface of dental porcelains. The most commonly used fluoridated dentifrices and mouth washes when exposed to the glazed ceramic surfaces may cause loss of glaze and further leading to staining of the porcelain restoration. Since porcelain restorations are used in the aesthetic zone, these may eventually cause the restoration to be discarded and replaced. How much effect the pH of the particular fluoride carrier has is required to be studied.

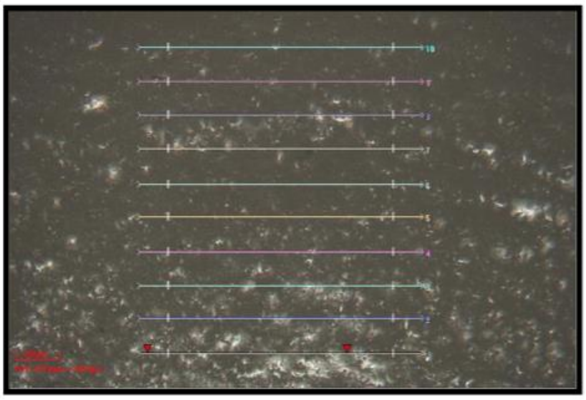

Fig 4: Showing SEM photograph of Group IV porcelain fused to metal samples

MATERIALS AND METHOD

This study was carried out to evaluate and compare the surface roughness of porcelain fused to metal samples induced by different fluoride solutions at different intervals of time. For the study 64 porcelain fused to metal samples were fabricated. The 64 samples were then divided into 4 groups. Each group containing 16 samples

Group I –Sodium Fluoride (2%) (Colgate ® total toothpaste) (Colgate Palmolive, India, Pvt Ltd)
Group II– Stable Stannous Fluoride (0.4%) (Colgate® Gel.kam Toothpaste) (Colgate-Palmolive, India, Pvt Ltd)
Group III –Sodium Fluoride (4.4 mg) (Colgate ®Phos-flurMouthrinse) (Colgate-Palmolive, India, Pvt Ltd)
Group IV – Sodium Fluoride (1.23%) (Topical Fluorovil ThixotropicGel) (Vishal Dentocare India, Pvt Ltd).

The study was divided into following steps:

1. Fabrication of porcelain fused to metal samples

2. Masking the samples and immersion of the samples in different fluoride solutions at different intervals of time.
3. Evaluation of surface roughness of samples using Zeta -20 Optical Microscope at 16 minutes, 32 minutes, 6hrs and 12 hrs.

Fabrication of porcelain fused to metal samples.

For fabrication of metal substructure Modeling wax was used for making rectangular blocks measuring 10mm x 10 mm x 0.5 mm. The rectangular block was spruced using 14.00 mm sprue former. The wax pattern was invested in the casting ring using Phosphate bonded material. Nickel-Chromium (Ni-Cr) alloy pellets was used for casting the metal blocks in centrifugal casting machine at 1300°C-1500°C. The sprues on the casting were separated by using cutting discs and the casting was finished using metal finishing bur. Similar procedure was followed for fabrication of all 64 samples. After fabrication of the metal block, one side of all the metal blocks were sandblasted using 110µm of sand particles in the sandblasting machine. A Ceramco 3 kit was used for layering of porcelain over the sandblasted surface of the rectangular metal blocks. The porcelain was layered and baked in the ceramic furnace as per the manufacturer's instructions. The desired thickness of 1.5 mm for all samples were measured using metal caliper. After which a layer of glaze was applied and baked in ceramic furnace and cooled at room temperature.

Masking the samples and immersion of the samples in different fluoride solutions at different intervals of time.

All the 64 samples were half masked with modeling wax Half of the glazed surface of all the samples were covered using 0.5 mm modeling wax. The surface which was covered, was considered as control side and the uncovered surface was considered as the test side. The 64 samples were divided into 4 groups, as per the fluoride solutions used.

Evaluation of surface roughness of porcelain fused to metal samples using Zeta -20 Optical microscope. (Figure 1 ,2,3,4)

For surface roughness (Ra) evaluation of samples ZETA-20 Optical Microscope was used. The test side of porcelain fused to metal sample was placed under the microscope of 5X objective lens. By using the Zeta software, the sample were divided into 10 segments, equidistance of 200 mm. The samples were scanned for measuring the surface roughness induced on the porcelain fused to metal surface. The surface roughness (Ra) was then calculated in microns (µ). After evaluating the surface roughness (Ra) of the test side, the modeling wax was placed over the control side allowing the controlled side to be evaluated. The same procedure was followed for all 64 samples.

	Control (In µ)		Test (In µ)		Difference			
	Mean	SD	Mean	SD	Mean	S.E.	t-value	p-value
16 minutes	.341	.105	.666	.010	-0.32467	0.060782	-5.341	0.006*
32 minutes	.441	.119	.445	.106	-0.004	0.092128	-0.043	0.967
6 hours	.442	.189	.253	.030	0.189	0.110255	1.714	0.162
12 hours	.568	.135	.501	.040	0.066667	0.08128	0.82	0.458

Table 1: Mean surface roughness (ra) of the control and The test surface, the difference in the mean surface roughness, standard deviation, 't' and the 'p' value for group I samples.

	Control (In µ)		Test (In µ)		Difference			
	Mean	SD	Mean	SD	Mean	S.E.	t-value	p-value
16 minutes	.665	.098	.507	.009	0.157667	0.056884	2.772	0.05
32 minutes	.389	.096	.359	.114	0.03	0.08599	0.349	0.745
6 hours	.465	.063	.268	.058	0.197333	0.049492	3.987	0.016*
12 hours	.406	.169	.204	.038	0.201333	0.099737	2.019	0.114

Table 2: Mean surface roughness (ra) of the control and The test surface, the difference in the mean surface roughness, standard deviation, 't' and the 'p' value for group II samples.

	Control (In µ)		Test (In µ)		Difference			
	Mean	SD	Mean	SD	Mean	S.E.	t-value	p-value
16 minutes	.785	.095	.618	.036	0.166667	0.058735	2.838	0.047*
32 minutes	.579	.035	.429	.051	0.150333	0.03569	4.212	0.014*
6 hours	.479	.083	.278	.106	0.201	0.077455	2.595	0.06*
12 hours	.502	.038	.329	.084	0.173	0.052942	3.268	0.031*

Table 3: Mean surface roughness (ra) of the control and The test surface, the difference in the mean surface roughness, standard deviation, 't' and the 'p' value for group III samples.

	Control (In μ)		Test (In μ)		Difference			
	Mean	SD	Mean	SD	Mean	S.E.	t-value	p-value
16 minutes	.518	.033	.366	.051	0.151667	0.034906	4.345	0.012*
32 minutes	.627	.063	.448	.064	0.179	0.051629	3.467	0.026*
6 hours	.430	.073	.347	.057	0.082667	0.053533	1.544	0.197
12 hours	.475	.014	.255	.040	0.219333	0.024377	8.998	0.001**

Table 4: Mean surface roughness (ra) of the control and The test surface, the difference in the mean surface roughness, standard deviation, 't' and the 'p' value for group IV samples.

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p-value
Group I	Group II	-.323333*	.071591	.008
	Group III	-.443333*	.071591	.001
	Group IV	-.176333	.071591	.141
Group II	Group III	-.120000	.071591	.394
	Group IV	.147000	.071591	.246
Group III	Group IV	.267000*	.071591	.024
*. The mean difference is significant at the 0.05 level.				

Table 5: Tukey's multiple comparison test of comparison of surface roughness (Ra) of Porcelain fused to metal samples for 16 minutes (Group I, Group II, Group III, Group IV) .

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p-value
Group I	Group II	.052000	.068875	.872
	Group III	-.138333	.068875	.261
	Group IV	-.186000	.068875	.102
Group II	Group III	-.190333	.068875	.093
	Group IV	-.238000*	.068875	.035
Group III	Group IV	-.047667	.068875	.897
*. The mean difference is significant at the 0.05 level.				

Table 6: Tukey's multiple comparison test of comparison of surface roughness (Ra) of Porcelain fused to metal samples for 32 minutes (Group I, Group II, Group III, Group IV)

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p-value
Group I	Group II	.159000*	.025962	.001
	Group III	.048000	.025962	.320
	Group IV	.300000*	.025962	.000
Group II	Group III	-.111000*	.025962	.012
	Group IV	.141000*	.025962	.003
Group III	Group IV	.252000*	.025962	.000
*. The mean difference is significant at the 0.05 level.				

Table 7: Tukey's multiple comparison test of comparison of surface roughness (Ra) of Porcelain fused to metal samples for 6 hrs (Group I, Group II, Group III, Group IV).

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p-value
Group I	Group II	.296667*	.044034	.001
	Group III	.171667*	.044034	.019
	Group IV	.245667*	.044034	.002
Group II	Group III	-.125000	.044034	.084
	Group IV	-.051000	.044034	.667
Group III	Group IV	.074000	.044034	.392
*. The mean difference is significant at the 0.05 level.				

Table 8 - Tukey's multiple comparison test of comparison of surface roughness (Ra) of Porcelain fused to metal samples for 12 hrs (Group I, Group II, Group III, Group IV)

RESULTS

The surface roughness of the control and test surface for each group was calculated at 16 minutes, 32 minutes, 6 hrs and 12 hrs (Table 1 , 2 , 3 , 4). For each group, p-value less than that of 0.05 indicates significance of difference between test and control group. Tukey's Multiple comparison test was used to compare surface roughness between groups at 16 minutes, 32 minutes, 6 hrs and 12 hrs (Table 5,6,7,8). Anova test was also used for comparison of Groups at different test times- Test Group (Table 9). It was found that p-value for the 16 minutes in test group is less than that of 0.05 which indicates significance of difference between the means four groups. The p-value for the 32 minutes in control group is less than that of 0.05 indicates significance of difference between the means four groups. The p-value for the 6 hours in control group is greater than that of 0.05 indicates no significance of difference between the means four groups. The p-value for the 12 hours in control group is greater than that of 0.05 indicates no significance of difference between the means four groups.

		Sum of Squares	Df	Mean Square	F	p-value
16 Minutes	Between Groups	.160	3	.053	52.743	.000
	Within Groups	.008	8	.001		
	Total	.168	11			
32 Minutes	Between Groups	.016	3	.005	.672	.593
	Within Groups	.062	8	.008		
	Total	.078	11			
6 Hours	Between Groups	.016	3	.005	1.115	.399
	Within Groups	.038	8	.005		
	Total	.053	11			
12 Hours	Between Groups	.151	3	.050	17.323	.001
	Within Groups	.023	8	.003		
	Total	.174	11			

Table 9: ANOVA test results of comparison of Groups atdifferent test times- Test Group.

DISCUSSION

Ceramometal restorations may be treated daily with fluoride preparation. The presence of these acids may cause changes in surface and weight of dental materials.[5] Hydrofluoric acid/phosphoric acid are added to lower pH. The presence of these acids may cause changes in surface and weight of dental materials.[6] Ceramics have retained their importance in the human societies ever since they were introduced during the Stone Age more than 10,000 years ago. Dental porcelain consists primarily of glasses, porcelain, glass- ceramics, or highly crystalline structures.[7]

In vitro studies show that some topically applied fluoride agents cause surface changes and weight loss of dental materials including porcelain, glass ionomer material and composite restoration. These dental materials are composed of glass-like elements; susceptible to reaction at acidic pH.[8] The highly glazed surfaces of porcelain restorations can be etched and roughened by repeated application of fluoride.[9] The Colgate® Total toothpaste contains 2% sodium fluoride having a pH of 7, the Colgate® Gel. kam toothpaste contains 0.4% of stannous fluoride. Stannous fluoride having a pH of 7, the Colgate® Phos-flur mouthrinse contains 4.4 mg of sodium fluoride, the Sodium Fluoride (Topical Fluorovil Thixotropic Gel) contain 1.23% of APF gel having a pH of 3.5.

The ADA Council of Dental Materials, Instruments and Equipment and Council on Dental Therapeutics recommends that nonacidic fluoride preparation effective in reducing caries be considered as alternatives for patients with porcelain.[10] The SEM Photographs of porcelain fused to metal samples exposed to topical fluoride agents showed that different agents and time durations had different effects on the morphology of porcelain surfaces.[11] The degree of etching and pitting was related to the concentration of the product, the pH of the product, and the duration of immersion. When immersed for a longer period of time, some porcelain surfaces developed crystal deposition.[12] APF gel containing 1.23% sodium and hydrogen fluoride was applied for 16 minutes simulating 1-year therapy, and for 32 minutes simulating 2 years of therapy. 0.04 % SnF_2 was applied for 6 hours simulating 1 year therapy and for 12 hours simulating 2 years of therapy.[13]

Porcelain surfaces that are ground and not glazed are more susceptible to stain and plaque accumulation.[14] A porcelain surface is therefore subjected to etching by acidulated fluoride solutions. It appears that as the pH of the fluoride gel decreases, the ability to etch dental porcelain surface increases. In addition to surface etching and pitting, crystal deposition also appears to occur on the porcelain surface. The crystals are formed from elements released from the porcelain surface and the Na and F existing in the fluoride gel.[9] Acidulated fluoride gel 1.23% concentration was applied for 5 minutes and analyzed with the surface analyzer. The study concluded that there is no significant difference with respect to the changes in the surface roughness in glazed feldspathic ceramic before and after being treated with acidulated gel based fluoride.[15] A higher fluoride concentration and a more viscous gel probably retains a greater quality of fluoride on the tooth surface.[16] Clinicians prescribing daily home fluoride treatment for individuals with existing porcelain restorations are advised to use the products that would cause less surface damage to the restoration.[17] Dental porcelains contains a large glass component that can be easily etched and pitted by the attack of fluoride ions on the silicon- oxygen network.[18] An acidulated fluoride gel is effective in etching and pitting porcelain surfaces. It appears that as the pH of the fluoride gel decreases, the ability to etch dental porcelain surface increases.[19] If the esthetic appearance of the restoration is of great concern, a neutral fluoride solution is recommended to avoid damage to the porcelain surface.[20] Roughened surfaces can accumulate stains and organic debris that will also affect esthetics susceptibility of composite resins to wear.[21-24]

CONCLUSION

This study suggests that Sodium Fluoride (1.23%) (Topical Fluorovil Thixotropic Gel) induced greater amount of surface roughness on porcelain fused to metal samples as compared to that of Sodium Fluoride (2%) (Colgate® Total toothpaste), Stable Stannous Fluoride (0.4%)(Colgate® Gel.kam toothpaste) and Sodium Fluoride (4.4 mg)(Colgate® Phos-flur mouthrinse).

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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