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Effectiveness and acid/tooth brushing resistance of in-office desensitizing treatments—A hydraulic conductance study

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ABSTRACT

Objective: To evaluate dentin permeability and tubule occlusion of in-office desensitizing treatments, and to analyze their resistance to erosive/abrasive challenges.
Design: Ninety-one 1mm-thick dentin discs were immersed in EDTA solution for 5 min. After analyzing the maximum dentin permeability, the specimens were randomly allocated into 7 experimental groups (n = 10): Control (no treatment); Er,Cr:YSGG laser; Nd:YAG laser; Gluma Desensitizer; Duraphat; Pro-Argin toothpaste; Calcium Sodium Phosphosilicate (CSP) paste. The post-treatment permeability was assessed and then the specimens were subjected to a 5-day erosion-abrasion cycling protocol: 4x/day of immersion in citric acid solution (5 min;0.3%), followed by exposure to clarified human saliva (60 min). After the first and last acid challenges, specimens were brushed for 15 s, with exposure to the toothpaste slurry for total time of 2 min. Dentin permeability was re-measured (post-cycling). Percentage of dentin permeability for each experimental time was calculated in relation to the maximum permeability (%Lp). Data were analyzed with 2-way repeated measures ANOVA and Tukey tests (α = 0.05). Surface modifications were analyzed by scanning electron microscopy.
Results: In both experimental time CSP paste and Gluma Desensitizer did not differ from each other (p = 0.0874), and were the only groups that presented significantly lower %Lp than the Control (p = 0.026 and p = 0.022, respectively). After treatment, they were able to reduce dentin permeability in 82% and 72%, respectively. The %Lp post-cycling was higher than post-treatment value for all groups (p = 0.008). Dentin permeability increased 21% for CSP paste and 12% for Gluma, but they remained significant different from Control. Deposits on the surface were observed for CSP paste; and for Gluma, tubule diameters were shown to be smaller.
Conclusions: CSP paste and Gluma Desensitizer were the only treatments able to decrease dentin permeability post-treatment and to sustain low permeability post-cycling.

1. Introduction

Dentin hypersensitivity (DH) has become a common condition nowadays. The pain arises from exposed dentin, stimulus-induced, of short duration, and not related to any disease or other dental pathology (Canadian Advisory Board on Dentin, 2003). DH has shown high prevalence among populations worldwide (West, Seong, & Davies, 2014). Many studies have shown a strong association between the presence of DH and tooth wear (O'Toole & Bartlett, 2017; Yoshizaki et al., 2017). Thus, it is important for dental professionals to investigate the conditions related to tooth wear, with the purpose of eliminating the predisposing factors.

As DH occurs when dentin with opened dentin tubules has been exposed, treatments capable of causing tubule occlusion and/or acting directly on the pulpal nerves, preventing depolarization and the transmission of the pain to the central system have been suggested (Lin et al., 2013; West, Seong, & Davies, 2015).

The treatments can be performed in-office, where one application usually results in immediate pain relief. These treatments are indicated mainly in cases of localized or severe DH and/or in cases of persistent pain after primary treatment (Canadian Advisory Board on Dentin, 2003; West et al., 2014, 2015). Among the in-office therapies for DH,

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application of fluoride varnish is widely used. The varnishes contain high concentrations of fluoride, capable of forming a mechanical barrier on the exposed dentin (West et al., 2014). Lasers have also been used to treat DH. High power lasers, such as the Nd:YAG and the Er,Cr:YSGG, act through increasing the temperature on the dentin surface, promoting surface changes that would result in tubule occlusion (Naylor, Aranha, Eduardo Cde, Arana-Chavez, & Sobral, 2006; Palazon et al., 2013; Yilmaz, Cengiz, Kurtulmus-Yilmaz, & Leblebicioglu, 2011). Furthermore, they can act on the pulp nerves by diminishing the pain threshold (Ryu et al., 2010; Whitters et al., 1995; Yilmaz, Kurtulmus-Yilmaz, Cengiz, Bayindir, & Aykac, 2011). Some prophylactic pastes may have active agents that act by blocking the dentinal tubules. Examples of these agents are arginine/calcium carbonate and calcium sodium phosphosilicate (CSP) (Earl, Leary, Muller, Langford, & Greenspan, 2011; Kleinberg, 2002; Layer, 2011; Panagakos et al., 2016; Petrou et al., 2009; Wang et al., 2010; Wefel, 2009). Another treatment option is the use of an aqueous solution containing hydroxyethyl methacrylate (HEMA) and glutaraldehyde. These components react with the dentinal fluid, and are polymerized within the dentin tubules (Ishihata, Finger, Kanehira, Shimauchi, & Komatsu, 2011; Qin, Xu, & Zhang, 2006; Schupbach, Lutz, & Finger, 1997).

As regards to the above-mentioned treatments, in addition to acting immediately after their application, they should provide long-term effects. Frequent exposure to acids, together with toothbrushing abrasion, has been shown to play an important role not only in the onset of new lesions, but also, in maintaining the dentin tubules opened (Absi, Addy, & Adams, 1992; Prati, Montebugnoli, Suppa, Valdre, & Mongiorgi, 2003; West et al., 2014). Exposure to acids and abrasion can also influence the durability of treatments (Naylor et al., 2006). Many studies have compared the efficacy of the different in-office desensitizing treatments in vitro and clinically (Ding, Yao, Wang, & Song, 2014; Olley et al., 2012; Palazon et al., 2013; Wang et al., 2010; West et al., 2015; Yang, Wang, Lu, Li, & Zhou, 2016; Yilmaz, Cengiz et al., 2011; Zhu et al., 2015). However, analysis of their resistance to erosive and abrasive challenges has not yet been fully investigated.

In view of the foregoing, the aim of this study was to evaluate dentin permeability and tubule occlusion after the application of several different in-office desensitizing treatments, and to analyze their resistance to erosive and abrasive challenges. The null hypotheses tested were: 1) treatments would not differ regarding their ability to reduce dentin permeability immediately after their application; 2) there would be no difference among treatments relative to their ability to resist the 5-days of erosive-abrasive challenges.

2. Materials and methods

2.1. Specimen preparation

This study was conducted after approval from the local Ethics Committee on Research with Human Beings (process number: 1.402.193). Ninety-one sound human molars were selected. The crowns were first sectioned from the roots, and then dentin discs were prepared from the crowns using a precision cutting machine (Isomet 1000, Buehler Ltd, Lake Buff, Illinois, USA). Two cuts perpendicular to the long axis of the tooth were made in the middle region of the crown, with a distance of approximately 1.5 mm between them, thereby removing the pulp horns and the occlusal enamel. The surfaces were then flattened with a #600 grit abrasive disc in a polishing machine (Buehler Ltd, Lake Buff, Illinois, USA), under constant water cooling, until the discs reached a thickness of 1 mm. This procedure also removed any occlusal enamel that could have remained after the cut. The thickness of the discs was checked with a digital caliper (Mitutoyo, Tokyo, Japan). After the polishing procedure, the specimens were sonicated with distilled water for 3 min, to remove the debris.

2.2. Saliva collection

Human stimulated whole saliva was collected as described earlier (Scaramucci et al., 2016). Before the collection, the volunteers were informed about the nature of the research and had to sign a written informed consent term, in accordance with the regulation of the local ethics committee. The volunteers had to stimulate salivation by chewing a parafilm for 30 s and then swallowing all the saliva produced. After this, they continued chewing the parafilm for 10 min and the saliva produced was collected in an ice-chilled container (Navazesh & Christensen, 1982). The collections were always carried out in the mornings, and the volunteers were instructed not to eat or drink at least 1 h before the collections.

After the collection of each day, saliva from the different volunteers was pooled and immediately centrifuged (20 min, 4 °C, 3226 g-force). The supernatant was separated from the pellet and stored in tubes in a freezer at −80 °C. On the day before use, the necessary amount of saliva was transferred from the freezer to the refrigerator (4 °C). On the day of use, the saliva was removed from the refrigerator and left at room temperature for at least 2 h.

2.3. Maximum dentin permeability

To simulate a hypersensitive dentin, the specimens were immersed in 17% EDTA solution (pH 7.4) for 5 min, in order to open the dentinal tubules. The specimens were rinsed with distilled water and stored in a humid environment until the maximum dentin permeability evaluation, which was considered 100%. The specimens were then randomly allocated into the different experimental groups (n = 10; Table 1).

2.4. Application of the treatments

After opening the dentinal tubules and the maximum permeability assessment, the specimens were immersed in a protein solution for 5 min. The excess solution was removed with absorbent paper, without scrubbing. The protein solution that simulated the dentin fluid was prepared immediately before use by mixing 1 part of fetal bovine serum (FBS; Laborclin) in 4 parts of phosphate buffered saline (pH = 7; Biosystems) (Jain, Reinhardt, & Krell, 2000). This solution was important for the proper mode of action of the components present in the Gluma® Desensitizer.

The in-office treatments were performed according to the protocols established in the literature or according to the manufacturer's recommendations, as described in Table 1. For the purpose of standardization, the toothpaste and the prophylactic paste were mixed with clarified human saliva in the ratio of 1 part of paste to 3 parts of human saliva. The mixture was applied on the dentin surface with a rubber cup for 15 s, then washed with distilled water, and dried carefully with absorbent paper. The specimens were stored in a humid environment and a new evaluation of the dentin permeability was performed (%Lp - post treatment). Three extra specimens per group (total of 21 specimens) were used for the analysis of tubular occlusion and treatment penetration, by scanning electron microscopy (SEM).

2.5. Erosion-abrasion cycle

In order to evaluate the resistance of the desensitizing treatments studied, the treated specimens underwent a 5-day erosion-abrasion cycling protocol. Each cycle consisted of immersion in citric acid (0.3%, natural pH, ~2.6) for 2 min, followed by 60 min of immersion in clarified human saliva, under constant agitation (35 rpm, orbital shaker, AI9000IB, BrILabs), 4 times a day. Thirty min after the first and the last acid immersions, the specimens were brushed in an automatic brushing machine for 15 s (45 cycles, each cycle being considered a back and forth brush movement, load 2 N). Brushing was performed with standard brushes and a slurry of toothpaste with clarified human