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Research Article

The Effect of Desensitizing Agents on Open Dentine Tubules- An *In Vitro* Study

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Abstract

Rational: Dentin sensitivity can be treated by blocking the exposed dentinal tubules or by interrupting neural response for pain stimuli.

Objectives: To analyze *in vitro* the plugging effect of open dentin tubules by three desensitizing tooth pastes and a desensitizing agent.

Materials and Methods: V shaped cavities were made on the buccal surface of 18 extracted premolars. On each group of 3 premolars each, the exposed dentine was brushed with water (control), 3 desensitizing tooth pastes (Oral B-gum and enamel repair, Sensodyne-dual care, Colgate-sensitive pro-relief), a parodont expert toothpaste (Meridol) and a desensitizing agent (Riva Star desensitizing agent) twice a day for 30 seconds, for 10 days. Two days after the last brushing, the dentin surface was analyzed with SEM to observe the effect of the agents on dentine tubules. Using the Energy Dispersive X-ray Spectrometer (EDS) program the ion content of the dentine surface (%WC) was examined, in order to analyze the effect of toothpaste ingredients on the dentine.

Results: Tooth-brushing with water, Meridol and Sensodyne dual-care left the dentine tubules open with no plugging. Colgate-sensitive pro-relief toothpaste caused plugging of 40% of the tubules, while Oral B gum and enamel repair applied a plugging material on 100% of the tubules. Riva Star covered the dentin with amorphic material. The ion content of the dentin surface after using Oral B showed apposition of zinc, tin and titanium, Colgate showed apposition of zinc and Riva Star showed apposition of fluorine, aluminum, silver, iodine and tellurium on the dentin.

Conclusion: Oral B and Colgate plugged the open tubules (full or partial) while Riva Star covered the dentin with amorphic material.

Clinical Relevance: When recommending a desensitizing agent, the dentist should take into consideration the effect of the desensitizing agents on the dentine (closing the tubules openings or affecting nerve response) and the time that the agent should be used. Sensodyne was examined because of reports that it occluded dentin tubules [1] but our research showed that the dentin tubules openings were not affected, but probably affect the nerve response to the stimuli (due to content of potassium nitrate), while Colgate and Oral B toothpastes and Riva Star desensitizing agent reduce dentin hypersensitivity by occluding the tubules.

Keywords: Dentin Hypersensitivity; Dentin Tubules; Tooth Pastes; Desensitizing Agent

Introduction

Dentin hypersensitivity (DH) is defined as short, sharp pain arising from exposed dentin in response to external stimuli, like thermal, evaporative, tactile, osmotic or chemical, and which cannot be ascribed to any other form of dental defect or disease [2]. It is a well-known patient complaint which is patent in middle-aged people and increase with aging [3]. The basic requirements for having DH is exposed cervical dentin and open dentin tubules

[4]. The prevalence of DH symptoms range from 3 - 98%, with higher female incidence than male, commonly affecting premolar and incisor teeth, and the buccal aspect of the cervical area is the commonly affected site [5]. DH is a symptom complex, rather than disease, and a persisting problem, which without proper clinical management can have a significant impact on a subject's quality of life [6]. Localized attachment loss is probably the most widespread factor leading to root surface exposure and exposed dentin tubules. Loss of dental enamel in the cervical area, mainly caused by erosion, abrasion and abfraction is an alternative pathway of cervical dentin exposure [4]. The accurate mechanism of DH has yet to be identified, but it may be explained in part by the hydrodynamic theory suggested by Brannstorm: if the dentin is stimulated by heat or cold, fluid in the dentinal tubules expands or shrinks and these movements stimulates the baroreceptors, thus causing a neural signal and a painful sensation [7]. Therefore, DH can be treated by interrupting neural response for pain stimuli or blocking the exposed dentinal tubules [8]. Potassium is a nervous transmission controller and the use of a toothpaste containing 5% potassium nitrate and triclosan reduced DH in comparison with placebo [9]. Stannous fluoride, calcium sodium phosphor silicate and arginine containing toothpastes may reduce DH by acting as tubule plug [10]. The exact method of blocking dentin sensitivity of the commercial toothpaste has not been described.

Aim of the Study

The aim of this study was to analyze *in vitro* the plugging effect of open dentin tubules by several desensitizing tooth pastes and a desensitizing agent, in comparison to controls (water and a toothpaste suggested for periodontal treatment).

Materials and Methods

18 intact upper premolars, extracted during orthodontic treatment, were used. The patients and their parents approved to leave the extracted teeth at the clinic. Using a K2 diamond bur under a copious amount of water, a shallow V shaped preparation was performed at the cemento-enamel junction (CEJ), in order to expose the dentine tubules. Before treatment all teeth were analyzed by SEM in order to observe that the dentin tubules are open. The 18 premolars were divided into six groups of 3 teeth each. The buccal surfaces of five groups were brushed twice a day (morning and evening) using a soft small toothbrush (Colgate), with water only (control) or with four toothpastes. Each brush lasted for 30 seconds and the teeth were rinsed with water for 10 seconds to remove the toothpaste. Between brushes, the premolars were kept in artificial saliva solution (Biotene by GSK Consumer Healthcare, Waterford, Ireland, LOT 5147110. Exp 12.2021), and the liquid was replaced after every brush. The teeth were brushed with the water or toothpastes for 10 days. On the sixth group, the buccal lesions were covered with a desensitizing agent (Riva Star) according to manufacturer instructions.

The agents used were:

1. Water only (control)
2. Meridol- Parodont Expert
3. Oral-B, Gum and Enamel Repair (for sensitive teeth)
4. Sensodyne (GSK)- Dual care
5. Colgate, Sensitive PRO-Relief
6. Riva Star desensitizing agent (SDI, Australia).

Two days after the last brush, the exposed dentin at the CEJ of the premolars was examined and photographed under Scanning Electron Microscope (SEM, FEI, Quanta 200, Oregon, USA) in order to observe if the dentin tubules are open or occluded. On a representative frame of each group, at X2000 enlargement, the number of blocked tubules was numbered and assessed as %. Using the EDS (Energy Dispersive x-ray Spectrometer) program, the ion components (%Weight Concentrations) of the dentin surface, treated by the different toothpastes, were determined and compared to water brushing, in order to analyze the apposition of different ions by the desensitizing agents.

Results

SEM analysis: Figure 1-6 shows a representative dentin surface from each group, after brushing with water, the four different toothpastes and application of Riva Star. Figure 1 shows a sample from the control group- brushing with water only. All the dentin tubules remained open. Figure 2 and 3 (Meridol and Sensodyne) show similar results- the dentin tubules are open without any plugging. Figure 4 (Colgate) shows obturation of 40% of the dentin tubules (59 plugged tubules out of 150 tubules observed in the frame), and figure 5 (Oral B) showed 100% blocking of the dentin tubules. Figure 6 (Riva Star) shows apposition of an amorphous material on the dentin and no open tubules can be observed. Table

1 shows the mean ion content of the dentin surfaces, for each group of 3 premolars, determined by Energy Dispersive X-ray Spectrometer (EDS). The ion content of the dentin surfaces after brushing with water (control) and Meridol, showed similar concentrations of regular dentin. Brushing with Sensodyne increased the content of carbon and oxygen and reduced the content of nitrogen. The content of calcium and phosphate remained similar to control. Dentin surface after brushing with Colgate showed similar ion content to control and only zinc was applied (ingredient of the toothpaste). After brushing with Oral B the dentin surface showed significant reduction in calcium and phosphorus content and increase in carbon, oxygen, sodium and tin (sodium and tin- ingredients of the toothpaste). Riva Star application reduced the concentration of carbon and oxygen and applied on the dentin surface fluorine 1.1%, silver 5.5% (the bright points in figure 6), iodine 5.5% and tellurium 1.7%.

Element Symbol	Element Name	Riva Star	Oral B	Senso-dyne	Colgate	Meridol	Water
C	Carbon	12.1	21.7	19.4	16.3	15.1	15.1
N	Nitrogen	7.8	8.5	2.3	3.1	7.6	8.3
O	Oxygen	29.3	48.9	43.7	42.3	39.9	39.0
F	Fluorine	1.1				0.4	
Na	Sodium	0.6	3.0	0.4	0.2	0.5	0.9
Mg	Magnesium	0.2	0.2	0.45	0.3	0.5	0.3
Al	Aluminum	0.2					
Si	Silicon	0.3	1.2	0.1	0.2	0.4	0.1
P	Phosphorus	11.9	6.9	12.4	11.8	12.1	12.8
Ca	Calcium	24.3	8.8	22.9	25.6	23.5	23.5
Ag	Silver	5.5					
Te	Tellurium	1.7					
I	Iodine	5.5					
Zn	Zinc		0.7		0.8		
Sn	Tin		1.7				
Ti	Titanium		0.3				

Table 1: Ion content (%weight concentration) of exposed dentin after brushing with toothpastes and application of desensitizing agent.

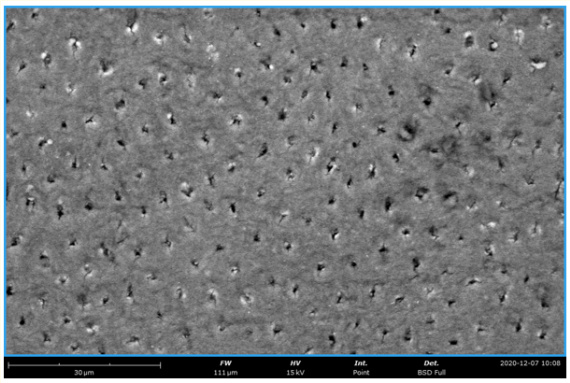

Figure 1: Dentin surface after brushing with water.

Note: All the dentin tubules are open.

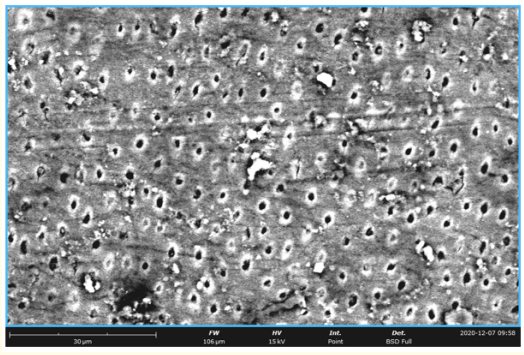

Figure 2: Dentin surface after brushing with Meridol toothpaste.

Note: The dentin tubules are open.

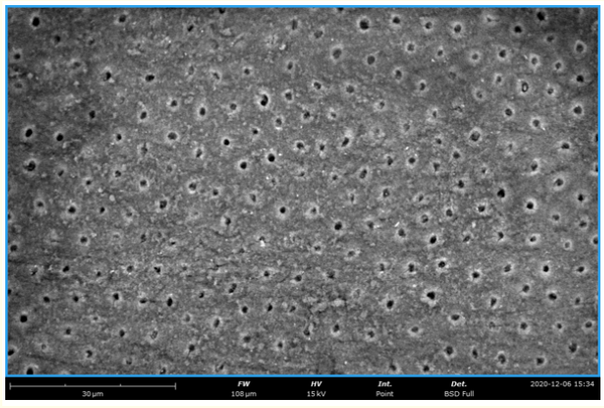

Figure 3: Dentin surface after brushing with Sensodyne toothpaste.

Note: All dentin tubules are open.

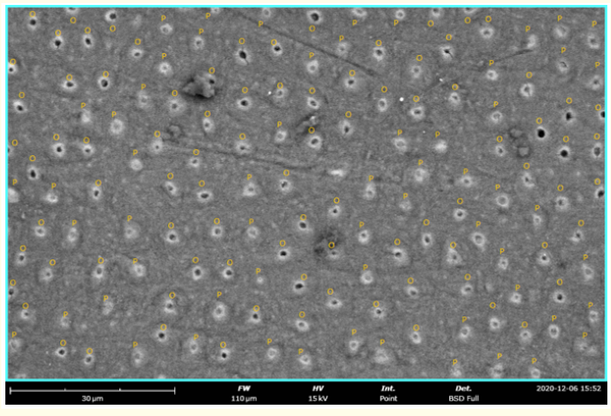

Figure 4: Dentin surface after brushing with Colgate toothpaste.

Note: O=open tubule, P=Plugged tubule. 40% of the tubules are plugged, 59 out of 150 tubules in this frame.

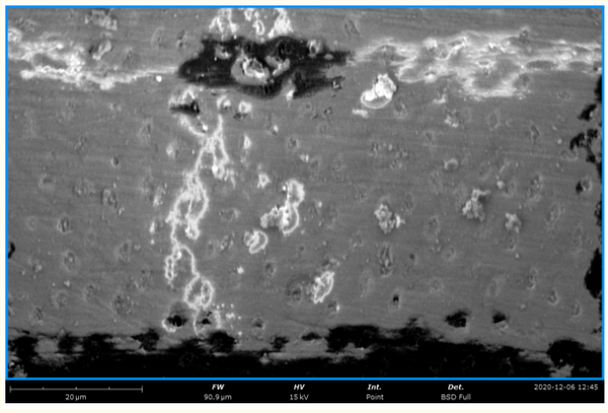

Figure 5: Dentin surface after brushing with Oral B toothpaste.

Note: All tubules are plugged.

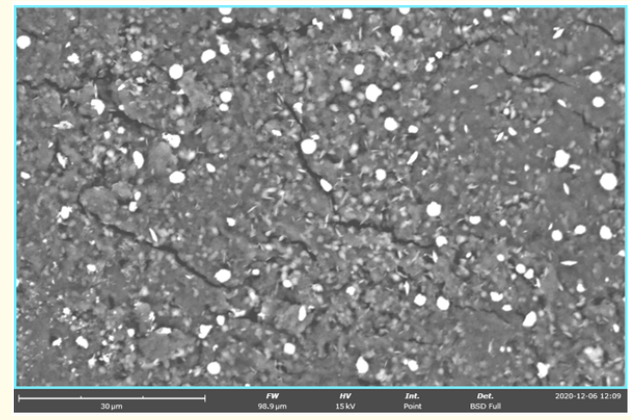

Figure 6: Dentin surface after application of desensitizing agent Riva Star.

Note: Amorphous substance on the dentin surface. The bright points are argentum.

Discussion

A systematic review and meta-analysis of the effect of desensitizing toothpastes versus placebo for dentin hypersensitivity showed that there is sufficient evidence to support the use of potassium, stannous fluoride, calcium sodium phosphosilicate and arginine containing toothpastes [10]. Aqueous glutaraldehyde-containing solutions have shown to be effective in reducing DH by precipitative intratubular occlusion [11,12], but potential biocompatibility hazards should be taken into consideration [13]. Zinc compounds in toothpastes was found to increased dentin tubule occlusion and decreased dentin permeability [14]. Zinc as zinc citrate is part of the ingredient of Sensodyne and Colgate toothpastes used in this research, zinc lactate is an ingredient in Oral B and zinc oxide is an ingredient in Colgate. Zinc was found on the dentin surfaces after brushing with Colgate toothpaste (obturation of 40% of the tubules) and with Oral B (total obturation of dentin tubules). Brushing with Meridol toothpaste (parodont expert- intended for treatment of periodontitis) or Sensodyne toothpaste did not affect the dentin surfaces. The Sensodyne toothpaste contains 5% potassium nitrate. Potassium is a typical nervous transmission controller and its penetration through the dentin tubules to the pulp is time dependent [15]. Due to effect on pulp nerves transmission, the use of Sensodyne toothpaste is restricted in time. Oral B and Colgate toothpastes may reduce the DH by intratubular occlusion and Oral B showed better results.

Dentin hypersensitivity is mainly a diagnosis of exclusion. The decision process is important to effectively control and treat underlying causative and modifying factors [16]. Cause-related therapy primarily aims to mechanically or chemically protect the pulp-dentin complex or to suppress or modify the nerve stimulation.

Treatment should start with minimally invasive and reversible approach, like using toothpastes designed to reduce DH. Sensodyne toothpaste will reduce the nerve transmission while Colgate or Oral B toothpastes will occlude dentin tubules, as shown in this research. If the self-performed therapy at home is not effective enough in-office treatment should be applied, like the use of Riva Star which will cover totally the exposed dentin. Another reliable technique to close dentin tubules is the application of a chemo-mechanical barrier between the dentin and the oral environment based on adhesive bonding technique [17].

Conclusion

Dentin hypersensitivity may be treated by home used toothpastes that either plugs the dentine tubules like Colgate Sensitive PRO-Relief or Oral B for sensitive teeth, or toothpaste that affects nerve transmission like Sensodyne Dual Care. Another option is the use of a desensitizing agent like Riva Star in the dental office.

Clinical Relevance

The dentists should be aware of dentin hypersensitivity and the possible treatments. The use of toothpaste that contains potassium nitrate should be restricted to four weeks only in order to minimize the effect on nerve transmission. Minimizing the effect on nerve transmission is important since the pulp innervation sends alarm signals when carious attack occurs. The plugging effect on the dental tubules differs from one toothpaste to another and may affect the choice of the patient and the recommendation made by the dentist. Application of desensitizing agent like Riva Star in the dental office can occlude the dentin tubules and minimize the dentin hypersensitivity.

Authors' Contribution

Baruch Nurit and Zilberman Uri made substantial contributions to the conception and design of the work and interpretation of data, drafted the work, approved the version to be published and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of Interest

Baruch Nurit declares that she has no conflict of interest. Zilberman Uri declares that he has no conflict of interest.

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Ethical Approval

This article does not contain any studies with human participants or animal performed by any of the authors.

Informed Consent

For this type of study, formal consent is not required.

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