Comparative evaluation of erosive potential of different beverages on enamel and tooth colored restorative materials: An *in vitro* study

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ABSTRACT

The purpose of this study was to determine and compare the erosive potential of different beverages on enamel and tooth-colored restorative materials. Freshly prepared orange juice, apple juice, tomato soup and tap water (control), extracted human prepared tooth free of caries (group II) and two tooth colored restorative materials namely, GIC (GC Fuji IX) Group I and nanocomposite (3M ESPE, Filtek™ Z350) group III were used in this study. Specimens of tooth-colored restorative materials were prepared using a cylindrical mould. The coronal portion of each tooth was sectioned longitudinally using a diamond disc. The crown sections and tooth colored restorative specimen (12 of each) were embedded in acrylic resin blocks. Surface smoothness of test specimens were checked by Non-contact profilometer (Veeco, Wyko NT 1100). Test specimens (3 of each) were randomly distributed to four beverages groups. Specimens were immersed at 37°C 1 hr and again post immersion roughness was measured by Non-contact profilometer. The results showed that before immersion, Group II (Enamel) had the minimum surface roughness followed by Group III (Nanocomposite) and Group I (GC Fuji IX) respectively. After immersion the results showed that erosion of enamel was significantly higher than tooth-colored restorative materials. Erosive potential of orange juice was highest followed by tomato soup and apple juice. All the beverages used in the study caused erosion of enamel and tooth-colored restorative materials. Erosion caused by orange juice was higher followed by tomato soup and apple juice. Erosion of enamel was significantly higher than GIC and nanocomposite.

Key words: Beverages, Erosion, Non-Contact Profilometer, Surface Roughness

Access this article online
Website:
www.jpediatrdent.org
DOI:
10.4103/WKMP-0028.121203
Quick Response Code:

INTRODUCTION

The clinical term dental erosion is used to describe the physical results of a pathologic, chronic, and localized loss of dental hard tissue that is chemically etched away from the tooth surface by acid and/or chelation without bacterial involvement. The acids responsible for erosion are not the products of the oral flora; but dietary, occupational, or intrinsic sources.[1,2]

As lifestyles have changed over the last decade, prevalence of dental erosion seems to have increased presumably due to an increase in the consumption of soft drinks and fruit juices.[3] It has been recognized as an important cause of tooth structure loss not only in adults but also in children.[4]

In the initial stage of erosive lesions only the enamel surface is involved and restoration may be inserted because of esthetic needs and or to prevent further progression. In advanced case dentin becomes exposed, restorative materials like glass-ionomer and composite resin should be used for reestablishing tooth structure, function and esthetics, as well as for controlling hypersensitivity.[5]

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The purpose was to evaluate erosive potential of different beverages and their effect on surface roughness on enamel and tooth colored restorative material using non-contact profilometer.

MATERIALS AND METHODS

The present study was conducted in the Department of Pedodontics and Preventive Dentistry, Kothiwal Dental College and Research Centre, Moradabad in association with the Department of Industrial and Mechanical Engineering, Indian Institute of Technology, Roorkee.

Materials

Four beverages were selected for the study; freshly prepared orange juice (pure) and apple juice (pure), tomato soup (freshly prepared and homemade), and tap water was used as the control group and two tooth-colored restorative materials; Nanocomposite (3M ESPE, Filtek^{TM} Z350) and Glass ionomer cement (GC Fuji IX). Extracted human primary teeth free of caries were carefully cleaned of calculus and other debris and stored in distilled water. Three experimental groups were made:- Group I- Glass ionomer cement, Group II- Enamel, Group III- Nanocomposite.

Method

Preparation of Enamel SpecimenTwelve specimens were used for enamel surface roughness measurement. Enamel specimen blocks were prepared by sectioning the crowns from the root surfaces using diamond bur in a high- speed hand piece with an air water spray. The crowns were then sectioned longitudinally from the buccal to lingual surface through the center of the crown using a high-speed saw cooled with water. The enamel sections were embedded in acrylic resin in molds with the outer enamel surface exposed [Figure 1]. The enamel surfaces were ground using 600 to 2000 grit abrasive paper and polished with alumina slurry.

Tooth-colored restorative material specimens

Twelve specimens were prepared from each of two tooth-colored restorative materials. Each material was placed in to a cylindrical acrylic mold (5 mm diameter and 2 mm thick) and covered with a glass cover slip during the curing process. Nanocomposite was light cured for 20 s following manufacturer's instructions, using a dental curing unit. Specimens were cured under the glass cover slip, had mirror smooth surface that did not require further grinding or polishing [Figure 2]. Glass ionomer cement (Fuji IX) was mixed according to manufacturer's instructions and left to set under cover slip [Figure 3]. Enamel, Glass ionomer cement and nanocomposite specimens were coated with nail varnish exposing a 2 mm window and were kept in distilled water before they were tested [Figure 4]. This established a base line evaluation prior to immersion in the beverage media. The pH of the beverages was checked with pH indicator.

Figure 1: Enamel specimens embedded in acrylic mold

Figure 2: Nanocomposite specimen after curing

Figure 3: GIC (GC Fuji IX) embedded in acrylic mold

Creation of the eroded lesions

The samples were suspended within four different glass pots filled with 250 ml of fresh apple juice, orange juice, tomato soup and tap water each at 37°C temperature and gently agitated for 1 h. After their removal from the erosive solution the samples were rinsed and stored in distilled water.

Assessment of surface roughness

The surface roughness of each specimen was again assessed by non-contact profilometer (Veeco, Wyko NT 1100) at the end of 1 h test period [Figure 5].

RESULTS

In the present study results showed that erosion of enamel was significantly higher than tooth- colored restorative materials. The erosive potential of orange juice was highest followed by tomato soup and apple juice. Erosion of enamel with orange juice was significantly higher as compared to GIC (GC Fuji IX) and nanocomposite (3M ESPE, Filtek™ Z350) while that of nanocomposite was significantly higher as compared to GIC. Erosion of enamel in tomato soup group was significantly higher as compared to that of GIC and nanocomposite and no significant differences between GIC and nanocomposite were seen. Erosion of enamel with apple juice was maximum as compared to nanocomposite and GIC and no significant differences between GIC and Nanocomposite were present [Tables 1 and 2] [Graphs 1 and 2].

DISCUSSION

Human primary tooth enamel contains significantly more carbonate ions than permanent enamel. The carbonate ions occupy two different positions in the hydroxyapatite structure namely the hydroxide position A and phosphate position B. In both positions, the carbonate ions cause distortion in the hydoxyapatite structure. Especially, the amount of carbonate in position A is increased in deciduous enamel which is assumed to distort the lattice more than in phosphate position and is less tightly bound than in B position. This feature might contribute to the increase in the susceptibility of enamel of primary tooth to caries as compared to permanent enamel.[6,7] Also human primary tooth enamel is more porous than human

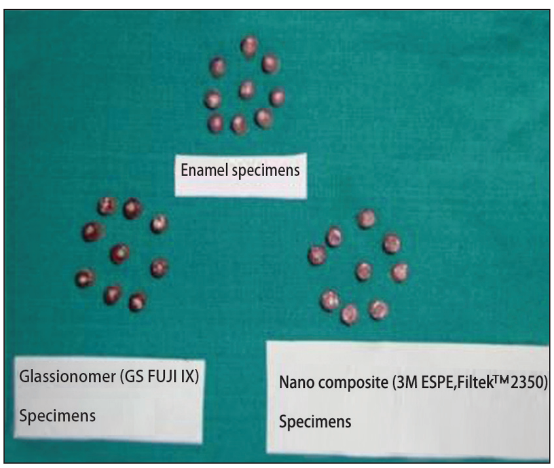
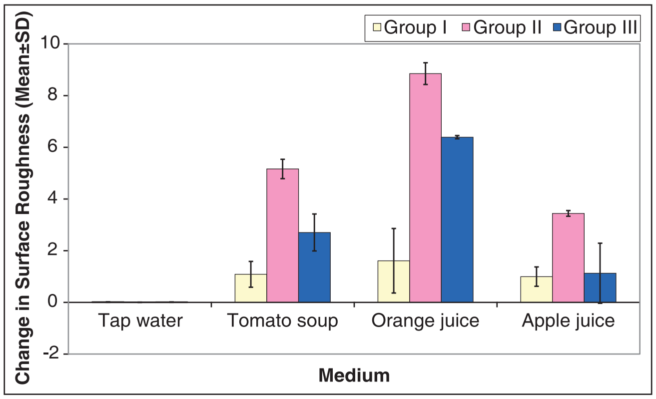


Figure 4: Nail paint applied

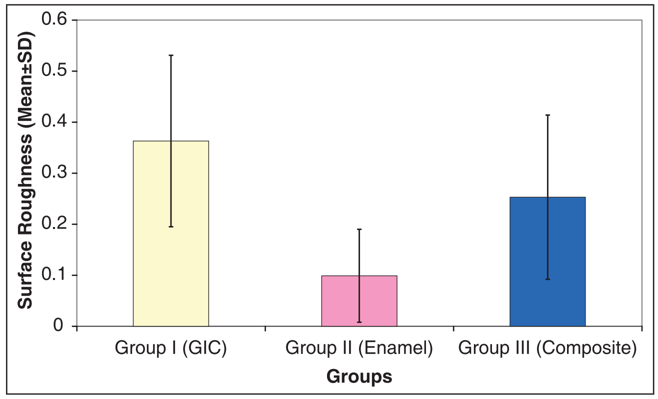
Figure 5: Non-contact profilometer (Veeco, Wyko NT 1100)

Table 1: Group wise distribution of mean pre-immersion surface roughness

S.No.	Medium	Group	Pre immersion (n=3)	Post immersion (n=3)	Mean change
1.	Tap water	I	0.161±0.140	0.173±0.150	0.012±0.010
		II	0.127±0.120	0.130±0.126	0.003±0.007
		III	0.221±0.191	0.228±0.197	0.007±0.009
2.	Tomato soup	I	0.443±0.053	1.529±0.448	1.085±0.499
		II	0.067±0.047	5.229±0.362	5.162±0.375
		III	0.260±0.188	2.963±0.664	2.703±0.716
3.	Orange Juice	I	0.371±0.119	1.979±1.236	1.608±1.248
		II	0.192±0.040	9.041±0.390	8.849±0.422
		III	0.281±0.185	6.671±0.128	6.390±0.062
4.	Apple Juice	I	0.478±0.168	1.472±0.208	0.995±0.374
		II	0.009±0.009	3.449±0.118	3.440±0.110
		III	0.249±0.184	1.376±1.345	1.126±1.161



Graph 1: Group wise distribution of mean pre-immersion surface roughness



Graph 2: Mean change in surface roughness in different groups

Table 2: Mean change in surface roughness

Group	N	Mean	Std. deviation
Group I (GIC)	12	0.363	0.168
Group II (Enamel)	12	0.099	0.091
Group III (Composite)	12	0.253	0.161
Total	36	0.238	0.178

permanent enamel.[8] It should be noticed that outline and arrangement of enamel rods in human primary teeth closely resemble the appearance in permanent teeth.[6]

Fruit juices are made from a concentrated source of fruit and consist of organic acids derived from the fruits such as citric acid from oranges and maleic acids from apple.[9] In our study, pH of drinks was checked by pH indicator. In general food stuffs having lower pH have greater erosive effect.[10] We found that orange juice caused highest change in surface roughness of tooth structure. Specimens were softened by orange juice (pH-2.74), tomato soup (pH-4.25), and apple juice (pH-3.5) but not by tap water (pH-7).

Evidently, pH is not the only factor affecting enamel erosion: Buffering capacity and titratable acidity can also modify the erosive process.[10] Chelation is another property independent of pH which contributes to erosion. Removal of metallic ions like Ca^+ from a biological calcium-phosphorus system may occur at neutral or even alkaline pH.[11]

Orange juice caused maximum surface roughness in this research work followed by tomato soup and apple juice. Erosive potential of pepsi cola was equal to orange juice and greater than apple juice as reported by Grobler *et al.* which are similar to our study.[12] West *et al.* found that orange juice had more erosive potential as compared to water under the *in situ* and *in vitro* condition.[13] Meuman *et al.* explained that there was no protection for enamel *in vitro* whereas pellicle formation occurring *in vivo* which would afford some benefit. The specimens *in vitro* neither have opportunity for the remineralization nor the effect of orange juice limited by the buffering capacity of saliva. Moreover, the orange juice had total contact time with the specimens *in vitro*, whereas *in situ* the specimens were exposed to a passing acid fluid mixed with saliva. Even though the methodology was not designed to provide extended acid exposure by requesting volunteers to sip the fluids over considerable periods of time, one can only estimate that the actual contact time would be dramatically less than the 100% contact time of the *in vitro* method.[13] Beverages containing citric acid have shown an increased potential for the dissolution of hydroxyapatite due to the formation of calcium citrate and chelating action of citric acids that withdraw calcium ions from the beverages resulting in an increased dissolution tendency due to the loss of common ion effect.[10]

Tomato soup used in our study caused more roughness as compared to apple juice and tap water (as control). Ascorbic acid which is a constituent of tomato soup is responsible for its erosive potential. Ascorbic acid is commonly used as an antioxidant food additive or preservative and may contribute to beverage acidity.[14] Till date none of the studies have evaluated tomato soup for its erosive potential.

Apple juice caused significantly higher erosion as compared to tap water (as the control group). The erosive activity of citric, maleic, phosphoric and other acids ingredients of beverages and food stuff has been demonstrated *in vitro*, *in situ* and *in vivo* studies.

Non-carbonated beverages such as flavored fruit juice or high sugar concentration drinks consist of organic acids such as citric (orange), maleic (Apple), and ascorbic (vitamin C), all of which can contribute to the beverage acidity but can be used as modifying or buffering and flavoring agents.[14] Some beverages appeared to be less erosive than others with in the same class. It may be also possible to reduce the erosive potential of beverages by modifying the amount and type of acid used in beverage formulation, for example using maleic acid instead of citric acid.

Erosion consistently increased with beverages for both tooth-colored restorative materials and enamel. Results of the present study illustrated significant differences between the tooth-colored restorative materials. Erosion of enamel was significantly higher than tooth-colored restorative materials.

Devlin *et al*. showed that primary teeth are more prone to erosion than permanent teeth because of the disordered crystal structure in their enamel and increased porosity. Primary tooth enamel has been shown to be softer than that of permanent teeth. Younger children have a lower salivary flow rate than adults, which further increases their susceptibility to tooth erosion.[15]

Daniela *et al.*[5] and Shabanian and Richards[16] reported that wear rates are higher in conventional GIC as compared to composite. This is contradictory to our study, where GIC has shown lesser wear rates than composites. The reason may be the high fluoride content of GIC and the reason for higher wear rate of composites may be due to the acid attack to the resin causing softening of bisphenol-A-glycidyl methacrylate (Bis GMA) based polymers,[5,10] and leaching of triethylene glycol dimethacyrlate (TEGDMA), which ultimately reduced the surface hardness.[5]

In the other studies, dental materials were immersed continuously in the acidic media for a period of 1 week. However, in the present study the total exposure of specimens to acids occurred for just 60 min and possibly this period was not able to promote roughness alteration and significant differences among the studied materials.[5] In addition, significant difference was present after orange juice immersion but not with apple juice and tomato soup.

In this *in vitro* study, orange juice, tomato soup and apple juice softened the enamel surface despite the relatively short contact period (1 h for only 1 day) between substrates and the acidic food stuffs. Accordance to the current literature, the enamel presented a higher wear when compared to the tooth-colored restorative materials. Preventive advice to the children, teenagers, parents and health care providers should include a warning about the danger of erosive sources to the teeth.[17] In certain groups, erosive fruits-based drinks tend to be introduced at a very early age, thereby increasing the time over which primary teeth are exposed to them. Milk or water should constitute the majority of the total drinks given to the children.[18]

CONCLUSION

The present study shows that erosion of primary tooth enamel was significantly higher than tooth-colored restorative materials. The erosive potential of orange juice was highest followed by tomato soup and apple juice.

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How to cite this article: Goyel P, Singh MG, Bansal R. Comparative evaluation of erosive potential of different beverages on enamel and tooth colored restorative materials: An *in vitro* study. J Pediatr Dent 2013;1:58-62.

Source of Support: Nil. **Conflict of Interest:** None declared.