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Sequence of stannous and sodium fluoride solutions to prevent enamel erosion

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ABSTRACT

Objectives: Investigate the timing of stannous (SnF_2) and sodium fluoride (NaF) application with and without salivary pellicle to prevent enamel erosion.
Methods: Human buccal molar enamel samples ($n = 120$, REC ref 12/LO/1836) were randomly assigned to three groups testing SnF_2 and NaF basic fluoride formulation and commercial mouthrinses with and without the presence of human saliva. Samples were randomly allocated to 2 subgroups: immersion in either fluoride for 1 min either before or after citric acid immersion (0.3%, pH 3.2, 10 min), and the cycle repeated 5 times. For human saliva group, samples were immersed in 80 ml of natural saliva for 24 h prior to the experiment. Analysis was done using non-contacting profilometry and microhardness change. Data were not normal and were log transformed. A linear model tested statistical differences between the groups.
Results: SnF_2 application before erosion statistically reduced step height compared to application after erosion for all groups (solutions: 6.5 μm (±1.2), 7.5 μm (±0.8); $p = 0.01$, mouthrinses: 3.2 μm (±0.6), 4.2 μm (±0.7); $p < 0.0001$, mouthrinses with saliva: 2.5 μm (±0.4), 3.1 μm (±0.6); $p = 0.002$, before and after respectively). In contrast, application of NaF before erosion increased step height compared to application after, but this was only statistically significant for the saliva group (before: 5.6 μm (±0.3) and after: 4.9 μm (±0.3); $p = 0.023$). Presence of saliva increased microhardness change ($p < 0.0001$). Within this group, greatest microhardness change was observed when SnF_2 was applied before erosion and when NaF was applied after erosion (SnF_2: 156.6KHN (±32.8), 123KHN (±20.1); $p = 0.02$. NaF: 119.5KHN (±33.5), 218KHN (±24.9), before, and after respectively).
Conclusion: SnF_2 reduced step height formation overall when compared to NaF, but particularly when applied before citric acid immersion. In contrast, NaF reduced step height when applied after citric acid immersion, but only in the presence of saliva.
Clinical significance: Stannous fluoride can be recommended over sodium fluoride to patients at risk of dental erosion and is optimally applied before erosion occurs. If sodium fluoride is to be used in the presence of saliva it is optimally applied after erosion has occurred.

1. Introduction

Tooth wear is a multifactorial condition consisting of erosion, abrasion and attrition and is common to many European adults [1]. Dental erosion is a condition of growing concern in the dental community and there is debate over the optimal timing of oral hygiene procedures in relation to an erosive challenge. After an erosive challenge, the softened enamel may be more susceptible to mechanical abrasion, such as, toothbrushing [2]. Based on previous laboratory and clinical studies some authors have recommended not to brush for at least one hour after an erosive challenge [3–5]. However more recently, other authors have demonstrated that eroded enamel showed no increased abrasion resistance even after a 2-4 hour remineralisation period [6,7]. Fluoride, applied as a mouthrinse either before [8] or after [9] an erosive challenge has been shown to protect enamel without an abrasive element.

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The two interpretations on the role of fluoride in erosion are surface protection or remineralisation of erosive lesions [10]. Two theories on surface protection are the presence of fluoride deposits on the dental surfaces and incorporation of the fluoride ion into the hydroxyapatite structure [11]. The concept of remineralisation in erosion is not universally accepted and is partly based on the caries process where the lost surface minerals are replaced by the fluoride ions [12].

The stannous ion shows promising results in the prevention of dental erosion, either combined with fluoride or in the form of other stannous salts [13]. Interestingly, there are indications that deposits of the stannous ion are more stable on dental surfaces than sodium fluoride deposits when facing an erosive challenge [14].

Both stannous and sodium fluorides have shown to be protective against an erosive challenge albeit under different conditions [9,15]. The properties of different fluoride compounds indicate they may react differently depending on the condition of the enamel and the environment (neutral or acidic) into which it is placed.

In vivo, tooth surfaces are covered with an acquired salivary pellicle which helps to protect enamel from tooth erosion [16]. The pellicle acts as a diffusion barrier aiding the protection against demineralisation [17]. Due to its high protein and mineral content saliva can increase mineralisation of demineralised enamel if the matrix is still intact [18]. Salivary pellicle can also alter the efficacy of products making them more effective [19,20].

In vitro studies provide the opportunity for highly controlled conditions to study individual risk factors or novel compounds on erosion to better understand their role. The aim of this study was to investigate the timing of application of fluoride in relation to the erosive challenge. The second aim was to investigate under laboratory conditions the application of sodium and stannous fluoride as a pure solution, a commercial mouth rinse or in the presence of a salivary pellicle. The first null hypotheses proposed that altering the timing of application of different fluorides to enamel would not affect enamel erosion. The second null hypothesis proposed that enamel erosion is not influenced by sodium and stannous fluoride applied as a solution or as a commercial mouthrinse with and without the presence of saliva.

2. Materials and methods

Enamel from previously extracted, caries free teeth were sectioned, using a circular saw (Isomet 1000 with an Extex diamond waffering blade; Buehler, Coventry, UK) at a speed of 300 rpm with a force of 150 g, from the buccal surfaces of molar teeth to produce 120 sound enamel specimens. The sectioned enamel specimens were placed into a custom-made silicone mould (specimen size $8 \times 21.5 \times 24$ mm) and embedded in cold cure acrylic resin (Oracryl; Bracon, East Sussex, UK). Specimens were then polished (Metaserv 3000 variable speed grinder-polisher; Buehler, Coventry, UK) using the Federation of European Producers of Abrasives (FEPA) standard silicon carbide sandpaper, starting at 80 grit, followed by the 180, 600, 1200, 2400 and 4000 grit. Following polishing, specimens were immersed in 80 ml of deionised water and ultrasonicated (GP-70; Nusonics, Lakewood, US) at 60 Hz for 15 min, after which they were rinsed and allowed to dry. Adhesive tape was placed on the enamel surface to create a window approximately $1\,\text{mm} \times 3\,\text{mm}$ wide for two reference areas. Specimens were stored in dry conditions prior to the erosive cycling except for the saliva experiment.

Citric acid (99%; Sigma Aldrich, Haverhill, UK) at 0.3% adjusted to pH 3.2 with sodium hydroxide was used as the erosive solution. Sodium fluoride (99%: Alfa Aesar, Lancashire, UK) and stannous fluoride (99%; Sigma–Aldrich, Haverhill UK) solutions were diluted with deionised water to create 225 ppm concentration of fluoride at pH 6 and 4 respectively. Commercial sodium and stannous fluoride mouth rinses were used at a 225 ppm concentration (Fluoriguard, alcohol free, sodium fluoride 0.05% w/w 225 ppm; Colgate, Surrey, UK, (pH 6) and Periomed alcohol free, stannous fluoride 0.63% w/w, fluoride 0.12% w/w; 3 M ESPE, Minnesota, US, diluted in deionised water to produce a 225 ppm fluoride concentration solution (pH 3.8)). Acid and fluoride solutions were freshly made each day. Stimulated human saliva was collected from healthy volunteers and was obtained after an absence of food or drink for 1 h prior to donation. Volunteers were asked to chew flavourless paraffin wax for 5 min while the saliva was collected in a 20 ml polypropylene tube. The samples were immediately frozen at -80 °C within 15 min of collection. Prior to use in the experimental cycling, the saliva was fully defrosted at room temperature and then pooled.

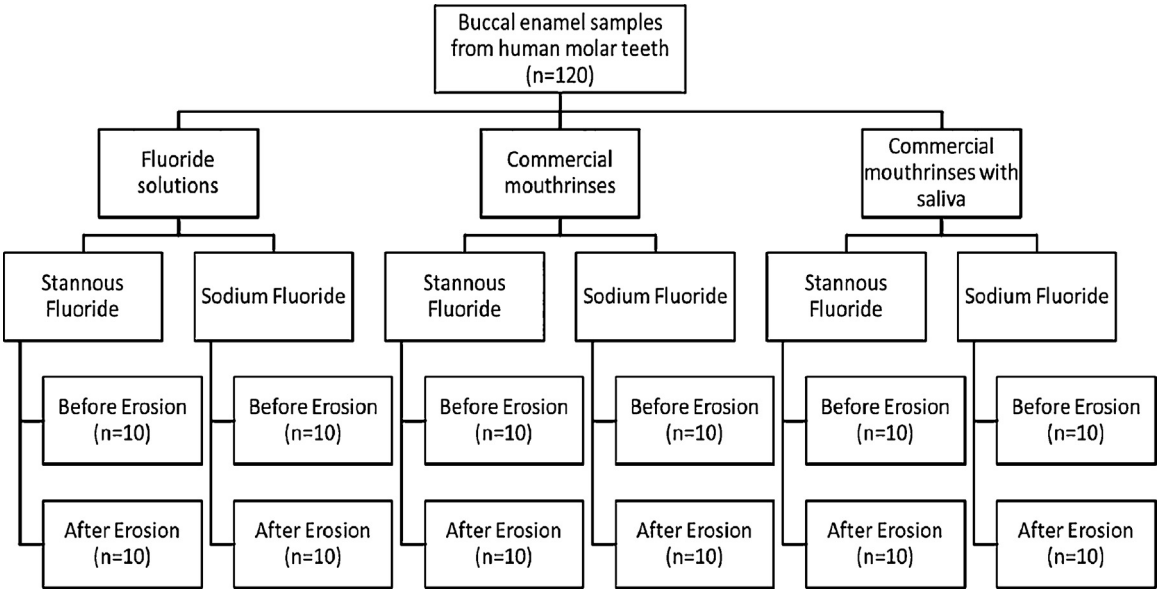

Fig. 1. Random allocation of samples.