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Effect of High-Fluoride Dentifrice on Enamel Erosion Adjacent to Restorations *In Vitro*

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Clinical Relevance

Since the prevalence of dental erosion is increasing, use of a high-fluoride dentifrice might be an important strategy to reduce the progression of tooth erosion around restorations.

SUMMARY

Aim: This *in vitro* study analyzed the antierosive potential of a high-fluoride dentifrice on enamel adjacent to restorations.

Methods and Materials: Enamel blocks (6 × 6 × 3 mm) from bovine incisor teeth were restored with three different restorative materials (resin, conventional glass ionomer cement, and resin-modified glass ionomer cement) and treated with dentifrices containing 0, 1100, or 5000 ppm F. After restorative procedures, initial surface Vickers hardness of the blocks were obtained. The specimens were submitted to pH cycles (4 × 90 seconds in soft drink) and treatments for five days. Between the challenges and overnight, the blocks remained in artificial saliva. At the end of the experiment, the final hardness was assessed and the percentage of surface mineral loss (%SML) was calculated. A 3 × 3 factorial design was used to conduct statistical analysis. Data were analyzed by analysis of variance and *t*-test, with significance level fixed at 5%.

Results: High-fluoride dentifrice decreased demineralization caused by erosive challenge regardless of the restorative material used ($p<0.001$). Likewise, the blocks restored with conventional glass ionomer cement showed lower values of SML irrespective of dentifrice used ($p<0.001$).

Conclusion: Use of a high-fluoride dentifrice on teeth restored with conventional glass ionomer cement offers additional protection against enamel erosion.

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INTRODUCTION

Dental erosion is defined as a chemical process that involves the dissolution of enamel and dentin by

Table 1: *Restorative Materials Used in the Study*

Material	Composition[a]	Manufacturer (Batch)
Filtek Z350 XT (resin)	Organic matrix: BIS-GMA, UDMA, TEGDMA, BIS-EMA, and camphorquinone	3M ESPE. St Paul, MN, USA, LOT 1315600839, Color A2B
	Inorganic matrix: surface-modified zirconia/sílica (3 μm or less), nonagglomerated/nonaggregated 20-nm surface-modified silica particles with 82% by weight (68% by volume)	
Ketac Fil Plus (Conventinal GIC)	Powder: fluoroaluminosilicate glass, strontium, and lantaniumr	3M ESPE, St Paul, MN, USA, LOT 460236, Color A3
	Liquid: polycarbonic, artaric, and maleic acids; wate	
Vitremer (resin-modified GIC)	Powder: fluoroaluminosilicate glass, redox system	3M ESPE, St Paul, MN, USA, LOT 1232700452, Color A3.
	Liquid: aqueous solution of a modified polyalkenoic acid, HEMA	

[a] *Manufacturers' information.*
GIC: glass ionomer cement, BIS-GMA: bisphenol A glycidyl methacrylate, UDMA: urethane dimethacrylate, TEGDMA: triethylene glycol dimethacrylate, BIS-EMA: bisphenol A ethoxylate dimethacrylate, HEMA: 2-hydroxyethyl methacrylate

acids not derived from oral bacteria, leading to a softening of those hard tissues.[1] First, erosive challenge induces enamel surface demineralization by allowing remineralization. Then, a long-term acidic attack causes irreversible loss of hard tissue, which is accompanied by a progressive softening of the surface.[2]

Currently, dental erosion is a frequent condition observed in clinical dentistry.[3] Several methods can be used to prevent or slow the progression of dental erosion, such as dietary intervention, change in consumption of acidic beverages, oral hygiene, and the use of fluoride (F).[4] Regarding F therapies, its effects are reported to be higher when applied at high concentrations, as has already been demonstrated with the use of dentifrices (5000 ppm F), gels (12,300 ppm F), and varnishes (22,500 ppm F).[5-7]

However, the role of F-releasing restorative materials such as glass ionomer cements on the prevention of erosion is not entirely known. It is well established that these cements can release F for a prolonged time and additionally reincorporate it through topical applications, maintaining its preventive effect.[8] Thus, considering that F released from glass ionomer cements can prevent the development of caries adjacent to restorations,[9] it could also reduce the effects of erosion, preventing the defects in dental substrates adjacent to restoration margins.

However, there is a lack of studies showing the combination effect of different F-concentration dentifrices associated with restorative materials on the erosion process. Thereby, the possibility of finding a material or combination of materials that can reduce or prevent dental erosion becomes relevant. Therefore, this study aimed to evaluate the effect of high-F dentifrice in enamel demineralization adjacent to different restorative materials *in vitro*. The null hypotheses tested were that there would not be any effect of type of restorative material or dentifrice use on the response variable assessed.

METHODS AND MATERIALS

Preparation of Blocks

Seventy-two enamel blocks were obtained from the crown of bovine incisors previously sterilized in 10% formol solution, pH 7.0, for at least 10 days. They were flattened and polished by using 400, 600, and 1200 grades of Al_2O_3 papers and polishing cloths with a 1-μm diamond paste, respectively,[10] showing dimensions of approximately 6 × 6 × 3 mm. The specimens were kept moist throughout all of the

Table 2: *Initial Vickers Hardness Number (IVHN), Final Vickers Hardness Number (FVHN), and Percentage of Surface Hardness Loss (%SHL) According to Dentifrices and Restorative Materials Used (Mean±SD, n=8)*[a]

Restorative Material	Dentifrice 0			Dentifrice 1100		
	IVHN[b]	FVHN[c]	%SHL	IVHN[b]	FVHN[c]	%SHL
Resin	210.40 ± 16.45	124.38 ± 15.34	41.04 ± 3.08	191.13 ± 30.60	126.16 ± 26.72	33.99 ± 9.20
Resin-modified GIC	218.56 ± 19.16	133.09 ± 20.33	39.35 ± 5.00	206.91 ±34.82	151.05 ± 20.22	28.27 ± 8.67
Conventional GIC	224.08 ± 34.59	162.45 ± 34.20	28.05 ± 4.29	202.38 ± 36.90	158.38 ± 31.59	21.35 ± 10.45

[a] *p Values of Analysis of Variance of %SHL data: dentifrice (p<0.0001), restorative material (p<0.0001), interaction of dentifrice × restorative material (p=0.6416).*
[b] *No statistical difference in IVHN among restorative materials groups in each dentifrice treatment (p>0.05).*
[c] *Statistical difference between IVHN and FVHN among restorative materials groups in each dentifrice treatment (p<0.05).*

steps. Before restoration placement, all cavities and slab surfaces were cleaned with rotating brushes and non-F dentifrice and washed with distilled water.

Restorative Procedures

Box-shaped standardized cavities (2 × 2 × 2 mm) were prepared at the center of each block with a cylindrical diamond bur (No. 1090, KG Sorensen, Barueri, SP, Brazil) replaced after every 8 preparations. The slots were made with high-speed rotation under water/airspray cooling. Enamel blocks were restored according to the manufacturer's instructions with the following materials: conventional glass ionomer cement (GIC), chemically activated resin-modified GIC, and nanohybrid resin composite as negative control (Table 1).

After placement of the material in the prepared cavity, the surface of the restorative material was covered with a polyester strip and a glass slab under pressure to expel excess material from the cavity. Ionomeric materials were hand mixed and placed in a single bulk with a syringe (Centrix Incorporation, Shelton, CT, USA). In addition, conventional GIC restorations were protected with varnish. For resin-modified GIC restorations, cavities were coated with Vitremer Primer (3M ESPE, St Paul, MN, USA). After primer polymerization, the GIC was placed and polymerized for 40 seconds. For composite resin restorations, cavities were etched for 15 seconds with 35% phosphoric acid (3M ESPE), rinsed thoroughly, and excess water was removed with disposable brushes (Microbrush, Grafton, WI, USA). The cavities were coated with the adhesive system (Single-Bond, 3M ESPE). Composite was placed in three layers of 0.5 mm, each polymerized for 20 seconds with a photo-curing unit. Final restorations were additionally polymerized for 40 seconds.

For all restorations, finishing and polishing were carried out 24 hours later with aluminum oxide discs (SofLex System, 3M ESPE), with each disk applied for 15 seconds. For photo-activated materials, cavities were restored and light polymerized using a halogen-based light-curing unit (Optilux 400, Demetron Research Corporation, Danbury, CT, USA). The light output was tested (480±32 mW/cm^2) before each use with a Demetron Model 100 radiometer (Demetron Research Corporation).

Table 2: Extended.

Dentifrice		
5000		
IVHN[b]	FVHN[c]	%SHL
170.83 ± 36.39	143.56 ± 29.71	15.32 ± 10.44
179.76 ± 53.05	161.93 ± 46.86	9.12 ± 8.50
209.92 ± 36.21	197.00 ± 29.78	5.84 ± 2.92

Dentifrices

Dentifrices were obtained from Manipulation Pharmacy and contained 5000 μg F/g (high concentration of F), 1100 μg F/g (standard concentration), or 0 μg F/g (negative control), all with silica as abrasive, neutral flavor, and F as NaF. Eight blocks restored with each material were randomized for each type of dentifrice studied.

Erosive Challenge

All specimens were submitted to five-day erosion cycles. Erosion was performed with freshly opened bottles of cola soft drink (Coca-Cola, pH 2.6, Brazil; 3 mL/specimen, unstirred, 25°C) four times daily for 90 seconds each. After demineralization, the specimens were rinsed with tap water (five seconds) and transferred into artificial saliva (pH 6.8, 5 mL/specimen, unstirred, 25°C) for one hour. The composition of the artificial saliva was 0.33g KH_2PO_4, 0.34g Na_2HPO_4, 1.27g KCl, 0.16g NaSCN, 0.58g NaCl, 0.17g $CaCl_2$, 0.16g NH_4Cl, 0.2 g urea, 0.03g glucose, and 0.002g ascorbic acid.[11] After the first and last erosive challenge, the blocks were treated with the dentifrice slurries (1:3 dentifrice/water) for one minute. A new aliquot of soft drink was used in each erosive challenge, and artificial saliva was replaced daily. After the last daily erosive treatment, the specimens were stored in artificial saliva overnight.

Determination of Surface Hardness Loss

After restorative procedures, the initial hardness of the enamel blocks was determined 100 μm from the restoration margin, using five indentations, spaced 100 μm from each other, using Vickers microhardness with 100g for 15 seconds. At the end of the experimental phase, the hardness around the restorations was once again measured and reported as a percentage of surface hardness loss (%SHL), using the formula (Initial Hardness – Final Hardness) × 100/Initial Hardness.[12]

Statistical Analysis

A factorial 3 × 3 was considered for the statistical analysis, and the factors under evaluation were the material used for restoration in three levels (resin, conventional GIC and, resin-modified GIC) and the concentration of dentifrice in three levels (0, 1100, or 5000 ppm F). All data had normal distribution of errors and were analyzed by analysis of variance. The comparison between the initial and final hardness of each group was evaluated by paired *t*-test. The SAS software (version 9, SAS Institute Inc., Cary, NC, USA) was used to perform the statistical tests, with the significance level set at 5%.

RESULTS

The erosive cycling model adopted in this study demonstrated the ability to demineralize the enamel surface, whereas significant differences ($p<0.05$) were observed between the initial hardness and the final hardness (after erosive challenge) for all study groups regardless of the material or dentifrice used (Table 2).

The %SHL data (Table 2) showed significant effects for the isolated factors: material ($p<0.0001$) and dentifrice ($p<0.0001$), but not for the interaction ($p=0.6416$). Thus, lower %SHL was observed in the groups that received the treatment with 5000 ppm F dentifrice, regardless of the material used. Likewise, lower %SHL was observed when the tooth was restored with conventional GIC regardless of the dentifrice used.

DISCUSSION

Treatment for teeth with erosive wear can include minimally invasive therapies for multidisciplinary interventions. Current evidence shows that frequent applications of agents with high F concentration are considered potentially effective approaches to reduce erosive tooth wear.[13] Moreover, in advanced cases of erosion, restorative treatment is necessary; in this case, selection of material depends on its esthetic properties, resistance to biodegradation, adhesive capacity, and F release.[14] Thus, studies evaluating the effect of erosive substances on restorative materials are extremely relevant because most patients have at least one restored tooth and are subject to a contemporary diet containing many erosive substances.[3]

According to the results, mineral loss was found less often in groups treated with the 5000 ppm F dentifrice, regardless of restorative material used. These results agree with those of Moretto and others,[5] who found that an experimental 5000 ppm F dentifrice was able to significantly reduce enamel erosion and erosion abrasion compared with a conventional 1100 ppm F dentifrice *in vitro*. Indeed, high-concentration F applications (such as oral rinses, gels, and varnishes) have been demonstrated to increase abrasion resistance and to decrease the development of erosion in enamel in other studies.[15,16] On the other hand, our findings disagree with those found by Rios and others,[17] because in their *in situ* study, no significant differences were found among 1100 and 5000 ppm F dentifrices for enamel wear. However, it must be considered that a different protocol of treatment with dentifrices was used, because in their study, the exposure to F dentifrice slurry occurred for only 30 seconds, and subjects rinsed their mouths afterward with water.

In addition, regardless of dentifrice used, less mineral loss was found when the tooth was restored with conventional GIC. In fact, lower demineralization closer to GIC restorations was already reported *in situ* and could be explained by a high local F concentration.[18,19] Although the erosive loss of GIC was not evaluated in this study, it has been previously demonstrated that it may be followed by an increase in the pH of the acid solution. This is because of GIC's buffer capacity, which could also protect the tooth from mineral erosive loss.[20]

Although the preventive action of F on dental caries is well documented,[21,22] its role in erosion is still a matter of debate. The present study, despite the limitations of an *in vitro* model, support a positive effect of combination F delivery methods on the enamel demineralization process by either caries or erosive challenge, thereby rejecting the null hypothesis raised.

CONCLUSION

In conclusion, use of a high-F dentifrice on teeth restored with conventional GIC provided an additional protection against enamel erosion; however, *in situ* and clinical trials are required to confirm the relevance of this combination.

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Regulatory Statement

This study was conducted in accordance with all the provisions, guidelines and policies of the Federal University of Piauí, Campus Universitário Ministro Petrônio Portella, in Brazil.

Conflict of Interest

The authors have no proprietary, financial, or other personal interest in of any nature or kind in any product, service, and/or company that is presented in this article.

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