Original Article

Comparative evaluation of surface properties of enamel and different esthetic restorative materials under erosive and abrasive challenges: An *in vitro* study

Simranjeet Kaur, Sameer Makkar, Rajneesh Kumar, Shinam Pasricha, Pranav Gupta

Department of Conservative and Endodontics, National Dental College and Hospital, Dera Bassi, Punjab, India

Abstract

Introduction: Noncarious tooth surface loss is a normal physiological process occurring throughout the life, but it can often become a problem affecting function, esthetics or cause pain. **Aim:** The purpose of this study was to assess the effect of erosive and abrasive challenges on the surface microhardness and surface wear of enamel and three different restorative materials, that is, nanofilled composite, microfilled composite and resin-modified glass ionomer cement (RMGIC) by using Vickers microhardness tester and profilometer respectively. **Subjects and Methods:** Nanofilled composite (Filtek™ Z350 × T), microfilled composite (Heliomolar®) and RMGIC (Fuji II LC) were used in the study. **Results:** Nanofilled composite resin has the best resistance to erosion and/or abrasion among all the materials tested, followed by microfilled composite and RMGIC respectively. **Conclusion:** Toothbrush abrasion has a synergistic effect with erosion on substance loss of human enamel, composites, and RMGIC. The susceptibility to acid and/or toothbrush abrasion of human enamel was higher compared to restorative materials.

Key words: Microfilled composite, nanofilled composite, resin modified glass ionomer cement, soft drink, tooth brush

INTRODUCTION

Noncarious tooth surface loss is a normal physiological process occurring throughout the life, but it can often become a problem affecting function, esthetics or cause pain. This loss of tooth structure or wear is often commonly termed abrasion, attrition, erosion and abfraction. The incidence of noncarious lesions has been increased in developed countries.[1] Tooth wear can be due to carious or noncarious reasons and can be physiological or pathological. The tooth wear is considered pathological if it occurs due to injury to tissues. The various causes of pathological tooth wear are erosion, abrasion, attrition, and abfraction. Erosion and abrasion are the regressive alterations of the teeth that occur as a result of tissue injury. They have apparently increased in the last few decades partly because of an increasing trend in the consumption of carbonated and citrus drinks and also because of the adult population retaining more natural teeth as they age. Erosion is defined as the local, chronic, pathologic and painless loss of tooth structure, through a chemical process of acidic dissolution without involving bacteria and acids of bacterial plaque origin.[2] The term "biocorrosion" has been supplanted for erosion these days.[3] The etiology of erosion is multifactorial, that is, the causes can be extrinsic or intrinsic. The extrinsic causes of dental erosion can be environmental, diet, medications and lifestyle. The intrinsic causes of erosion are the gastric juice entering the mouth due to reflux disease, psychological problems (bulimia nervosa and stress rumination), chronic alcoholism and pregnancy.[4]

Abrasion is pathological wearing away of tooth through abnormal mechanical process.[5] The most common cause is faulty brushing with inappropriate oral hygiene aids, occupational or habitual causes and ill-fitting clasps of partial dentures, which may also induce localized abrasive lesions. It usually occurs on the exposed

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Address for correspondence:
Dr. Pranav Gupta,
Department of Conservative and Endodontics, National Dental College and Hospital, Dera Bassi, Punjab, India.
E-mail: pranavgupta777@gmail.com

root surfaces and usually manifests as a V-shaped or wedge-shaped ditch, although it can also appear in other shapes like C-shaped defect, the undercut concave defect or as a divergent box. Abrasive lesions are usually generalized and most commonly seen on facial surfaces of canines and premolars.

Restorations may be performed in erosion and abrasion lesions to restore tooth structure, function and esthetics, as well as to control the hypersensitivity.[6] Various restorative materials have been advocated for restoring such noncarious lesions. These include the microfilled composites, resin modified glass ionomer cements (RMGICs) and most recently, nanofilled composites. Clinical performance of restorative materials is affected by erosive and abrasive challenges. Supra-additive interaction was found between the erosive attack and abrasive attack on the substance loss for enamel, polyacid modified composite and glass ionomer cement.[7] The oral hygiene methods may produce abrasive lesions that can also affect the physical properties of restorative materials. This knowledge would be important to dentists in planning, which kind of restorative materials to be used for restoration of teeth, which might frequently be exposed to erosion and/or abrasion. The methods used for measurement of the superficial alterations in this study include surface microhardness and surface wear. Hence, the purpose of this study was to assess the effect of erosive and abrasive challenges on the surface microhardness and surface wear of enamel and three different restorative materials, that is, nanofilled composite, microfilled composite and RMGIC by using Vickers microhardness tester and profilometer respectively.

SUBJECTS AND METHODS

Artificial saliva was prepared for the study. The composition per liter of the solution was: 14.4 mM NaCl, 16.1 mM KCl, 0.3 mM $MgCl_2.6H_2O$, 2.9 mM K_2HPO_4, 0.75 mM $CaCl_2.2H_2O$, 0.10 g/100 mL sodium carboxymethylcellulose (pH of solution = 7).

Sixty-four sound freshly extracted, noncarious human maxillary incisors teeth from the age group 18 to 40 years were taken. The teeth were cut using diamond disks mounted on a straight handpiece. The enamel surface was ground flat with different grits of sand papers [Figure 1]. The specimens were mounted in acrylic blocks and were then divided into four groups based on the type of restorative material used to restore them [Figures 2 and 3]. Each group was further divided into subgroups depending on the treatment to which they were subjected [Figure 4]. The teeth were divided into the following groups of 16 teeth each. Cavities of a standardized size (6 mm × 4 mm × 1.5 mm) were prepared on the surface using Mani Dia-Bur SF-12. Only Group A was left intact. In Group B, the enamel specimens were restored with Nanofilled Composite [Table 1].

In Group C, the enamel specimens were restored with Microfilled Composite (Heliomolar®). In Group D, the enamel specimens were restored with RMGIC. The same specimens were then subjected to microhardness determination test under Vickers microhardness

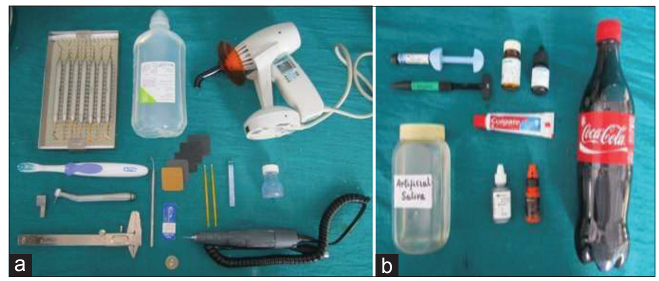


Figure 1: (a) Armamentarium used in the study, (b) Materials used in the study

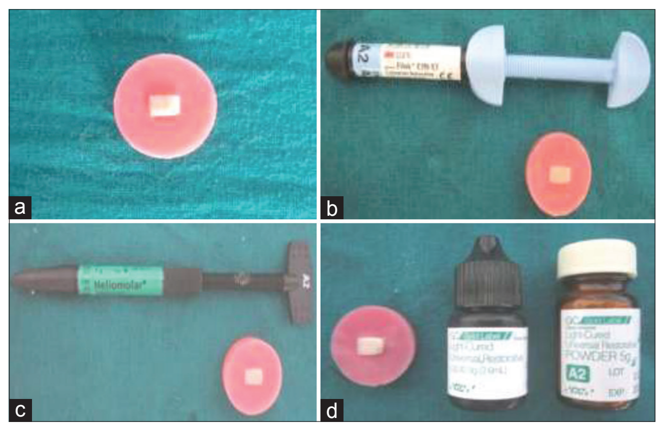


Figure 2: (a) Enamel, (b) Nanofilled composite, (c) Microfilled composite, (d) Resin modified glass ionomer cement

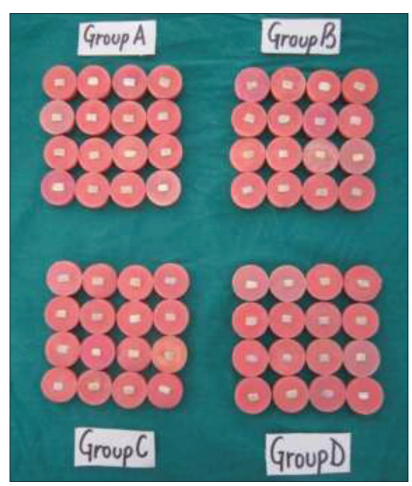


Figure 3: Grouping of 64 samples into four groups

Table 1: Materials used in study

Materials	Commercial name	Manufacturing company
Nanofilled composite	Filtek™ Z350 XT	3M ESPE, USA
Microfilled composite	Heliomolar®	Ivoclar Vivadent, Liechtenstein
RMGIC	Fuji II LC	GC, Japan

RMGIC: Resin modified glass ionomer cements

tester: Shimadzu, Japan available at Research and Development Centre for Bicycle and Sewing Machine, Ludhiana, Punjab [Figure 5]. The microhardness tester produced the indents at a load of 100 g for 15 s. The average surface roughness (R_a) was determined on the same specimens by using profilometer: Mitutoyo surftest-4 available at Research and Development Centre for Bicycle and Sewing Machine, Ludhiana, Punjab. It was determined by a contact stylus having tip diameter of 5 µm. For wear references, two layers of nail varnish were applied on half of the surface of the enamel and restorative material after microhardness and roughness assessment [Figure 6].

Later, all the groups were further divided into four subgroups: The Subgroup 1 (control subgroup) specimens of each group were stored in artificial saliva throughout the experimental period of 7 days. The Subgroup 2 (erosive subgroup) specimens of each group were subjected to an erosive pH cycle. It consisted of exposure to Coca-Cola for 5 min, thrice a day for 7 days. For the rest of the duration, the teeth were stored in artificial saliva. In Subgroup 3 (abrasive subgroup), the specimens were subjected to the abrasive challenge with the Oral-B powered toothbrush with a dentifrice (Colgate) equal to the size of brush head for 2 min thrice a day for 7 days. For the rest of the duration, the teeth were stored in artificial saliva. In Subgroup 4 (erosive and abrasive subgroup), the specimens were subjected to an erosive pH cycle for the same duration, followed by a similar abrasive cycle as above. After the surface treatment, nail varnish was carefully cleaned from the specimens with acetone-soaked cotton wool and a final microhardness was done. The same specimens were again subjected to Vickers microhardness test and surface roughness test. Then the specimens were subjected to statistical analysis.

RESULTS

The readings were tabulated and subjected to statistical analysis using ANOVA test. Mean and standard deviation were calculated for each group using ANOVA test and Tukey test.

Figure 4: Subgroup 1: Control subgroup, Subgroup 2: Erosion subgroup, Subgroup 3: Abrasion subgroup, Subgroup 4: Erosion and abrasion subgroup

Figure 5: (a) Vickers Microhardness tester: Shimadzu, Japan, (b) Profilometer: Mitutoyo surftest-4

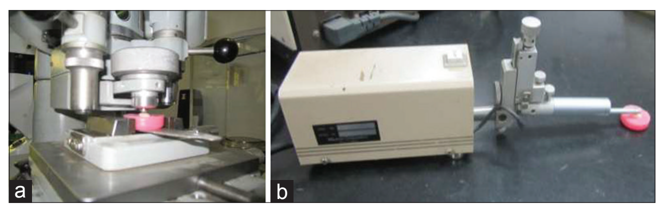


Figure 6: (a) Microhardness tester producing indent using a load of 100 g, (b) Profilometer stylus moving on the surface for assessment of surface roughness (R_a)

The standard value considered to demonstrate statistically significant differences was set at $P \leq 0.05$. Results of analysis were tabulated [Table 2] and [Graphs 1-10] were plotted as enclosed. The results of the study showed that the overall percentage surface microhardness change for groups was in the following order:
Group A (enamel group: 10.65% ±9.45012) > Group D (RMGIC group: 8.05% ±7.60738) > Group C (microfilled group: 6.62% ±5.95222) > Group B (nanofilled group: 4.41% ±5.61701).

The results of the surface wear were as:
Group A (enamel group: 2.07 µm ± 1.37912) > Group D (RMGIC group: 1.42 µm ± 1.01301) > Group C (microfilled group: 0.96 µm ± 0.60346) > Group B (nanofilled group: 0.79 µm ± 0.58986).

Table 2: Multiple comparisons dependent variable: Percentage change hardness Tukey HSD

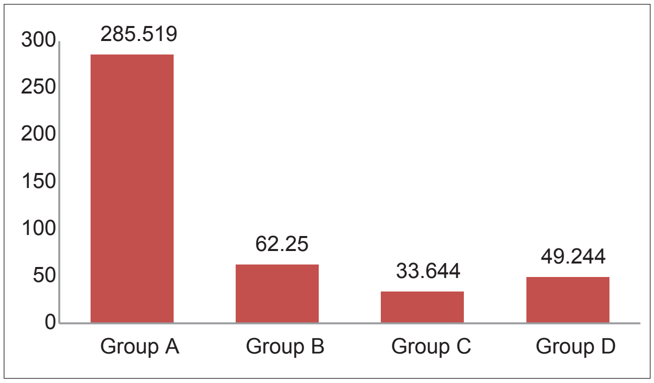
Subgroup	Group (I)	Group (J)	Mean difference (I-J)	SE	Significant	95% CI	
						Lower bound	Upper bound
SUBGP 1: Control	A	B	−1.25874	1.03513	0.629	−4.3319	1.8144
		C	−3.00638	1.03513	0.056	−6.0796	0.0668
		D	−2.22500	1.03513	0.193	−5.2982	0.8482
	B	A	1.25874	1.03513	0.629	−1.8144	4.3319
		C	−1.74764	1.03513	0.371	−4.8208	1.3256
		D	−0.96625	1.03513	0.788	−4.0394	2.1069
	C	A	3.00638	1.03513	0.056	−.0668	6.0796
		B	1.74764	1.03513	0.371	−1.3256	4.8208
		D	0.78139	1.03513	0.873	−2.2918	3.8546
	D	A	2.22500	1.03513	0.193	−.8482	5.2982
		B	0.96625	1.03513	0.788	−2.1069	4.0394
		C	−0.78139	1.03513	0.873	−3.8546	2.2918
2: Erosion	A	B	11.42053(*)	2.78066	0.007	3.1650	19.6760
		C	9.37718(*)	2.78066	0.025	1.1217	17.6327
		D	5.16347	2.78066	0.296	−3.0920	13.4190
	B	A	−11.42053(*)	2.78066	0.007	−19.6760	−3.1650
		C	−2.04335	2.78066	0.001	−10.2988	6.2121
		D	−6.25706	2.78066	0.001	−14.5126	1.9984
	C	A	−9.37718(*)	2.78066	0.001	−17.6327	−1.1217
		B	2.04335	2.78066	0.001	−6.2121	10.2988
		D	−4.21371	2.78066	0.001	−12.4692	4.0418
	D	A	−5.16347	2.78066	0.001	−13.4190	3.0920
		B	6.25706	2.78066	0.001	−1.9984	14.5126
		C	4.21371	2.78066	0.459	−4.0418	12.4692
3: Abrasion	A	B	3.40284	2.28938	0.475	−3.3941	10.1998
		C	2.00803	2.28938	0.817	−4.7889	8.8050
		D	1.26640	2.28938	0.944	−5.5305	8.0633
	B	A	−3.40284	2.28938	0.475	−10.1998	3.3941
		C	−1.39481	2.28938	0.927	−8.1917	5.4021
		D	−2.13644	2.28938	0.788	−8.9334	4.6605
	C	A	−2.00803	2.28938	0.001	−8.8050	4.7889
		B	1.39481	2.28938	0.001	−5.4021	8.1917
		D	−0.74163	2.28938	0.001	−7.5386	6.0553
	D	A	−1.26640	2.28938	0.001	−8.0633	5.5305
		B	2.13644	2.28938	0.001	−4.6605	8.9334
		C	0.74163	2.28938	0.988	−6.0553	7.5386
4: Erosion and abrasion	A	B	7.38836	4.87112	0.001	−7.0735	21.8502
		C	3.72752	4.87112	0.001	−10.7344	18.1894
		D	−1.72971	4.87112	0.001	−16.1916	12.7322
	B	A	−7.38836	4.87112	0.001	−21.8502	7.0735
		C	−3.66084	4.87112	0.017	−18.1227	10.8010
		D	−9.11808	4.87112	0.016	−23.5800	5.3438
	C	A	−3.72752	4.87112	0.001	−18.1894	10.7344
		B	3.66084	4.87112	0.001	−10.8010	18.1227
		D	−5.45724	4.87112	0.001	−19.9191	9.0046
	D	A	1.72971	4.87112	0.001	−12.7322	16.1916
		B	9.11808	4.87112	0.001	−5.3438	23.5800
		C	5.45724	4.87112	0.685	−9.0046	19.9191

*The mean difference is significant at the 0.05 level. SE: Standard error; CI: Confidence interval

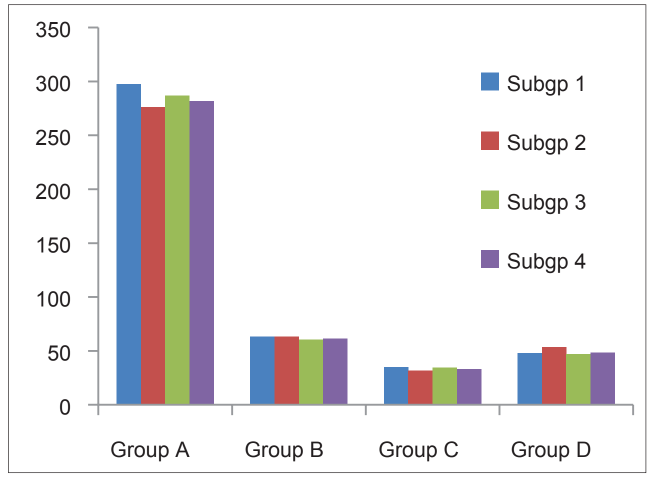
In microhardness changes and wear, the values of all groups were statistically significant when compared to the other three groups ($P < 0.05$).

DISCUSSION

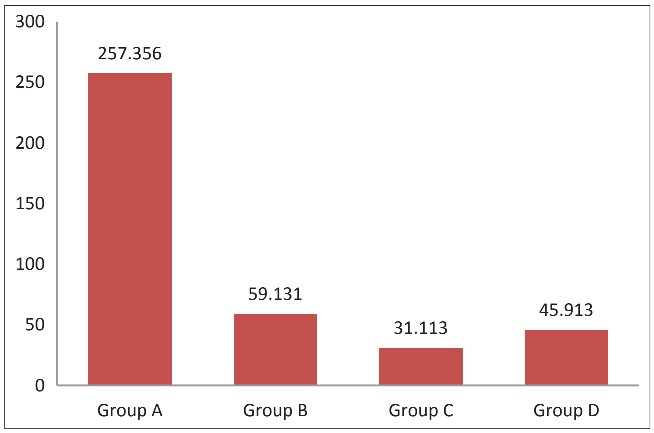
Noncarious tooth tissue loss has become a significant problem in the modern era. It poses the next most significant threat to the function and longevity of human dentition after trauma, caries and periodontal disease.[8,9] It appears that the consumption of citrus fruits and soft drinks may be a major factor in the etiology of the disease. The most important aspect in development of tooth wear is the frequency of consumption followed by method of consumption.[10] Hence, soft drinks consumed at meal times are less injurious than those consumed alone and continuous sipping is considered more harmful to dentition than consuming an entire beverage at once. It has been reported that cola beverages are retained on dental enamel and are less likely to be removed by saliva as compared to other beverages, which increases its cariogenicity.[11] Oral products and toothpastes are used to prevent or to decrease the progression of erosion.[12] But in reality it has been seen that erosion can act in synergy with abrasive factors, including



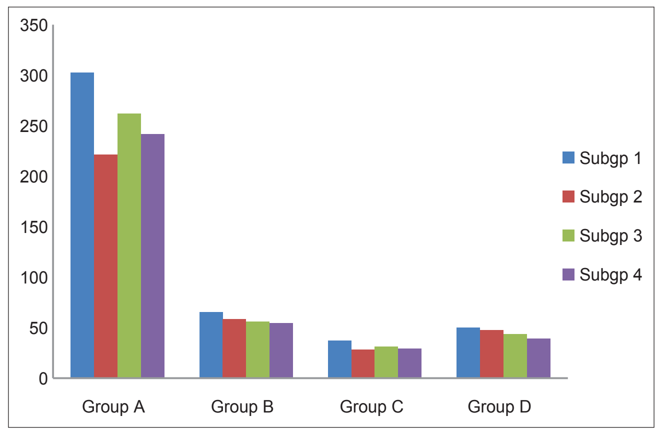
Graph 1: Average surface microhardness at baseline for four groups (VHN)



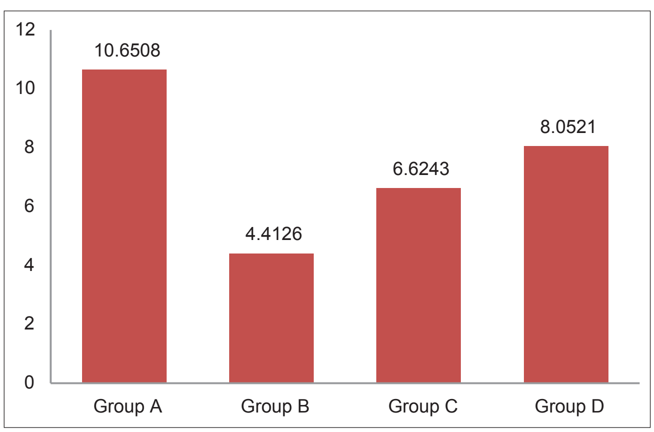
Graph 2: Mean average surface microhardness of all subgroups at baseline (VHN)



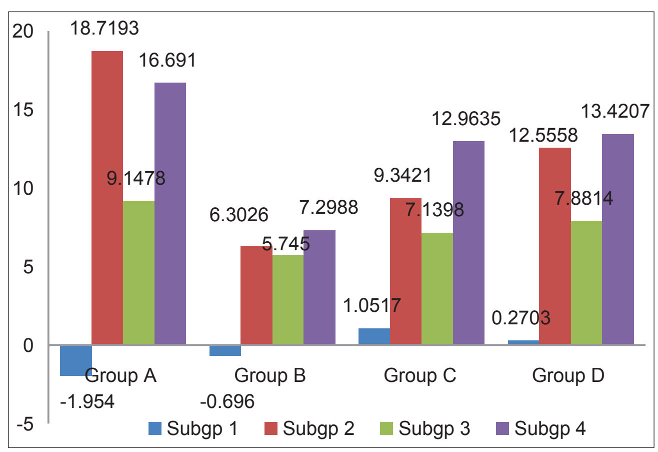
Graph 3: Mean of average surface microhardness (VHN) posttreatment (groups)



Graph 4: Mean of average surface microhardness (VHN) posttreatment (subgroups)

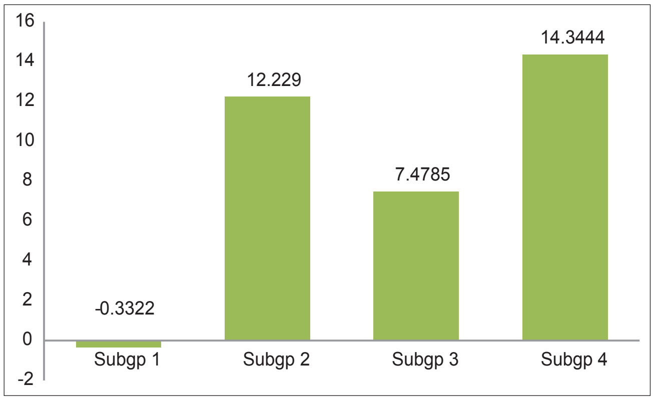


Graph 5: Percentage surface microhardness change for groups (VHN)

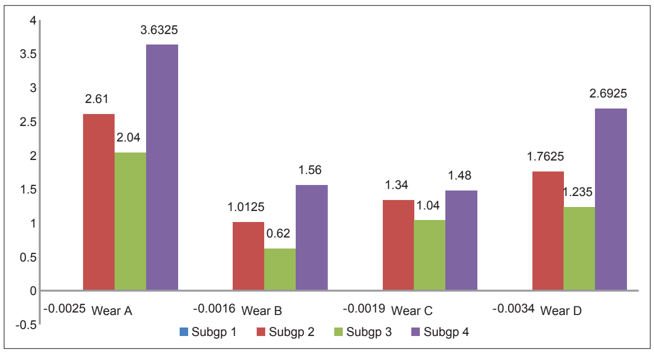


Graph 6: Percentage surface microhardness change for 16 subgroups (VHN)

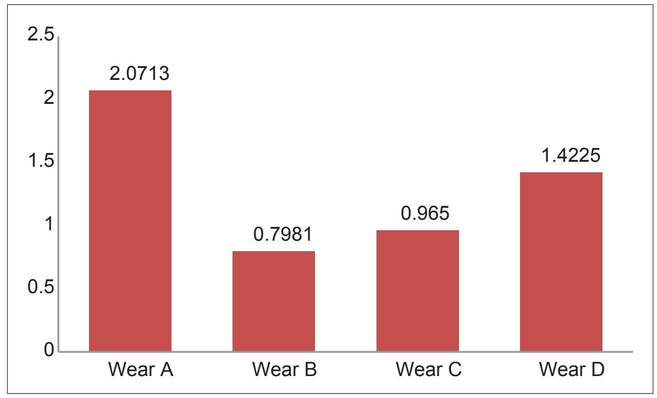
toothpaste. The abrasion resistance of softened dental hard tissues is lower than that of sound surfaces.[13,14] The present study aimed to study the effects of erosive and abrasive challenges on the percentage microhardness change and surface wear of enamel, nanofilled composite, microfilled composite and RMGIC. Standardized rectangular specimens of teeth were prepared in accordance with the study of Francisconi *et al*.[6] In our study, the restorative materials were cured through a mylar strip. Although the esthetic restorative materials that are light cured against a matrix strip are not devoid of imperfections, they present the smoothest surface that is possible to achieve.[15] Coca-Cola was used for the abrasive



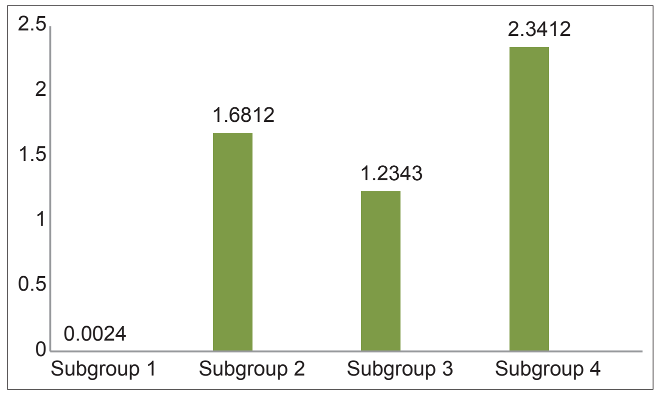
Graph 7: Percentage surface microhardness change for four subgroups (VHN)



Graph 9: Wear for 16 subgroups (μm)



Graph 8: Wear for groups (μm)



Graph 10: Wear for four subgroups (μm)

challenge in the study because it is the most common soft drink consumed among youngsters. The erosive cycle of 3 times a day for 1-week was carried out to simulate daily intake of the drink in accordance with the study of Francisconi *et al*.[6] In previous studies, substrates usually contacted acidic solution for a prolonged period of time or did not account for the role of saliva. The current study used artificial saliva and was designed to overlap the above-mentioned limitation of *in vitro* studies and simulate the clinical situation maximally in accordance with other studies.[7] The composition was in accordance with that given by Hooper *et al*. 2003.[9] The artificial saliva provides protection in between erosive and abrasive attacks. In order to standardize abrasion, the specimens were brushed extraorally with an electric toothbrush using a common toothpaste used in the region (Colgate). In this study, each respective specimen was brushed for 2 min 3 times a day making a total of 6 min brushing per day for 1-week. This is in accordance with the study of Yu *et al*.[7] Enamel and three restorative materials were used for the study which were divided into Groups A, B, C and D. Group A was enamel group. The specimens of this group were left intact. Group B was nanofilled composite group. Filtek™ Z350 XT (3M ESPE) was used in this study. The nanofilled composites have increased strength, owing to a higher filler content, improved filler technology, modifications in the organic matrix and better polymerization. They also exhibit a good polish and gloss retention. Group C was microfilled composite group. Heliomolar® (Ivoclar Vivadent) was used in this study. The main characteristics of these composites are the high polish that can be maintained over time and excellent enamel-like translucency. Therefore, they are indicated for the restoration of anterior teeth and cervical abfraction lesions. They should not be used in heavy stress-bearing areas because they frequently exhibit marginal chipping and bulk fracture. Very small particles contained in microfilled resins result in an even wear pattern and thus retention of a smoother surface.[16] Their physical properties are inferior to those of hybrid composites because of their lower filler content; but their compressive strength is relatively high. Group D was the RMGIC group. Fuji II LC (GC America) was used in our study. RMGIC's are widely used because of various favorable properties which include their coefficient of thermal expansion being close to that of dentin, low volumetric contraction during the setting reaction, chemical adherence to the dental structure, biocompatibility with the pulp tissue, fluoride release, aesthetics, anti-cariogenic action and antimicrobial activity.[17] Surface hardness loss and wear develops in response to abrasion and acid erosion of restoration surfaces. If present in a significant amount, they significantly compromise their longevity and limit their indications. To assess the surface microhardness and wear of the above groups, we have used Vickers microhardness tester and profilometer respectively. Hardness is defined as the resistance to permanent indentation or penetration. Vickers microhardness test involves the use of a static diamond tip under a specific load, over a tested material and over a specific period of time, which forms a pyramid-square shaped microscopic indent after removal of the load. To assure an optimized clinical performance of restorations, it is of paramount importance to employ materials with hardness at least similar to that of the dentinal substrate, not only superficially, but also in depth, since an accentuated decrease in hardness would adversely affect their mechanical properties and marginal integrity.[15] The surface wear was measured in this study by profilometry, which measures the bulk tissue loss occurring after erosive impacts and is the most illustrative method when the clinical appearance of tooth wear defects is considered. This method is appropriate for the evaluation of enamel and restorative materials since the subsurface changes in mineral content are relatively small.[18]

Clinically, surface roughness must be observed, as it plays a decisive role in the retention and accumulation of dental biofilm. Profilometry is the measurement of the surface height variation of an object. The profilometer measures the average surface roughness (R_a parameter).[19] It is defined as the arithmetic average value of all absolute distances of the roughness profile from center line within the measuring length. Wear was determined as the difference between the average roughness values at baseline level (pretreatment) and after treatment (posttreatment). The negative values in the wear results indicate increased roughness or wear after treatment.

The results for Group A are explained as the flattening and polishing of specimens in this study which possibly rendered enamel surfaces more susceptible to acid and toothbrush than would be the case under normal clinical conditions.[13] According to Francisconi *et al*. and Yu *et al*. (2009) the resistance of enamel to acid and toothbrush was less than the three restorative materials. The results for Group D are explained as resulting from the matrix dissolution peripheral to glass particles of RMGIC, which could result from dissolution of the siliceous hydrogel layer. The facts that RMGIC exhibited significantly greater surface changes and wear than the nanofilled and composite resin may be due to the higher acid resistance of polymer matrices in resin based materials (Yu *et al*. 2009). The wear rates of resin modified glass ionomers are high.[20] The results for Groups C and B are explained as the acid also attacks the resin, but to a lesser extent, resulting in a possible degradation of the surrounding resin matrix or silane coupling agent and loss of filler particles of composite resin (Yu *et al*. 2009). For Group C, the higher percentage microhardness change and wear may be attributable to the lower filler content in microfilled composites.[21] In Group B, significant improvement in surface smoothness/polish retention has been reported for nanofilled composites compared with conventional microfilled composites.

In Group A (enamel group), Subgroup 2 produced the maximum percentage change microhardness among all groups, followed by Subgroups 4, 3 and 1 respectively. The highest results for Subgroup 2 in microhardness changes are due to flattening and polishing of specimens in this study, which possibly rendered enamel surfaces more susceptible to acid dissolution than would be the case under normal clinical conditions. Erosion may have resulted from some direct loss of the superficial enamel layer, and in addition, may have softened the underlying layer, thus resulting in such results.[13] This was followed by Subgroup 4, which can be explained as the eroded and softened enamel was extraordinarily susceptible to toothbrushing performed immediately after an erosive challenge, resulting in exposure of a harder enamel surface.[13] Hence, it caused lesser microhardness change than Subgroup 2. The highest results for wear were seen in Subgroup 4 due to supra-additive interaction between the erosive attack and abrasive attack on the substance loss for enamel (Yu *et al*. 2009). In Subgroup 2 acid exposure alone lead to enamel wear, but the wear was less than that when combined with toothbrush. This finding is supported by Eisenburger and Addy[22] who proposed that enamel wear increased with acid exposure. In Subgroup 3, the enamel samples showed high hardness and wear resistance compared to erosion or combined erosion and abrasion. The total enamel loss was very small. Most toothpastes produce only minimal abrasion to enamel.[9] In Subgroup 1, there was slight increase in surface microhardness due to partial rehardening of the enamel specimens immersed in saliva and a slight gain in surface profile leading to decreased wear.

In Group B, Subgroup 4 produced the maximum percentage change microhardness and wear among all groups followed by Subgroups 2, 3 and 1 respectively. For Subgroup 4, supra-additive interaction was found between erosion and abrasion on microhardness change and wear. In Subgroup 2, the application of nanotechnology and high filler loading makes the nanofilled composites extremely resistant to acid attack (Saunders 2009). Previous studies have reported that acidic challenge had detrimental effects on wear of composite resins. In Subgroup 3, nanofilled composites are extremely wear resistant due to their high filler loading. Their resistance to abrasion is higher than their resistance to acid attack. This finding is supported by Saunders 2009. In Subgroup 1, water sorption of the samples was seen which resulted in a small gain of surface profile as suggested by Okada *et al*. (2001) and Yu *et al*. (2009). In our study, the nanocomposite yielded higher microhardness values as compared to microfilled composite. This may be attributable to the higher filler content.[23]

In Group C (microfilled group), Subgroup 4 produced the maximum percentage change microhardness and wear among all groups followed by Subgroups 2, 3 and 1 respectively. The microhardness change in Group C was higher than Group B due to the lower filler content, hence resulting in decreased mechanical properties. (Saunders 2009) Subgroup 4 supra-additive interaction was found between the erosive attack and abrasive attack on the microhardness change and substance loss for composites as explained above (Yu *et al*. 2009). The composites with larger fillers presented higher weight loss and roughening than the finer materials.[24,25]

In Group D (RMGIC), Subgroup 4 produced the maximum percentage change microhardness and wear among all groups followed by Subgroups 2, 3 and 1 respectively. McKinney *et al*. (1987) suggested that the wear pattern is more uniform in glass ionomer cements than the conventional resin-based composites, where filler “pluck-out” predominates. In Subgroup 1, immersion in artificial saliva did not much change the surface microhardness. This is supported by the study of Okada *et al*. (2001). Hence, in all groups the maximum wear was produced in case of combined erosion and abrasion followed by erosion, abrasion and control group respectively.

It can be concluded that toothbrush abrasion has a synergistic effect with erosion on substance loss of human enamel, nanofilled composite, microfilled composite and RMGIC. It also should be emphasized that the surface demineralization of enamel caused by acidic substances may also be repaired by the influence of saliva. Therefore, patients have been advised to avoid toothbrushing for at least 1 h after having soft drinks in order to minimize tooth substance loss by toothbrush abrasion.[26] There have been attempts to reduce the erosive potential of soft drinks. Addition of low concentrations of calcium, phosphate and fluoride may exert a significant protective potential with respect to dental erosion. Casein and ovalbumin have also produced good results.[27] The potential drawbacks of this approach include a detrimental effect on taste and a potential reduction in the shelf life of the product. Other preventive strategies include the salivary stimulation by chewing gum after an erosive or erosive/abrasive attack. Protective effect of acidified fluoride gel on enamel abrasion has also been shown. Rinsing with an iron solution after an erosive attack, followed or not by an abrasive episode, may be a viable alternative to reduce the loss of dental structure.[28] High-concentration sodium fluoride applications (5000 ppm and 19,000 ppm) have been shown to improve the abrasion resistance of eroded enamel and dentine *in vitro* and *in situ*.[29] *In vivo*, the salivary pellicle provides a physical barrier that confers a degree of protection against an erosive challenge, however the pellicle is susceptible to desorption under acidic conditions.[30] According to Ganss *et al*.,[31] sound enamel is relatively resistant to physical impacts, whereas significant tissue loss can occur after exposure to acids. Similar to sound enamel, the main effect on tissue loss appears to be due to the action of abrasives rather than to the impact of the toothbrush itself, at least in early stages.

This result highlights the need to control factors that contribute to enamel loss by diet modification and by performing restorations, or to resort to full-coverage restorations under extreme situations. Importantly, it must be noted that, at least in the case of human enamel, the results of the present study must be interpreted with caution because the erosion and abrasion process might be influenced by the presence of pellicle in the oral cavity. Hence, further research to better understand the exact mechanism of the progression of tooth wear and how materials respond to such erosive and abrasive challenges in the complex oral environment is needed.

SUMMARY AND CONCLUSION

Tooth wear is a well-recognized problem that has apparently increased in the last few decades. Various restorative materials may be used in erosion and abrasion lesions in our study were nanofilled composites, microfilled composites and RMGICs. Since the longevity of these restorations depends on its properties, such as surface microhardness and wear resistance, the aim of our study was to assess the effect of erosive and abrasive challenges on the above-mentioned properties of enamel and restorative materials. Standardized cavities were prepared on enamel specimens and were either left intact (for enamel group) or restored with restorative materials. They were then subjected to erosion, abrasion, combined erosion and abrasion or immersed in artificial saliva. The microhardness and wear of the samples were assessed using Vickers microhardness tester and profilometer respectively. Within the limitations of the present study, it can be concluded that:

- Toothbrush abrasion has a synergistic effect with erosion on substance loss of human enamel, composites and RMGIC
- The susceptibility to acid and/or toothbrush abrasion of human enamel was higher compared to restorative materials
- Nanofilled composite resin has the best resistance to erosion and/or abrasion among all the materials tested, followed by microfilled composite and RMGIC respectively.

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