ORIGINAL ARTICLE

Effect of Routinely Consumed Drinks on Polished and Glazed Porcelain Surfaces

Shingwekar Shuchi [1], Thombare Ram [2], Kulkarni Vishal [3]

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1- Assistant Lecturer, Department of Prosthodontics, Chhattisgarh Dental College and Research Institute, Rajnandgaon
2- Professor and Head, Sharad Pawar Dental College, Sawangi (Meghe), Wardha, M.S.
3- Assistant Professor of Pathology, Government Medical College Rajnandgaon

Abstract

Aim: *Evaluation of the effect of routinely consumed drinks like tea, coffee, milk, carbonated drinks and packaged drinking water on the polished and glazed surfaces of porcelain, using profilometry and also by Scanning Electron Microscopy (SEM).* ***Methods:*** *Polished and overglazed ceramic discs were subjected to 'Contact stylus profilometry'. The average 'Ra' values were calculated for 100 discs before and after exposure to these drinks i.e. Tea, Coffee, Milk, Carbonated beverage and packaged drinking water. The pH values of these drinks were recorded using digital pH meter.* ***Results:*** *The effect of carbonated beverage was maximum on surface roughness values of both polished and glazed ceramic discs. SEM revealed that glazed ceramics have smoother surface morphology than the polished ones. The ceramic discs exposed to tea and coffee showed stains which were observed more on polished surfaces than on glazed ones. Surfaces exposed to carbonated drink shows roughest surfaces with pits and stains.* ***Conclusion:*** *Carbonated drinks have comparatively higher percentage changes in surface roughness of both glazed and polished ceramic surfaces. Packaged drinking water doesn't have any effect. More acidic pH of carbonated drink exhibits more erosion of the surface of ceramic discs.*

Keywords: *Ceramic Surface Roughness, pH, Profilometry, Scanning Electron Microscopy*

Address for correspondence: Dr. Shingwekar Shuchi. Assistant Lecturer, Department of Prosthodontics, Chhattisgarh Dental College & Research Institute, Sundra, Rajnandgaon, Chhattisgarh. Email: shuchivkulkarni@gmail.com

Introduction

In the past few decades, an increasing number of ceramic materials have been developed. Each material is having different and specific technology to improve the mechanical properties without being detrimental to the esthetic qualities of the ceramic. Ceramic restorations should retain their surface glaze when placed in the oral environment for long duration, and even when they are exposed to various food and beverages consumed by the patient. Apart from the well-known effect like staining, these liquids also affect the surface morphology of even the natural teeth. Ceramic restorations are no exception to such changes. Ceramic surface changes can occur on exposure to these liquids, especially the acidic ones, resulting in a rough surface which is the undesirable quality for any restorative material for maintaining hygiene and esthetic values of the restorations. Rough surfaces are susceptible to stain and also cause abrasion of the surfaces of the opposing teeth and also promote accumulation of plaque over these rough / abraded surfaces. [1]

This study was carried out to evaluate the effect of routinely consumed drinks like tea, coffee, milk, carbonated drinks and packaged drinking water on the surface of polished and glazed porcelain restorative material, using profilometry and to determine which of the liquids have significant effect on both porcelain surfaces and decide which surfaces of ceramic provide better resistance for the surface changes by Scanning Electron Microscopy (SEM).

Materials & Methods

A stainless steel mould (Figure 1) was specially designed and fabricated to be used in this study for fabricating ceramic discs. In all, 104 ceramic

discs admeasuring 10mm in diameter and 02mm in thickness were fabricated. 52 discs (Group I) were polished using Porcelain adjustment kit and remaining 52 ceramic discs were then overglazed (Group II). Out of 52, 50 samples from each group were then further divided into 5 subgroups of 10 discs each for exposure to 5 liquids used in this study.

Figure- 1: Metallic Mold for the fabrication of Ceramic discs

Subgroups

A: Ceramic discs exposed to Tea
B: Ceramic discs exposed to Coffee
C: Ceramic discs exposed to Pasteurized Milk
D: Ceramic discs exposed to Carbonated drink
E: Ceramic discs exposed to Packaged water
X: Four ceramic discs were not exposed to any of the above liquids.These discs were used as control group to evaluate surface texture using SEM, (2 each from polished & glazed groups).

The ceramic discs were subjected to 'Contact stylus profilometry' by using a profilometer "Surface roughness tester" (Surf test / Surfpack –Mitutoyo, Japan) and the values were recorded five times for each (disc) sample. The discs were marked as A-P, B-P, C-P, D-P, E-P and A-G, B-G, C-G, D-G, E-G, where the first letter denoted the subgroup and the second letter denoted the groups (polished or glazed). The average 'Ra' values were then calculated and tabulated for all samples before exposure which served as a control.

The test solutions i.e. Tea, Coffee, Milk, Carbonated beverage and packaged drinking water were prepared and the pH values of these liquids were recorded using digital pH meter. The pH values of these test solutions were recorded 5 hourly, and were found to be constant. The observed pH values were: Tea: 5.6, Coffee: 5.8, Milk: 5.7, Carbonated beverage: 2 and packaged drinking water: 6.9. All the discs were exposed to their respective test solutions for a stipulated period of 60 hrs. The Ra values for ceramic discs were calculated after exposure to the solutions.

The qualitative analysis of the surface of the ceramic discs were carried out by SEM (SEM, JSM 6380A, Japan). Two discs each from group of both groups I and II were randomly selected. Four control group discs which were not exposed to any liquid were subjected for SEM analysis. Subsequently, analysis of the SEM images of ceramic discs (both polished and glazed) which were exposed to tea, coffee, milk, carbonated beverage and packaged drinking water were carried out.

Results

Statistically significant changes were observed in the surface roughness values (Ra) after exposure to Tea, Coffee, Milk and Carbonated beverage, and packaged drinking water as compared to their pre-exposure roughness ($p<0.05$). The effect of carbonated beverage is highest on surface roughness values of both polished and glazed ceramic discs while the effect of packaged drinking water is lowest. When all the beverage groups were compared with each other, statistically significant changes in the surface roughness (Ra) values of carbonated beverage were observe compared to tea, coffee, milk and packaged drinking water. The effect of carbonated beverage was highest on surface roughness values of both polished and glazed ceramic discs followed by milk, coffee, tea (for polished) and coffee, milk, tea (for glazed discs) while the effect of packaged drinking water was lowest (Table- 1&2).

Table- 1: Surface roughness (Polished discs)

Groups	Exposure	Mean Ra	SD	MD
A-P	Before	2.33	0.08	0.15*
	After	2.48	0.06	
B-P	Before	2.34	0.14	0.18*
	After	2.52	0.15	
C-P	Before	2.33	0.04	0.21*
	After	2.54	0.10	
D-P	Before	2.25	0.06	0.35*
	After	2.60	0.09	
E-P	Before	2.23	0.04	0.02*
	After	2.25	0.05	

***p<0.05, MD-Mean Difference**

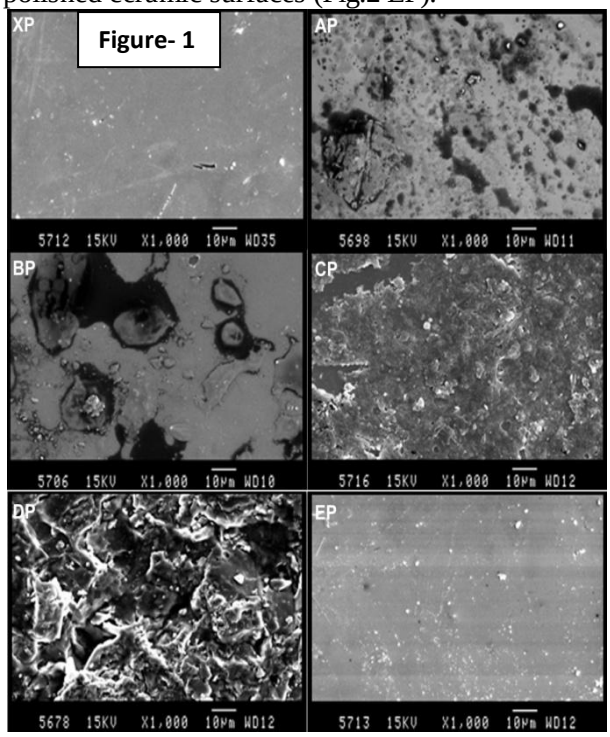
The ceramic discs exposed to Tea and Coffee showed stains which were observed more on

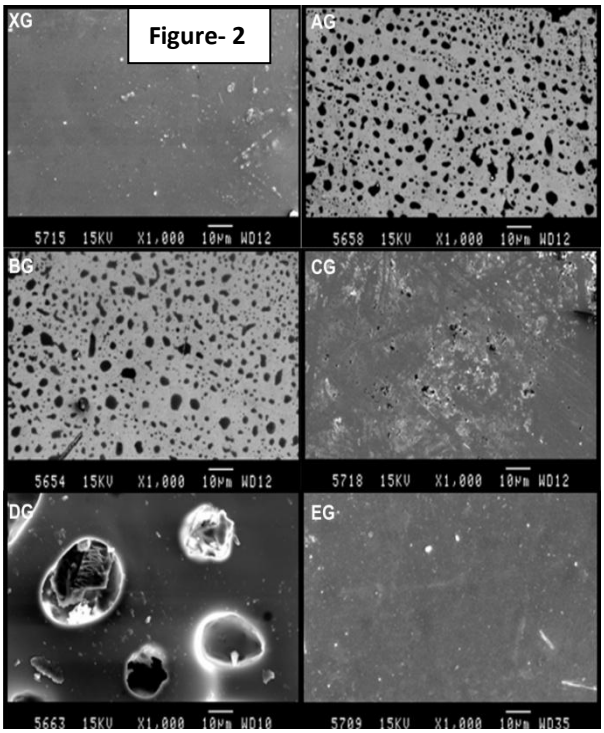
polished ceramic surfaces than on glazed ones (Fig. 2XP) while the SEM images of ceramic discs exposed to Milk showed few stains and roughness which were observed more on polished ceramic surfaces than on glazed ceramic surfaces (Fig. 2CP). The SEM images of ceramic discs exposed to carbonated drink showed roughest surfaces with pits and stains which were observed more on polished ceramic surfaces (Fig. 2DP) & the SEM images of ceramic discs showed smooth surfaces of which glazed surfaces appeared smoother than polished ceramic surfaces (Fig.2 EP).

Table- 2: Surface roughness (Glazed discs)

Groups	Exposure	Mean Ra(µ)	SD	MD
A-G	Before	1.34	0.14	0.15
	After	1.49	0.13	
B-G	Before	1.33	0.08	0.23
	After	1.56	0.06	
C-G	Before	1.23	0.04	0.15
	After	1.38	0.05	
D-G	Before	1.27	0.09	0.28
	After	1.55	0.10	
E-G	Before	1.33	0.04	0.02
	After	1.35	0.04	

***p<0.05, MD-Mean Difference**





Discussion

Wearing of tooth surfaces of the porcelain restorative material may be evaluated with advanced methods such as image analysis, SEM or by Profilometry, which are considered as the most accurate methods. [1] Roughness is a measure of texture of surface and it plays an important role in determining how a real object interacts with its environment. The results of the profilometric analysis have to be interpreted along with observations of the SEM. [2]

After critical evaluation of the results, it would be modest enough to state that, the pH of the solutions remains the most important factor influencing the wear of surfaces of restorations. Carbonated beverage with the lowest pH 2 had showed maximal surface roughness changes in both polished and glazed groups which was confirmed by Profilometery and also by SEM. On the contrary, Packaged drinking water with the pH of 6.9 (almost neutral) showed minimal surface roughness (insignificant or negligible) changes. Tea, coffee and milk with pH 5.6, 5.8 and 5.7 respectively showed intermediate level of changes between carbonated beverage and water. Although the multifactorial influence on wear of tooth and restorations has been widely accepted, the pH of the liquids remains a centre stage amongst the factors which is also observed in similar studies. [3,4,5,6,7]

It was also observed that the effect of these five drinks were more on glazed ceramic surfaces (13.07%) as compared to that on the polished ceramic surfaces (7.98%). The qualitative

analysis of the surface of the ceramic discs unexposed and exposed, were carried out by SEM. For all 24 discs gold sputtering was carried out to make the surface electrically conductive. The SEM images of the control group were obtained and evaluated which revealed that glazed ceramic surfaces have smoother surface morphology than the polished ceramic surfaces.

Subsequently, the observations of the SEM images of ceramic discs (both polished and glazed) which were exposed to tea, coffee, milk, carbonated beverage and packaged drinking water were made. A comparative analysis of these images revealed that the surface morphology of ceramic discs exposed to carbonated beverage was maximally affected, showing a rougher surface along with pits, which were more on the polished surface as compared to the glazed ones. It can be explained as dental porcelain by composition, contains large glass components which can be easily etched or pitted in an acidic environment [1,8]. These SEM images of exposed ceramic surfaces showed comparatively more stains on the surface of ceramic discs exposed to coffee, followed by tea and by milk, which were more on the polished surfaces than the glazed surfaces. The SEM images of polished and glazed ceramic surfaces exposed to packaged drinking water showed similar morphology as that of the control group meaning no effect on the surface texture. The profilometric analysis revealed that the effect of tea, coffee, milk, carbonated beverage and packaged drinking water was more on the glazed ceramic surfaces than on the polished ceramic surfaces. On the contrary, the SEM analysis revealed more stains and rougher surfaces on the polished ceramic surfaces than the glazed surfaces. This apparent contradiction between the results of the Profilometric and the SEM analysis could be explained by the difficulty of numerically quantifying roughness. The surface roughness parameter quantifies just one aspect of roughness, but it is necessary to discriminate the shape and contour from roughness and the profilometric analysis does not always allow this.

Conflict of Interest: *None declared*
Source of Support: *Nil*
Ethical Permission: *Obtained*

Conclusion

Within the scope and limitations of this study, it can be concluded that by Profilometric analysis polished and glazed ceramic surfaces can be affected significantly after exposure for 60 hrs to tea, coffee, milk, carbonated beverage. Amongst these the effect is more on glazed ceramic surfaces than on the polished ceramic surfaces. Ceramic discs exposed to carbonated drink have comparatively higher percentage changes in surface roughness followed by coffee, milk, tea on glazed ceramic surfaces and milk, coffee and tea on polished ceramic surfaces respectively. Packaged drinking water doesn't have any effect. More acidic pH of carbonated drink exhibits more erosion of the surface of ceramic discs. The glazed ceramic surfaces appear smoother than the polished ceramic surfaces after exposure on SEM.

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