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Short communication

Effect of fluoride gels supplemented with sodium trimetaphosphate on enamel erosion and abrasion: *In vitro* study

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ABSTRACT

Objective: This *in vitro* study aims to evaluate the effect of low fluoride (F) gel associate sodium trimetaphosphate (TMP) on erosion with or without abrasion.

Design: Enamel blocks (4 mm × 4 mm) selected through surface hardness (SH) is divided into five groups ($n = 12$): gel without F and TMP (placebo), gel containing 4500 ppm F (4500), gel containing 4500 ppm F plus TMP5% (4500 TMP5%), gel containing 9000 ppm F (9000), and gel containing 12,300 ppm F (acid gel). Those groups were additionally subdivided into conditions of erosion (Ero) and of erosion plus abrasion (Ero/Abra). The blocks have undergone a single application of gel on the first day of the study. The erosion challenge was produced by Sprite Zero® for five minutes four times a day and abrasion was carried out by machine brushing for 15 s. After the challenges, the surface hardness (%SH), wear and cross-sectional hardness (ΔKHN) were analyzed. The data were analyzed using a 2-way ANOVA test followed by a Student-Newman–Keuls ($p < 0.05$).

Results: Lower values of %SH, wear and ΔKHN were observed for erosion challenge ($p < 0.001$). The %SH was lower in groups treated with fluoride gels, differing in the placebo ($p < 0.05$). With addition of TMP to the gel 4500, enamel wear was lower when compared with another groups ($p < 0.05$).

Conclusion: *In vitro* conditions, the 4500 5%TMP gel showed greatest effect against erosion and erosion/abrasion.

1. Introduction

Erosion and erosive tooth wear refers to the chemical and chemical-mechanical process that has become more prevalent in 11 to 16-year-old children.[1,2] As dental caries disease, the tooth erosion is a multifactorial condition (patient-related and nutritional factors) and over time, the interaction of all these factors may lead to either progression.[3] Different methods have been indicated to prevent or slow the progression of dental erosion such as the use of topical fluorides.[4]

Fluoride therapy has been suggested as a preventive measure against tooth erosion, and its effects are reported to be higher when applied at high concentrations.[5–10] Despite the gel be a more affordable vehicle (lower cost) with high concentrations of fluoride, there are few studies where compounds are added to improve its effect against erosion.[11]

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Utilisation of sodium trimetaphosphate (TMP) and fluoride (F) association has shown decreased enamel demineralisation[10,12–15] in caries and dental erosion. In addition, a low fluoride topic gel (4500 ppm F) associated to TMP presented same ability to produce enamel remineralization than the fluoride acid gel (12,300 ppm F).[16] However, the erosive challenge is a process that occurs at a pH of <4.0 and the pH of the dissolution of calcium fluoride, fluorapatite or any precipitate that might be formed in the presence of fluoride is exceeded during the erosive challenge. Considering the good results against dental caries and which differs from erosion process, the present *in vitro* study evaluated the effect of low-F gels (4500 μg F/g) plus TMP on the erosion, associated or not with abrasion, of tooth enamel.

2. Materials and methods

2.1. Experimental design

Bovine enamel blocks (n = 120) were selected through analysis of surface hardness (SH) and randomly divided into 5 groups, according to the following treatments: (a) gel without F and TMP (placebo), (b) gel containing 4500 μg F/g (4500), (c) gel containing 4500 μg F/g + TMP5% (4500 TMP5%), (d) gel containing 9000 μg F/g (9000), and (e) gel containing 12,300 μg F/g (Acid gel). Based on a previous study with similar methodology[12] and considering an α-error of 5% and a β-error of 20%, twelve enamel blocks were determined for each experimental group. Enamel blocks were protected in their half with nail varnish (control area), so that half of their surface was exposed to the treatment with the gels and to the erosive (Ero) or to the erosive/abrasive (Ero+Abra) challenges. Ero was produced in all blocks by immersion in soda (Sprite Zero, pH 2.8, 4 times/day, 5 min each time), while ERO+ABR was done in half of the blocks by brushing after each erosive challenge. The protocol was tested for 3 days. Enamel blocks were analyzed by profilometry and cross-sectional hardness. The factors studied were: type of gel (5 types) and type of challenges (Ero and Ero+Abra).

2.2. Gel formulation and determination of fluoride in products

Experimental gel of neutral pH was prepared in a laboratory and had the following ingredients: carboxymethylcellulose, sodium saccharin, glycerol, peppermint oil, and water. The fluoride (NaF; Merck, Darmstadt, Germany) was added to the gel in a concentration of 0, 4500, or 9000 μg F/g. Subsequently, TMP (Sigma–Aldrich Co., St. Louis, MO, USA) was added at a concentration of 5% to gels with F concentration of 0 and 4500 ppm F. A commercial acidic gel was used as a positive control (12,300 μg F/g, Acid gel, pH = 4.5, *DFL*; Indústria e Comércio S.A, Rio de Janeiro, RJ, Brazil). The F concentration in the gels was determined using a specific electrode for the F ion (9609 BN; Orion Research Inc., Beverly, MA, USA) attached to an ion analyzer (Orion 720 A^{plus}; Orion Research Inc., Beverly, MA, USA) and calibrated with standards containing 0.125–2.000 μg F/g. Approximately 100 mg of each product was dissolved in deionized water and transferred to a volumetric flask. The volume was then adjusted to 100 mL using deionized water. For each product, 3 dilutions were made. Subsequently, 2 samples of 1 mL were buffered with total ionic strength adjustment buffer II (TISAB II).

2.3. Preparation of enamel blocks

Enamel blocks (n = 120, 4 mm × 4 mm) were obtained from bovine incisors and polished to remove around of 200 μm of the enamel surface.[12] Surface hardness (SH) was determined by performing 5 impressions in the central region of the blocks surface (Knoop diamond, 25 g, 10 s; Buehler, Lake Bluff, USA). Blocks with mean hardness between 330.0 and 370.0 kgf/mm^2 were selected. To maintain a reference surface for determining the wear of enamel by profilometry, half of the surface of each block was protected with nail varnish.

2.4. Experimental protocol

A thin coat of gel was applied on the exposed area of enamel blocks using a microbrush. Each block was subjected to 1 min of treatment in 3 g of gel and removed with deionized water. Ero was performed every 2 h, by dipping the enamel blocks in Sprite Zero (Companhia de Bebidas Ipiranga, Ribeirão Preto, Brazil), pH 2.8, 4 times/day, during 5 min each time.[17]

Ero+Abra was performed on half of the blocks by using a mechanical brushing machine (250 g axial load, 5 strokes/s; Elquip Maq Escovação, São Carlos, Brazil) immediately after the erosive challenges (4 times/day). Brushing was performed for 15 s each time, using a placebo dentifrice slurry (1:3, weight:weight). The other half of the blocks (Ero only) was immersed in the placebo dentifrice slurry for 15 s after the erosive challenges.

2.5. Determination of surface wear

The nail varnish on the reference surfaces was removed carefully with acetone-soaked cotton wool. Enamel loss was determined in relation to the reference surfaces by profilometry (Surftest SJ 401 – Mitutoyo American Corporation), by scanning the surface of each block from the reference surfaces (control) across the exposed surfaces. The mean value of 5 readings was calculated for each block.

2.6. Analysis of cross-sectional hardness

Blocks were sectioned at the center, and half of each block was included in acrylic resin and subsequently polished. Cross-sectional hardness (SH) was determined (Knoop diamond, 5 g, 10 s, Buehler, Lake Bluff, USA). A sequence of eight prints at distances of 10, 15, 20, 25, 30, 40, 50 and 70 μm from the external surface of the enamel was performed in the center of blocks, for both the control and the test areas. The integrated area of hardness (KHN × μm) of the demineralized and sound enamel was calculated using the trapezoidal rule (GraphPad Prism, version 3.02) and subtracted from the integrated area of the hardness of sound enamel loss resulting integrated hardness (ΔKHN).[10]