In Vitro Comparison of Three Desensitizing Prophylaxis Pastes: A Morphological Analysis

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Abstract

Background and Objective: Dentine hypersensitivity (DH) characterizes for short sharp pain arising from exposed dentine. Nowadays, there is a vast choice of products to overcome it. The aim of the present observational study was to compare the efficacy of three prophylaxis pastes in occluding dentinal tubules from in an in vitro setting.

Methods: Longitudinal mesio-distal sections were obtained from a sample of ten extracted teeth. Morphological analysis with scanning electron microscopy (SEM) assessed the penetration of three different prophylaxis pastes in dentinal tubules: Nupro by GSK, Stomyprox by Biorepair, Colgate Pro-Sollievo. The use of the Energy Dispersive X-ray Analysis (EDX probe) allowed assessing the exact composition of each product.

Results: The SEM analysis revealed that only Stomyprox by Biorepair could penetrate the dentinal tube due to its low crystallinity. Its small sized particles (1.60 µ) fit better the tubules lumen if compared to the other two pastes with higher sized granules. The small sample size and the lacking of a quantitative evaluation of tubules filling limit this result.

Conclusion: The occlusion of dentinal tubules is one of the possible ways to reduce dentine hypersensitivity in a professional setting. Small sized particles fit better the lumen of tubules. In conclusion, there is a biological rationale in preferring prophylaxis pastes characterized by a low crystallinity. It is worthy to investigate furthermore, and in a clinical setting, the efficacy of the prophylaxis paste made by small sized particles of Hydroxyapatite.

Keywords: Dentine hypersensitivity; Prophylaxis paste; Hydroxyapatite

Introduction

Dentine hypersensitivity (DH), clinically, is as an exaggerated response to a non-noxious sensory stimulus (osmotic, thermal or mechanical changes). The prevalence of DH in general population ranges between 4-57% and females are more affected [1]. DH derives from the underlying exposed dentine, after the enamel or cementum at the root surface has been eroded away [2]. DH is most commonly reported at the buccal-cervical zone of permanent teeth [3] and this is due to its peculiar etiology that is multifactorial. The most common clinical cause of DH is gingival recession, which exposes the root surface, due to periodontal treatment, surgical/dental operative procedures, gum diseases, aging and incorrect tooth brushing or association of two or more of these factors. Other factors include patients’ deleterious habits, poor hygiene and diet, exposure of teeth to chemical products, excessive occlusal forces and premature occlusal contacts [4].

Histologically, sensitive dentine is characteristic for the patency of dentinal tubules, and it has been reported that there is a positive correlation between the density of open dentinal tubules and the intensity of pain responses [5]. Therefore, plugging tubules should overcome DH symptoms, as well as preventing fluid flow, or dulling the nerves.

An accurate diagnosis is the key in preventing the occurring or the recurring of DH. In fact, the treatment should be appropriate to the specific etiology of DH in each patient. Individualization of treatment protocols is the best way to obtain both hygienist and patient satisfaction. This is true not only for timings and maneuvers, but for specific product usage also.

Nowadays, there is a vast choice of products that both the doctor and the patient could use at the end of an oral hygiene session to reduce dentine hypersensitivity. They come in different formulas such as solutions, gels and prophylaxis pastes containing various components. There could be fluorides, calcium hydroxide, strontium chloride, potassium nitrate, sodium citrate, glutaraldehyde and hydroxyethylmethacrylate, potassium, or ferric oxalate [6].

The aim of the present observational study was to compare the efficacy of three prophylaxis pastes (Nupro by GSK, Colgate Pro-sollievo, Stomyprox by Biorepair) from a histological point of view. Our null hypothesis was that there was no significant difference between the three pastes in occluding dentinal tubules.

Materials and Methods

The study took place at the Stomatologic Institute of the Versilia hospital (Lido di Camaioare). Ten extracted permanent teeth constituted the sample of the present in vitro observational study. The small sample size is due to the nature of this in vitro research, which is a pilot observational study. Three molars, three premolars and four incisors

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composed the sample in analysis. Inclusion criteria for the extracted teeth were absence of decays, absence of brushing abrasion, absence of root canal therapy, and absence of prosthetic restorations. The reason for extraction was severe periodontal disease for every tooth in the sample.

The teeth have been washed out with a 5.25% sodium hypochlorite solution to dissolve any residual proteic material that could interfere with the morphological analysis. The operator let the teeth rest in the sodium hypochlorite solution for a night after a few shake of the test tube containing them. This procedure led to the standardization of the sample: the rinsed teeth resulted in a uniform surface with patent tubules ready to receive the product.

One of the ten teeth (one of the four incisors) was left untreated, in order to perform an initial testing of the Scanning Electron Microscopy (SEM), in order to visualize correctly tooth surface and its tubules. Once cleaned with the sodium hypochlorite solution, the remaining nine teeth were divided in three groups: each group consisted of a molar, a premolar, and an incisor. The three different prophylaxis pastes were randomly assigned to one of the three groups. The operator distributed uniformly one of the three products on the entire tooth surface with a small rotatory brush for one minute.

The laboratory-trained technician cut the teeth in clean longitudinal sections in a mesio-distal direction. The thickness of each section was 1 mm. The sections obtained at the mid-point of each tooth were analyzed at the SEM to visualize the penetration of products in dentinal tubules. The probe for the Energy Dispersive X-ray Analysis (EDX probe) helped to visualize the exact composition of the materials in study.

Nupro by GSK is a prophylaxis paste containing fluoride and a part of calcium sodium phosphosilicate (Figures 1 and 2). The formula of Colgate Pro-Sollievo contains arginine, which is an amino acid naturally present in the saliva, and to an insoluble calcium composite in the form of calcium carbonate (Figures 3 and 4). Stomyprox by Biorepair is a prophylaxis paste based on hydroxyapatite with low crystallinity, with dimensions and morphology able to fit the tubules (Figures 5 and 6).

**Results**

The SEM analysis, conducted on the sections treated with Nupro by GSK, presents a product consisting of particles sized few microns (4.80 µ). The EDX probe image (Figure 2) shows that the composition is mainly calcium and phosphate.

Figure three shows that Colgate Sensitive Pro Sollievo is made of irregular micrometric aggregates (12.0 µ). In Figure 4 (EDX probe), we can appreciate how Colgate Sensitive Pro Sollievo is mainly constituted by calcium, as described in the data sheet.

Figures five and six (EDX probe) show that Stomyprox by Biorepair is made of calcium-phosphate irregular micro aggregates with smaller sizes (1.60 µ) than those found in the previous pastes. The ratio calcium-phosphorus identified through the EDX probe is different from that found in Nupro by GSK for the same elements. The image shows the presence of silica as well. An extra analysis carried out through X-Ray diffraction (XRD) revealed that the inorganic phase in Stomyprox was made of micrometric hydroxyapatite; unlike Nupro, which contains both calcium and phosphorus, but in salt and not in apatite form.

The mid-point 1 mm section, obtained from each tooth type, was analyzed with the SEM. For simplification, the possible result was dichotomous: absence of tubules filling, presence of tubules filling. There were no differences in tubules filling, based on the type of tooth type.
treated. Instead, the filling was consistently different between treatment groups, as described below.

Figure 8 reports a dentine section treated with Nupro. This image shows that the dentine tubules appear perfectly clear and with no filling. Figure 9 reports the dentine tubules treated at the surface with Colgate Sensitive Pro Sollievo: even in this case the tubules appear to be empty. Figure 10 shows the SEM analysis of a tooth section treated with Stomyprox. The tubule visible at the center of Figure 10 is full of tiny micrometric granules.

A deeper investigation through the EDX probe (Figure 11) shows that there are only calcium and phosphorus in a precise ratio where the filling is not present.

The EDX probe investigation (Figure 12) of the tubule visible in Figure 10 shows the presence of calcium and phosphorus (in a ratio
The etiology of DH is multifactorial and the most widely accepted explanatory theory is the hydrodynamic one, proposed by Brannstrom [7], who suggested that exposed dentine with patent tubules, allows the movement of tubule fluid, which leads to dentine sensitivity. The centrifugal fluid movement activates the nerve endings at the end of dentinal tubules or at the pulp–dental complex.

The pathogenesis of DH includes two stages: lesion localization and lesion initiation. The localization stage refers to the moment when loss of enamel occurs; the lesion initiation is secondary to the removing of the protective covering of smear layer, leading to exposure and opening of dentinal tubules [5]. Scanning electron microscopy (SEM), in fact, has shown that tubules of teeth clinically characterized as ‘sensitive’ are eight times more numerous, two times wider in diameter and more penetrable [8].

The branching pattern of dentinal tubules reveals an intricate anastomosing system, criss-crossing the intertubular dentine. Major branches, 0.5-1.0 micron diameter, are typically at the periphery of the toothy. Fine branches, of 300–700 nm in diameter, forked off at 45 degrees, are abundant where the density of the tubules is relatively low. Micro-branches, 25-200 nm in diameter, extend at right angles from the tubules and are the most common [9].

Free liquids account for 75% of the dentinal tubule volume. A slight reduction of the dentinal tubule diameter can greatly reduce the flow of liquid within the dentinal tubules, subsequently alleviating the sensitivity of the nerve [10].

The results of the present study on the SEM reveals that, by comparing three prophylaxis pastes, with different major components, only the Stomyprox, containing hydroxyapatite, succeeded in filling dentinal tubules. Hydroxyapatite is the major component of human bones and teeth. It is a mineral form of calcium apatite with the formula Ca5(PO4)3(OH).

Research into the use of the mineral components of the inorganic portion of the tooth structure has inspired the preparation of hydroxyapatite (HA), for occlusion of dentinal tubules [11]. The rationale of using HA as a desensitizer is that it would permanently occlude the open dentinal tubules and blend with them. Synthetic HA comes in various forms and size of its particles. The recent biomimetic approach in biochemical research is leading to the development of nanomaterials for inclusion in a variety of dental products. Examples are pastes containing nano-apatites for biofilm management at the tooth surface, and products that contain nanomaterials for the remineralization of early enamel lesions [12]. There are clinical studies investigating the desensitizing property of formulations containing HA [13]. SEM images showed that ordinary dentifrice with added HA leads to a significantly increased effect of dentinal tubule occlusion after only 7 days of brushing; the measured rates of dentinal tubule occlusion by the HA dentifrice were all above 90% [14-19].

Discussion

The main aim of the present study was to evaluate the in vitro efficacy of three prophylaxis pastes in occluding dentinal tubules. Our results disproved the hypothesis that there were no differences in tube filling between the three pastes tested. The prophylaxis paste containing hydroxyapatite in small granules (1.60 µ) resulted in the occlusion of the lumen of dental tubules despite the type of tooth treated as evaluated on the morphological analysis with the SEM. The other two prophylaxis pastes, characterized by bigger particles (4.80 µ and 12.0 µ), resulted in no filling of dental tubules, in spite of the site and the tooth-type treated.

One of the limitations of the present observational study is the small sample size. That was due to the preliminary nature of the research, which was originally designed as a pilot study. The next step would be the identification of a standardized unit measure to describe tubules filling, despite their orientation, and despite the tooth site. Of course, the study lacks also in the statistic aspect, since there was no quantitative evaluation of the entity of filling, or counting the number of tubules occluded by the pastes granules. At last, a clinical evaluation would be useful, in order to match the histological evidence with the eventual symptoms relief.

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Figure 11: EDX for the dentinal tubule of Figure 10.

Figure 12: EDX probe for STOMYPROX referring to the tubule in figure 10.
better.

Conflict of Interest
The authors report no conflicts of interest related to this study.

References