Original Article

The Preventive Effect of Remin Pro and Neutral Sodium Fluoride on Erosion of Dental Enamel: An In Vitro Study

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Abstract

Background and Aim: Carbonated diet soda is the most common etiologic factor for dental erosion, and fluoride products have been proposed as an option for the prevention of that problem. This study evaluated the effect of Remin Pro and neutral sodium fluoride on the prevention of dental enamel erosion using profilometry.
Materials and Methods: This study was conducted using an experimental-laboratory method on 20 extracted premolars with no corrosion, abrasion, crack or hypocalcification. For a proper evaluation, the buccal aspect of each specimen was polished using 800- to 1200- and 2500-grit silicon carbide papers. Enamel was analyzed by surface profilometry. Samples were randomly allocated into two groups of Remin Pro and neutral sodium fluoride for pretreatment. After pretreatment, the surface roughness of enamel was measured. In the third stage, the samples were exposed to cola, rinsed with deionized water, and stored in artificial saliva, and surface loss and roughness were measured. Independent samples t-test and repeated measures analysis of variance (ANOVA) were used to analyze the data.
Results: According to the results of this study, neutral sodium fluoride foam and Remin Pro reduced enamel erosion. The mean surface roughness after pretreatments with Remin Pro and neutral sodium fluoride foam was less than that after polishing (P=0.004) and exposure to acid (P=0.026).
Conclusion: Neutral sodium fluoride foam and Remin Pro have the same effect on preventing dental erosion.
Key Words: Enamel, Erosion, Sodium Fluoride, Remineralization

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Introduction

Dental erosion is a multifactorial phenomenon that challenges enamel in early stages but gradually extends to dentin and cementum. Erosion is defined as the loss of enamel, dentin, and tooth structure due to the function of acids, irrespective of bacterial activity [1]. Nowadays, by changing lifestyles, consumption of acidic beverages and the prevalence of erosion have increased. Various studies have evaluated the role of fluoride-containing compounds on the prevention of erosion [1,2]. Application of ionized fluoride on tooth surfaces results in deposition of calcium fluoride (CaF_2) on the enamel surface. Under the neutral condition, this layer can remain for weeks, even months, on the tooth surface. Proteins and phosphate ions can also incorporate into the structure of this deposited layer and result in stability, hardness, and increased abrasion resistance [2]. When enamel and dentin are

exposed to fluoride ions, the calcium and phosphate present in the tooth structure form fluorapatite crystals with these ions. This compound is more acid-resistant than hydroxyapatite [2].
Recent laboratory studies have shown that calcium-containing compounds and products contain hydroxyapatite and xylitol and are able to prevent dental erosion [3,4]. Remin Pro comprises three compounds including hydroxyapatite, 1450 ppm (parts-per-million) of fluoride, and xylitol which prevent enamel demineralization and promote remineralization of enamel subsurface lesions [5,6]. The aim of this study was to assess the efficacy of Remin Pro and neutral sodium fluoride foam in prevention of enamel erosion using profilometry.

Materials and Methods

This in-vitro experimental study was conducted on 20 sound human premolars (without caries or fractures) that had been extracted as a result of periodontal disease or for orthodontic treatment. Tooth surfaces were cleaned from calculus and debris using a fluoride-free prophylactic paste containing pumice and a low-speed handpiece operating at 500-1500 rpm (revolutions per minute). The teeth were disinfected with 0.5% chloramine-T solution for a period of 48 hours at 4˚C. Next, the absence of enamel defects and microscopic caries or cracks was confirmed by evaluation of the samples under a stereomicroscope (SMZ10; Nikon, Tokyo, Japan) at 10× magnification, and the samples were stored in deionized water.
First, buccal surfaces of the samples were ground flat and polished with 800- to 1200- and 2500-grit silicon carbide papers respectively in order to compare the surface roughness of the samples after each stage. Next, the surfaces of the samples were rinsed with deionized water and mounted using acrylic resin. The surfaces of the samples were covered with nail varnish, leaving a 3 mm × 5 mm window. The samples were divided into two groups of 10 each, and the baseline measurement using profilometry was made to determine the initial surface roughness.
The two groups received preventive treatment before being placed in an acidic solution. In the first group, Remin Pro (VOCO GmbH, Cuxhaven, Germany) was applied to the samples twice a day (every 12 hours), 5 minutes each time for 7 days. In the second group, the samples received pretreatment with neutral sodium fluoride foam (Pascal, Washington, USA) twice a day (every 12 hours), 5 minutes each time for 7 days. After each phase of pretreatment, the teeth were rinsed with deionized water. Then, the second measurement was made using profilometry.
After each phase of treatment, all the samples were stored in artificial saliva containing NaCl (400 mg/l), KCl (400 mg/l), $CaCl_2H_2O$ (795 mg/l), $Na_2H_2PO_4H_2O$ (690 mg/l), KSCN (300 mg/l), $Na_2(S)_9H_2O$ (5 mg/l), and urea (1000 mg/l) at a pH of 6.5 at 37°C. After completion of pretreatment phases, all the samples were exposed to cola (pH=2.41) three times a day (every 8 hours), 2 minutes each time for 3 days (Figure 1). The pH levels of cola soft drink and artificial saliva were measured with a pH meter (Lovibond® SensoDirect pH 110, Germany). Then, the samples were rinsed with deionized water and stored in artificial saliva, and the third measurement was made using profilometry.

Figure 1. Samples after exposure to acidic drink

The amount of surface roughness (Ra) of the samples was measured by profilometry (hand-held roughness tester TR200, Germany). The measurement range of surface roughness by the device was 0.025 to 12.5 µm, and it was measured by ≤±10% accuracy. Finally, the treated surface, the eroded surface, and the initial surface in the two groups were compared.
Data were analyzed using SPSS software (version

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18, IBM Co., Chicago, IL, USA). Normal distribution of the data was evaluated using one-sample Kolmogorov-Smirnov test. For comparison of the baseline surface roughness, independent samples t-test was used. To assess the effect of the type of substance (Remin Pro and neutral sodium fluoride foam) and different conditions (baseline surface, pretreatment surface, and surface after exposure to acid), repeated measures analysis of variance (ANOVA) and Bonferroni pairwise comparisons were used. The composition of each material is shown in Table 1.

Table 1. Materials used in the present study and their compositions

Material	Composition
Cola Soft Drink	Water, sugar, carbon dioxide, caramel color, phosphoric acid, flavorings, caffeine
Artificial Saliva	Deionized water, NaCl, CaCl2, NaH2PO4, NaF, NaN3
Remin Pro	Hydroxyapatite, xylitol, sodium fluoride
Neutral Sodium Fluoride	NaF 0.2%

Results

Ten samples were evaluated in each group. The amount of surface roughness at the baseline in the two groups was not significantly different (P=0.557). The results of repeated measures ANOVA showed that the two substances did not have any statistically significant differences in surface roughness (P=0.565). However, the amount of surface roughness in different conditions was different (P<0.01). Comparison of different conditions using Bonferroni test showed that surface roughness at the beginning of the study and after exposure to acid did not have any significant differences (P=1.0). The mean surface roughness after treatment was significantly less than that at the baseline (P=0.004) and less than that after exposure to acid (P=0.026). The interaction between the substances and the conditions was not significant (P=0.647), which indicates that the abovementioned pattern in the two substances was the same (Table 2).

Discussion

Erosion is the chemical tooth wear resulting from acids in foods and beverages. The role of acids in tooth erosion has recently come into the spotlight. Dentin hypersensitivity is among the direct outcomes of erosion that may occur on clean tooth surfaces. Acid reflux and acidic foods and beverages can dissolve the smear layer and expose dentinal tubules to the oral cavity, resulting in aggravation of dentin and enamel hypersensitivity [2]. Consumption of acidic foods and beverages plays a significant role in the occurrence of acid erosion in teeth. Considering the growing consumption of soft drinks and increased prevalence of dentin and enamel hypersensitivity among patients, the present study was conducted to evaluate the role of preventive factors in the prevention of erosion due to consumption of cola which is a popular drink worldwide. Researchers have studied various methods for prevention of tooth erosion. Many of these methods are based on the use of fluoride-containing products [2]. Some substances have been introduced which are effective in the prevention and treatment of erosion; however, their accuracy has not been confirmed yet. There are some limitations and inconsistencies among previous studies. Therefore, this study investigated the effect of Remin Pro and neutral sodium fluoride on the prevention of dental enamel erosion using profilometry. Although the effect of Remin Pro and neutral sodium fluoride foam on reducing erosion has been examined in several studies, until now, no study has compared the efficacy of Remin Pro and neutral sodium fluoride foam in reducing enamel erosion.

The effectiveness of fluoride in toothpastes, mouthwashes, and foams is mainly because of strengthening the tooth surface against dissolution

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[2]. Studies conducted on caries have shown that fluoride supplementation in mouthwashes and foams increases the concentration of fluoride ion in the mouth, which subsequently results in the strengthening of dental surfaces [2]. Topical application of fluoride compounds leaves behind a considerable amount of fluoride on dental surfaces due to the porosities and water content of dentin [7]. In deeper dentinal layers, high fluoride concentrations act as a fluoride reservoir.

Various studies have compared different fluoride-containing solutions and varnishes [7], fluoride mouthwashes with different compositions [8], gels containing fluoride [9], fluoride products in combination with other preventive materials [10-12], and the efficacy of fluoride compounds at various pH levels for prevention of erosion [13]. The reason we have chosen Remin Pro is that it contains xylitol, hydroxyapatite, and fluoride, and these three substances in Remin Pro are effective in decreasing of surface roughness and erosion and in reducing remineralization [5,6].

Table 2. Statistical indices of the amount of surface roughness in the two groups

		Roughness 1 (μm)	Roughness 2 (μm)	Roughness 3 (μm)	P-value
Remin Pro	Mean	0.29	0.19	0.25	<0.01
	N	10	10	10	
	Std. Error	0.06	0.04	0.01	
	Minimum	0.03	0.07	0.14	
	Maximum	0.65	0.53	0.32	
Neutral sodium fluoride	Mean	0.24	0.15	0.25	<0.01
	N	10	10	10	
	Std. Error	0.04	0.02	0.03	
	Minimum	0.08	0.01	0.05	
	Maximum	0.54	0.25	0.42	
P-value		0.55	0.56	0.56	

Cola was used as an acid in this research because today, people use cola in their meals more than other acidic beverages. Some studies have shown that cola has phosphoric acid that causes less erosion than citric acid, but some studies have shown that cola has a high erosion potential [14]. Various studies have examined the erosive effect of different temperatures of acidic beverages [15,16], fluid flow [16], different times of exposure, different acidic pH levels [17], different acidic densities [16], the effect of acid on surface softness [15], different types of beverage, and different acids [18,19].

Based on previous studies, each sample was treated by Remin Pro and neutral sodium fluoride foam for 7 days. For better effectiveness, Remin Pro and neutral sodium fluoride were used twice a day and each time for 5 minutes according to the manufacturer's instructions. Then, each group was exposed to the acid for 3 days, 3 times a day and each time for 2 minutes [15,20].

The amount of erosion was evaluated using profilometry with a contact probe. This is a common method for erosion evaluation, which has been used in different studies, and the accuracy of this device has been proven [6,21-23]. The samples were polished well so the surface roughness of the samples was in the range of the measuring device (0.025 to 12.5 μm) with ≤±10% accuracy.

In the present study, Remin Pro and neutral sodium fluoride foam reduced surface roughness and erosion, which is in agreement with the results of some previous studies [13,20,21]. The amount of erosion in the two groups was reduced to the same degree. The average surface roughness at the baseline was almost the same in the two groups,

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which means that the data have a normal distribution. The average surface roughness after pretreatment in the two groups was significantly reduced compared to the first and third stages, but Remin Pro was more effective in decreasing the surface roughness. This was in line with previous reports on this material [5,6].

It should also be noted that, as mentioned earlier, xylitol, hydroxyapatite, and fluoride can be effective in the decrease of surface roughness by inducing supersaturation of calcium and phosphate ions to promote remineralization, filling porous area, forming a protective film on the tooth surface, and inhibiting the adhesion of bacterial plaque [22]. Hydroxyapatite fills superficial enamel lesions and irregularities that arise from surface demineralization. Furthermore, fluoride is converted to fluorapatite on the tooth surface, which makes the tooth more resistant to acid attacks [22].

In addition, fluoride ions are deposited in dentinal tubules and seal them. The high concentration of surface fluoride also may provide a reservoir for fluoride, which promotes remineralization [5,6]. Xylitol is a five-carbon natural sugar alcohol, which is not fermentable by most oral bacteria; therefore, no acid is produced [23]. It has been suggested that xylitol may enhance remineralization and help arrest dentinal caries [3]. Xylitol and fluoride have a preventive role against caries and erosion [3]. Some studies have shown that Remin Pro can be absorbed by saliva pellicle, creating an enriched reservoir of calcium that is able to increase remineralization. Furthermore, Remin Pro can increase microhardness [5,6,22].

In the current study, surface roughness after exposure to acid was increased in the two groups, but in Remin Pro groups, this enhancement of surface roughness was less than the initial surface roughness. In neutral sodium fluoride groups, enhancement of surface roughness after exposure to acid was more than the initial surface roughness, and these differences were not statistically significant. Some studies have reported that fluoride alone cannot decrease erosion and surface roughness [24,25]. One of the reasons that sodium fluoride could not prevent erosion by acid is probably related to the fact that the existence of a polymer system with fluoride could prevent decomposition of hydroxyapatite crystals and increase the durability of fluoride on dental surfaces [24,25]. Further studies are required to investigate any significant interaction between different substances and methods and prevention of erosion. It is necessary to prepare detailed instructions for clinicians on the handling of materials and possible differences among them.

Conclusion

Neutral sodium fluoride foam and Remin Pro have the same effect on preventing dental erosion.

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