The Effect of Single-Application Fluoride Treatment on Simulated Gastric Erosion and Erosion-Abrasion of Enamel In Vitro

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Purpose: To compare single-application fluoride formulations on enamel erosion and erosion-abrasion in vitro. ***Materials and Methods:*** Enamel specimens were pretreated with either sodium, tin, titanium, or sodium/calcium fluoride and subjected to either an erosion model or an erosion-abrasion model, after which optical profilometry was used to measure enamel step height loss. ***Results:*** For erosion, the titanium fluoride ($P < .001$) reduced enamel loss, whereas the calcium, tin, and sodium treatments showed no significant effects ($P > .05$). For erosion-abrasion, the titanium fluoride increased enamel loss in comparison to control ($P < .001$). ***Conclusions:*** Titanium fluoride has differing effects on enamel loss from erosion and erosion-abrasion models. *Int J Prosthodont 2014;27:425–426. doi: 10.11607/ijp.3956*

Topical fluorides have been recommended as part of prophylactic management strategies for patients at risk of dental erosion.[1–3] Recently, interest has grown in the antierosion properties of fluoride compounds containing polyvalent metal cations such as stannous fluoride (SnF_2) and titanium tetrafluoride (TiF_4), which might provide a protective glaze on enamel surfaces.[4] Laboratory studies suggest conventional fluorides, such as sodium fluoride (NaF) and amine fluoride (AmF), form a calcium-rich (CaF_2) layer on the tooth surface, which may then provide a physical barrier and a mineral reservoir promoting remineralization and thus modify the erosive process; however, the role of these fluorides in protecting enamel from erosion-abrasion is less certain. The aim of the present study was to compare the effect of one topical application of different fluoride formulations on enamel erosion and erosion-abrasion mediated by hydrochloric acid (HCl).

Materials and Methods

Sixty enamel samples (REC no. 09/H0808/109) were randomly allocated to one of five surface pretreatments: deionized water (negative control); NaF solution (9,500 ppm F; 0.5 mol/L; pH 8.0); SnF_2 solution (9,500 ppm F; 0.5 mol/L; pH 2.6); TiF_4 solution (9,500 ppm F; 0.5 mol/L; pH 1.2); and Bifluorid 10 varnish (curently not available in the United States, VOCO), containing ethyl acetate, cellulose nitrate, isopentyl propionate, sodium fluoride 5%, and calcium fluoride 5% (45,200 ppm F; pH 5.5). Samples were then subjected to one of two in vitro wear protocols: erosion (one cycle = 2-minute exposure to 0.01 mol/L HCl + 60 minutes remineralization in artificial saliva) or erosion-abrasion (one cycle = erosion cycle + brushing with a 1:3 nonfluoride toothpaste/artificial saliva slurry (200 g, 120 strokes, 2 minutes). At the end of nine cycles of experimental erosion or erosion-abrasion, the samples were scanned using a white-light confocal profilometer (Xyris 4000WL, TaiCaan Technologies), and volume enamel loss was calculated using surface analysis software (MountainsMap Universal, version 6.2; Digital Surf). Data were assessed for differences between wear processes (erosion and erosion-abrasion) and fluoride groups using analysis of variance (ANOVA) with the Bonferroni multiple comparisons posttest applied and $P < .05$ considered statistically significant.

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Table 1 Mean Volume (μm³/mm) of Enamel Loss After Erosion

Group	Volume (SD)
Control	2.59 (0.64)
Sodium fluoride (9,500 ppm F)	2.80 (0.78)
Stannous fluoride (9,500 ppm F)	2.76 (0.76)
Titanium tetrafluoride (9,500 ppm F)	0.63 (0.56)*
Bifluorid 10 varnish (45,200 ppm F)	2.52 (0.70)

**P* < .001.

Table 2 Mean Volume (μm³/mm) of Enamel Loss After Erosion-Abrasion

Group	Volume (SD)
Control	2.95 (0.44)
Sodium fluoride (9,500 ppm F)	2.34 (1.13)
Stannous fluoride (9,500 ppm F)	2.80 (0.65)
Titanium tetrafluoride (9,500 ppm F)	4.06 (1.06) *
Bifluorid 10 varnish (45,200 ppm F)	3.15 (0.61)

**P* < .05.

Results

As seen in Table 1 for the erosion experiment, there were statistically significant differences for the titanium fluoride, which significantly reduced enamel loss ($P < .001$) compared to the control. There were no statistical differences between the other fluorides and the control. Comparing the products to one another, titanium fluoride showed statistically less erosion than any other fluoride treatments ($P < .001$). As seen in Table 2 for the erosion-abrasion experiment, titanium fluoride significantly increased enamel loss ($P < .05$) compared to the control. There were no statistical differences between the other fluorides and the control. Comparing the products to one another, titanium fluoride showed statistically increased enamel loss compared to any other fluoride treatments ($P < .05$). There was a slight increase in wear with the abrasion model compared to the erosion only but this did not reach significance.

Discussion

The results of this study have demonstrated that titanium fluoride affects enamel to varying extents, depending on the nature of the wear challenge. The titanium containing fluoride solution showed more potential for protection of the enamel surface against erosion, but this superiority was lost for a combination of erosion-abrasion, and more enamel was lost in comparison to the other fluorides, which showed a potentially protective effect.

The protocols for the present laboratory method using erosion and abrasion and profilometry have been published before.[5] In this study, the authors aimed to investigate the action of HCl in relation to fluoride for those patients in whom gastric reflux was a causative factor. The authors could have used a dietary-style acid such as citric acid, which, because of its chelating action, may have produced greater tissue loss. Therefore, the results of this study question the clinical relevance of titanium fluorides, which have been reported in numerous erosion-only studies. The present data suggest that the benefit created by titanium fluoride in an erosion-only model is lost under an abrasive action.

Conclusions

Although titanium tetrafluoride confers an acid resistant effect to the enamel from a solely chemical challenge, any potentially protective effect against a combined chemical and mechanical challenge, such as seen clinically in tooth wear, is much less certain. Indeed, this study has shown that the titanium tetrafluoride may even result in an enamel surface that is more vulnerable to mechanically induced damage, which suggests that further investigations into this fluoride are required, before the mechanism of action is fully understood.

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