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Effect of dental treatment gels and non-aerated drink on the surface roughness of autoglazed and polished surfaces of dental ceramics- An *in vitro* study

Dr. Mohaneesh Bhoria
Assistant Professor and Incharge Department of Dentistry, World College of Medical Sciences, Research and Hospital, Jhajjar, Haryana, India

Abstract

Background: Despite outstanding properties, resistance against degradation of dental ceramics in oral environment needs to be corroborated for clinical integrity of dental ceramics.

Aims: To evaluate qualitatively and quantitatively the effect of two treatment gels and one packaged fruit juice on the polished and autoglazed surfaces of dental ceramics.

Material and Method: A total of 40 ceramic discs of IPS d. SIGN (group A) and 40 ceramic discs of IPS e max Ceram (group B) with dimensions of 12mm diameter x 2 mm thickness were prepared with autoglazed surface on one side and polished surfaces on other. They were randomized into 10 samples per group and subjected to cyclic immersion in distilled water, 1.23 % acidulated phosphate fluoride gel, and 16 % carbamide peroxide gel, packaged apple juice at 37ºC. The surface roughness was evaluated using surface profilometer and scanning electron microscopy (SEM), both pre-immersion and post-immersion. Data collected was assessed using mean surface roughness values, standard deviation and test of significance of mean values both pre-exposure and post-exposure using paired t test and independent t test.

Results: A significant interaction between dental ceramics and treatment preparations, packaged apple juice was found. A statistically significant differences were noted where the polished surface appeared least affected than the autoglazed surface for both ceramics tested.

Conclusion: Within the limitation of present investigation, data support the traditional hypothesis of chemical degradation of dental ceramic surface. In addition, chemical inertness of polished surfaces was found more than that of autoglazed surfaces. Hence, these findings can be utilized as objective guidelines for providing dental ceramics with polished surface.

Keywords: Dental ceramic; surface roughness; carbamide peroxide; acidulated phosphate fluoride gel; fruit juice

1. Introduction

Professional application of topical fluorides and bleaching agents has become clinical manoeuvre frequently offered on routine basis. In recent year 1.23% (12300 ppm fluoride ion) Acidulated Phosphate Fluoride (APF) gel is gaining popularity as acidity improves the uptake of the fluoride ion. The low pH APF gel releases hydrofluoric acid that causes etching of the silica, a major component of dental ceramics[1-3].Night-guard bleaching agent (10-16% carbamide peroxide)proved to affect the restorative materials which are directly related to the peroxide concentration used. Although, low concentrations appeared relatively safe, but repeated use has the same effects as higher concentration used over shorter period of time [4-6] the fruit drink market has grown 20-25 percent in the recent years; tetra packs have offered a solution to provide fruit juice practically fresh. Apple juices for example, contain several sugars (glucose, fructose and sorbitol), phenolic compounds (such as hydroxymethylfurfural) and non-volatile organic acids such as quinic, malic, citric and fumaric acids. These low pH fruit drinks causes erosion. [7-9]. The potential erosive effect of fruit juices on enamel surfaces was well documented but limited clinical report and studies appear about effect on the surface characteristic of dental ceramic.

The null hypothesis of present investigation was low pH gel and solution has no adverse effect on the surface properties of dental ceramics. Hence, the present study was aimed to evaluate qualitatively and quantitatively the effect of 1.23% acidulated sodium phosphate fluoride thixotropic gel, 16% carbamide peroxide formulated gel and packaged apple juice on the surface roughness of polished and autoglazed surfaces of dental ceramic.

2. Material and Methods

Two commercially available dental porcelains (IPS d SIGN Ivoclar Vivadent AG, Schaan, Liechtenstein, IPS e max ceram, Ivoclar Vivadent AG, Schaan, Liechtenstein) were selected. The study was done in accord to ISO standard 6872. [10] All specimens were prepared by the same operator to maintain standardization. Multi-part mould was used to prepare the test specimen where dental porcelain paste was poured, continued vibrated and absorption was done until no further liquid appeared on surface. The condensed paste was levelled by mean of a bevelled glass microscope slide. Once condensed the upper part of mould was slides over and gently tap to release raw ceramic disc from the mould. (Figure 1) The raw specimens were subjected to ceramic firing cycle (PROGRAMAT EP 3000, Ivoclar Vivadent AG). The porcelain specimens were then contoured to require dimensions (diameter 10mm x width 2mm) while finishing with Dura-Green (Shofu Dental Corp., Menlo Park, California) silicon carbide grit at slow speed of 20,000rpm. After finishing, discs were cleaned in distilled water and dried at room temperature.

These specimens then submitted to autoglazing procedure. After autoglazing, one side of each disc was polished using a porcelain adjustment kit (Shofu Dental Corp., Menlo Park, California). (Figure 2)

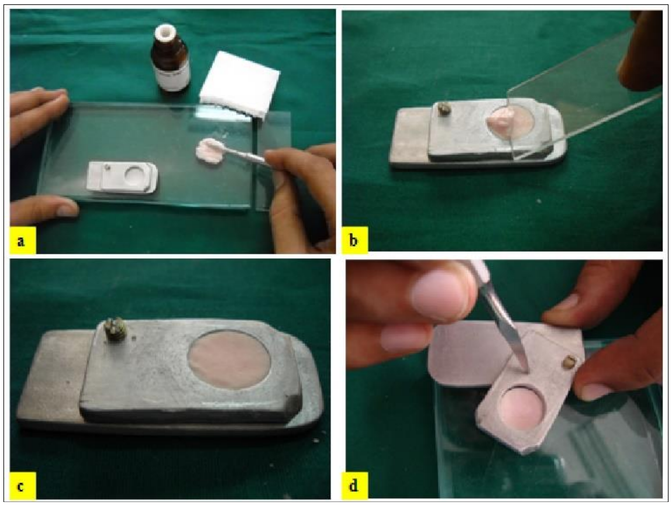

Fig 1: Preparation of porcelain specimen

Fig 2: Dimensions measured of prepared porcelain specimen.

A total of 40 IPS d SIGN porcelain specimen and 40 IPS e max Ceram porcelain specimens were prepared and broadly divided into Group A- IPS d SIGN porcelain specimens and group B- IPS e max Ceram porcelain specimens. The baseline measurement of surface roughness of each discs (glazed and polished surface) were analyzed by performing three measurements. Each specimen was subjected to the stylus profilometer (stylus profiler DEKTAK 8, Vecco instruments Inc, Arizona) in an area of 10mm with 8mg of stylus force. A black dot was placed on each specimen in order to relocate the starting point.Three transverse of the stylus were made across the diameter for each specimen at three different regions. The mean roughness (Ra, µm) for each specimen was recorded as the average of three readings. All readings were performed by the same operator. For the surface texture of the pre-exposure0 porcelain specimen, two specimens from each groups (IPS d. SIGN, IPS e. max ceram), was observed using scanning electron microscope (SEM) (Hitachi S-3000N SEM, Unified Engineering Inc. Aurora). Eachspecimens were mounted on aluminium stubs using double adhesive tape, sputter coated with gold in Hitachi HUS-5GB vacuum evaporator and observed in Hitachi S-3000N Scanning Electron Microscope at an acceleration voltage of 10Kv. Randomization of the specimens: both the group was divided into 4 equal subgroup of 10 specimens (n=10). Each subgroups were immersed in separate beakers containing distilled water [uninterrupted immersion time for 168 hours at 37^{0}c (in incubator)], 1.23 % acidulated phosphate fluoride gel [Uninterrupted immersion time for 32 minutes at 37^{0}c (in incubator) simulating 2 years of fluoride therapy at high risk of caries], 16% carbamide peroxide gel [total immersion time was 112 hours mimicking 14 cyclic application of a home bleaching agent that is average of 8 hrs/day at 37^{0}C (in incubator) for 2 weeks], 25 ml of an apple juice [interrupted immersion for 30 minutes in apple juice and in 25 ml of distilled water for 5 minutes for 7 cycles at 37ºC (in incubator), total immersion time was 245 minute]. (Figure 3) After the immersion, the specimens were cleaned with distilled water, blot dried and subjected to post-exposure surface roughness measurement using stylus profilometer. The mean roughness (Ra, µm) for each specimen was recorded as the average of three readings. The post exposure surface texture change of the porcelain specimens was observed by means of scanning electron microscope (SEM).

Fig 3: Immersion in test solutions/gels and fruit juice.

3. Result

For both the groups, 1.23% acidulated phosphate fluoride gel significantly affected both autoglazed surfaces and polished surfaces. Whereas with 16% carbamide peroxide gel and the apple juice significant interaction were noted with autoglazed surfaces then the polished surfaces. (Table 1, Table 2)

Scanning electron microscopic photomicrographs taken of representative specimens for all subgroups of study and were presented in Figure 4 to Figure 7. Based on scanning electron microscopy (SEM) photomicrography, alterations in surface characteristics of porcelain were appreciated as generalized severe degradation of exposed surface. Also, intact polished surfaces were also seen. Based on these finding, a variable degree of surface destruction can be appreciated denoting interaction of porcelain with various treatment preparation and acidic beverages hence, demonstrating that porcelain fail to resist chemical degradation.

Table 1: Computational Detail of t-Test for dependent Samples.

Group A						
Sub Groups		**Mean Difference**	**T**	**df**	***p(two tailed)***	**Confidence Intervals 0.95**
a	Polished	0.003	1.41	9	*0.19*	±0.004
	Autoglazed	0.008	0.43	9	*0.67*	±0.004
b	Polished	0.02	3.12	9	*0.01*	±0.01
	Autoglazed	0.01	3.28	9	*0.009*	±0.009
c	Polished	0.004	1.5	9	*0.1*	±0.006
	Autoglazed	0.01	2.28	9	*0.04*	±0.010
d	Polished	0.006	1.62	9	*0.13*	±0.008
	Autoglazed	0.01	2.94	9	*0.01*	±0.01
Group B						
Sub Groups		Mean Difference	T	Df	*p (two tailed)*	Confidence Intervals 0.95
a	Polished	0.12	0.74	9	*0.48*	±0.37
	Autoglazed	0.009	0.74	9	*0.47*	±0.02
b	Polished	0.03	2.53	9	*0.03*	±0.02
	Autoglazed	0.05	3.06	9	*0.01*	±0.04
c	Polished	0.003	1.15	9	*0.27*	±0.005
	Autoglazed	0.004	2.24	9	*0.05*	±0.005
d	Polished	0.01	1.59	9	*0.14*	±0.01
	Autoglazed	0.02	2.85	9	*0.01*	±0.01

Table 2 Computational Detail of t-Test for independent Samples.

Group A						
Surfaces	n	Mean	Std. Dev.	t	df	P(Two-Tailed)
Polished	40	1.85	0.10	-7.32	78	0.0001
Glazed	40	2.41	0.11			
Group B						
Surfaces	n	Mean	Std. Dev.	t	df	P(Two-Tailed)
Polished	40	1.80	0.10	-8.48	78	0.0001
Glazed	40	2.46	0.11			

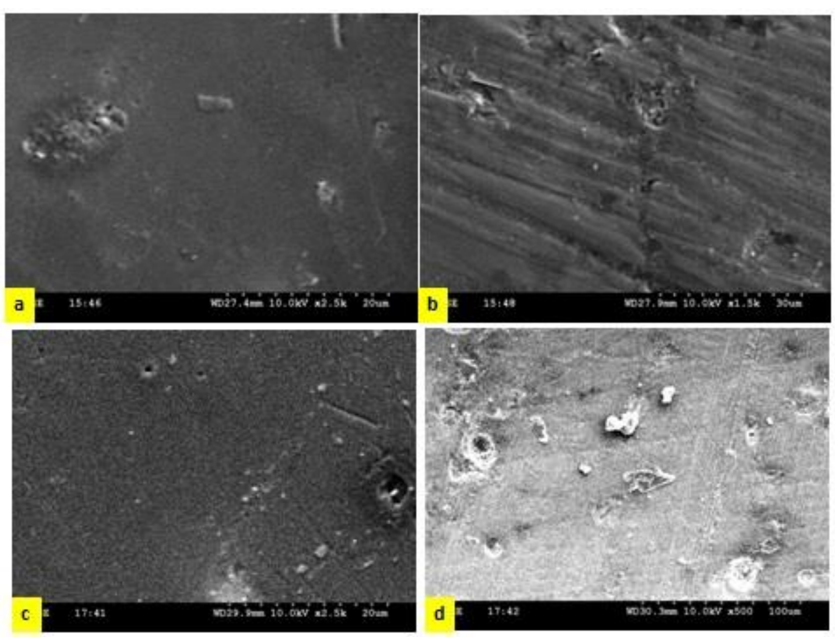

Fig4: Pre-exposure SEM photomicrographs of Group A (a-b) and Group B (c-d) where autoglazed surfaces (a, c) and polished surfaces (b, d)

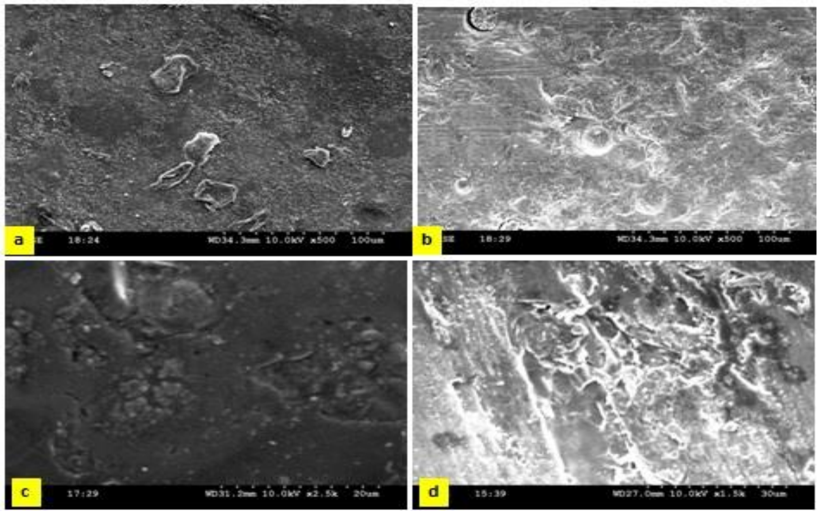

Fig 5: 1.23% APF exposed SEM photomicrographs of Group A (a-b) and Group B (c-d) where autoglazed surfaces (a, c) and polished surfaces (b, d).

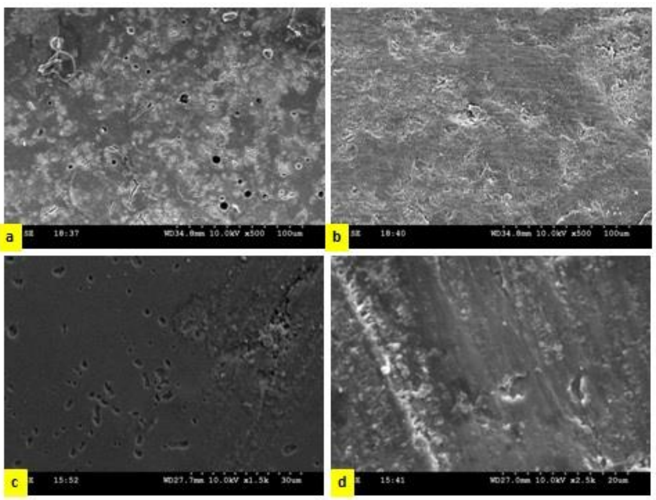

Fig 6: 16% Carbamide peroxide exposed SEM photomicrographs of Group a (a-b) and Group B (c-d) where autoglazed surfaces (a, c) and polished surfaces (b, d).

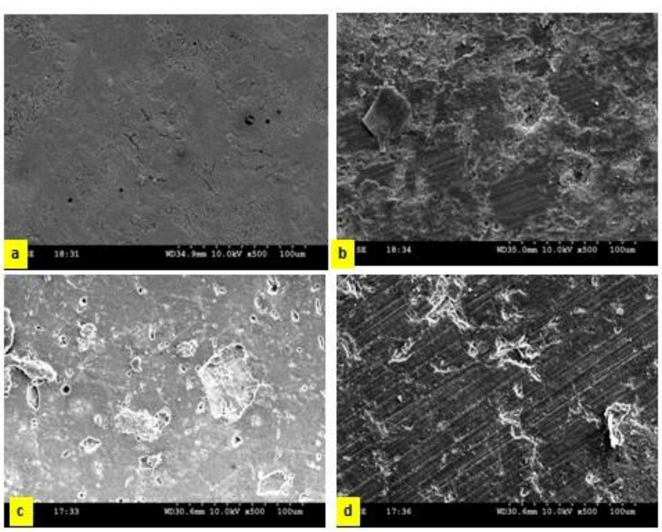

Fig 7: Apple juice exposed SEM photomicrographs of Group A (a-b) and Group B (c-d) where autoglazed surfaces (a, c) and polished surfaces (b, d).

4. Discussion

In this present study, the materials under investigation fluorapatite-leucite (IPS d. SIGN) and fluorapatite (IPS e max ceram) porcelain were tested under 1.23% acidulated phosphate fluoride (pH 3.1), 16% carbamide peroxide (pH 6.5) and tetra pack apple juice (pH 3.4). The result of present study was consistent with the previous studies that showed 1.23% acidulated phosphate fluoride cause significant surface alteration of both the autoglazed and polished porcelain surfaces. The reason may be the presence of silica in porcelain that can be easily etched and pitted by hydrofluoric acid thus causing selective leaching of sodium ions and disturbing the silica network of porcelain after several applications. [1-3] Also, there is availability of literature assessing the effect of bleaching on composite and cements, [4-6] only few authors have evaluated the effect of carbamide peroxide on the surface of porcelain. The present study revealed that the continual 16% carbamide peroxide application causes significant alteration of autoglazed surface. This could be the results of leaching of some components of porcelain matrix due to oxidative process under low pH. [5,6] Some of the previous studies showed that the reaction products from low pH interaction may result in an even more hostile environment which causes greater decomposition of glass network structure. Such reactions occurring within a crack or crevice at the surface of glass could easily result in a decomposition of glass within the crevice. [11,12] The packaged apple juice was considered as prototype of instant fruit juices [pH 3.4, titratable acidity (64.83 volume of 1mL NaOH to bring pH to 5.5 and 82.56 volume of 1mL NaOH to bring pH to 7.0)]. According to literature, the hydroxyl acids such as citric acid, malic acid, and tartaric acid were quantitatively the most common acids in fruits and fruit products. Malic acid is dominant in apple juices (World Health Organization, 1977). Organic hydroxyl acid, in particular citric, malic and tartaric acid, are thought to changes the surface characteristic of fluorapatite-leucite and fluorapatite porcelain due to chelating effects. [7-9].The present study clearly demonstrated significant alteration of autoglazed surfaces of dental porcelains after immersion in fruit juice.

Scanning electron photomicrography showed marked surface alteration of both surfaces after subjected to fluoride, carbamide peroxide, and fruit juice. This could be due to intrinsically multiple flaws such as inhomogeneous distribution of crystals in a glassy matrix, defects induced during ceramic processing and presence of subsurface porosity. Uncovering by chemical degradation or by grinding, thus exposes surfaces of porcelain material. It is apparent from the SEM photomicrography that none of the surfaces are chemical durable and showed alteration of varied degree.

5. Merit and Demerit

In the present study, experiment was carried under more realistic moist environment and the temperature was maintained at 37^{0}C. Few previous studies were carried out at temperature range 22-25^{0}C and porcelain surface changes might not be appreciated at this temperature. Hence, in this study the specimens were subjected to respective testing agents in the incubator and maintaining the temperature at 37^{0}C. 2) Moreover in this study the presence of saliva in the oral cavity and its washing effect has been simulated by cyclic immersion of specimen in testing solution and distilled water. 3) All specimens were prepared by the same operator to maintain standardization. 4) However, there are some limitations such as effect of surface roughness on strength, wear of opposing dentition and restorations, aesthetics, and health of surrounding dental tissue was not noted. 5) In addition, the present study evaluated only two dental porcelains materials. Therefore, further studies are required to elaborate the effect on other dental ceramics.

6. Conclusions

Within the limitations of the present study, following conclusions were drawn:

1. Porcelain restorations should be protected before subjecting to fluoride therapy and home bleaching procedure.
2. The current investigation corroborates existence of ceramic degradation. However, the polished surfaces appear most resistant to chemical degradation than the autoglazed surfaces.
3. Patients should be educated and motivated about the harmful effects of acidic food, sour fruits and drinks on ceramic restoration.

7. References

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