

Occlusion Effect of Dentinal Tubules of the Dentifrice containing Sodium Metasilicate

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Keyword: Desensitizing dentifrice, Dentinal tubule, Sodium metasilicate.

Abstract. Exposed dentine with patent tubules allows the movement of tubule fluid leading to dentine sensitivity. Occlusion of patent dentinal tubules effectively reduces the state of dentine hypersensitivity. Strontium chloride (SrCl₂) has been well known as a component of desensitizing dentifrice. Recently, new dentifrice containing sodium metasilicate was on the market for desensitizing dentifrice. The aim of this *in vitro* study was to compare the occlusion effect of dentinal tubule between the sodium metasilicate and the existing desensitizing dentifrices. Sixty-four human dentine specimens were embedded into a Teflon mold and were grinded with the use of silicone carbide papers to expose the surface of dentin. The dentin surface was etched with 37% phosphoric acid for 60 seconds and was treated with ultrasonic washing for 1 hour. The dentifrices used in the study are classified into four groups: G1-dentifrice containing Sodium metasilicate, G2-dentifrice containing Strontium chloride, G3-dentifrice containing Hydroxyapatite and G4-BSI reference dentifrice (control group). Toothpaste slurries were prepared as 20 gram of toothpaste in 80 ml of distilled water. Thirty-two specimens were brushed with the toothpaste slurries using V8 Cross Brushing Machine. Tooth-brushing was performed 5,000 times using a back-and-forth stroke. The pictures of the sizes of dentinal tubules were taken by scanning electron microscopy (×3000) and changes of tubule sizes were analyzed by digital analysis. The results showed that the difference of tubule size in descending order: G1-3.30±1.80, G2-2.82±1.73, G3-1.49±1.14, G4-1.04±0.94. The dentifrice containing Sodium metasilicate (22.5%) showed the highest dentinal tubule occlusion. Moreover, the dentifrice containing Sodium metasilicate statistically significantly increased occlusion of dentinal tubule as compared to BSI reference dentifrice (p<0.05). Thus, new desensitizing dentifrice containing sodium metasilicate was more effective than existing desensitizing dentifrice on occlusion of dentin tubules.

Introduction

Dentine hypersensitivity may be defined as a transient pain arising from exposed dentine, typically in response to chemical, thermal or tactile stimuli [1]. Dentine hypersensitivity symptoms appear variously according to the extent of exposed dentinal tubules. Exposed dentine inducing dentine hypersensitivity has been shown to have wider and increased numbers of dentinal tubules than non-sensitive dentine [2,3]. Thus, occlusion of patent dentinal tubules would be an effective means of treating dentine hypersensitivity.

Dentifrice abrasives, such as calcium carbonate, dicalcium phosphate and silica, have therapeutic potential for partially or completely occlusion of dentinal tubules [4,5]. Desensitizing

dentifrices containing some active agents have been introduced to the market several decades ago. These products are aimed at reduction of hypersensitivity symptoms generally through tooth brushing at home. A previous study showed that effective tubular occlusion has been obtained with silica based products [5]. Strontium chloride (SrCl_2) has been a well known component of desensitizing dentifrice 10% strontium chloride has a feature of antibiotics and plays a role in the increased ~~of~~ calcification in dentinal tubules. Therefore, the ingredient had shown treatment effects from 76% to 83% about dentine hypersensitivity [6]. Moreover, hydroxyapatite which is one of the minerals composing tooth indicated a desensitizing effect due to the adherence to dentinal tubules with a strong affinity. Recently, new dentifrice containing sodium metasilicate was on the market for desensitizing dentifrice. Sodium metasilicate (Na_2SiO_3) proved to be a good scrubbing solution stabilizer [7].

The aim of this study was to compare the occlusion effect of dentinal tubule between Sodium metasilicate and existing desensitizing dentifrices *in vitro*.

Materials & Methods

Recently extracted human molars were collected and the crown was removed from the root. To compare the status of the same tooth before and after the use of dentifrices, one dental root was cut to root apex direction on occlusion surface to be separated into two specimens. Sixty-four dentine specimens were embedded into a Teflon mold and were grinded with the use of silicone carbide papers (grits 600) to expose the surface of dentin. The dentin surface was etched with 37% phosphoric acid for 60 seconds and was treated with ultrasonic washing for 1 hour. The dentifrices used in the study are classified into four groups (group1: dentifrice containing Sodium metasilicate (Na_2SiO_3), group2: dentifrice containing Strontium chloride (SrCl_2), group3: dentifrice containing Hydroxyapatite (HA) and group4: BSI reference dentifrice). Toothpaste slurries were prepared as 20 gram of toothpaste in 80 ml of distilled water. Thirty-two specimens were brushed with the toothpaste slurries using V-8 CROSS BRUSHING MACHINE. Tooth brushing was at a force produced by a 150 g weight attached to the brush head and at a rate of 50 back-and-forth strokes per minute [2]. The dentifrice slurries were stirred every 1000 strokes. The specimens were rinsed with distilled water after 5000 strokes. After drying, the specimens were then mounted on metal holders for gold coating, and scanning electron microscopic (SEM) observation was then carried out with an accelerating voltage of 20 kV. The pictures of the sizes of dentinal tubules were taken by SEM ($\times 3000$) and changes of tubule sizes were analyzed by the MEDIA CYBERNETICS Image-pro plus(version 5.1). The size of dentinal tubule after 5000 times of tooth brushing was reduced from the size of baseline dentinal tubule and to obtain the mean values for each group. The result was analyzed with one-way ANOVA and Tukey test with using SPSS 12.0 statistical package program (SPSS Inc. U.S.A).

Results

Table 1 shows the change of dentinal tubule after tooth brushing with four dentifrice groups for 5000 strokes and displays the mean size of occluded tubules in each group. Generally, the size of dentinal tubules decreased after tooth brushing using dentifrices. The dentifrice containing Sodium metasilicate showed the highest dentinal tubule occlusion effect and statistically significant difference in BSI reference dentifrice ($p < 0.05$). Although sodium metasilicate group revealed the highest occluding effect in this study, there were no statistically significant differences in other existing commercial products like group 2 and 3. Fig. 1 shows the images of SEM for dentinal tubules after tooth brushing with various dentifrices for 5000 strokes. Fig. 1 (a) Base line specimen, which was etched with 37% phosphoric acid for 60 seconds, demonstrated widening dentinal tubules. Before tooth brushing, dentine specimens had been shown to have wider and increased numbers of opened dentinal tubules. Otherwise, Fig. 1 (b-d) displayed that dentinal tubules had occlude and decreased numbers after brushing with dentifrices containing desensitizing ingredient for 5000 strokes, but Fig. 1 (e) showed that specimen treated with BSI dentifrice was very similar to

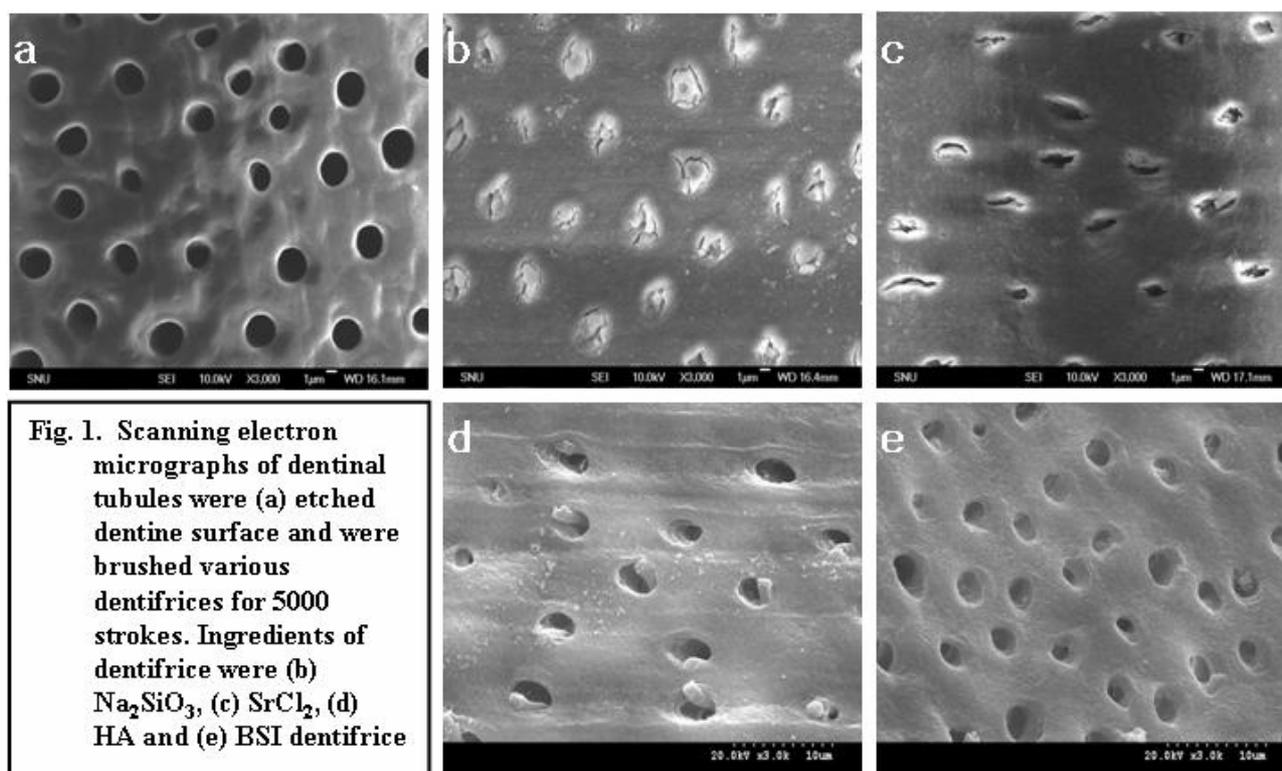
original etched dentine surface.

Table 1. Comparisons of dentinal tubule size after tooth brushing for 5000 strokes with each dentifrice (unit : μm)

Group	N	Dentinal tubule size		Difference of dentinal tubule size (Mean \pm SD)	
		Baseline (Mean \pm SD)	After (Mean \pm SD)		
1 Dentifrice containing Na_2SiO_3 (22.5%)	8	5.56 \pm 1.60	2.26 \pm 1.22	3.30 \pm 1.80	a
2 Dentifrice containing SrCl_2 (10%)	8	4.65 \pm 1.74	1.82 \pm 0.50	2.82 \pm 1.73	a b
3 Dentifrice containing HA (10-20%)	8	4.90 \pm 1.41	3.41 \pm 1.60	1.49 \pm 1.14	a b
4 Control dentifrice (BSI)	8	5.24 \pm 1.45	4.20 \pm 1.38	1.04 \pm 0.94	b

BSI, Standard dentifrice referenced British Standard Institute in UK.

^{a,b} The same letter indicates no significant difference at $\alpha=0.05$ by Tukey's multiple comparison test.



Discussion

Occlusion of patent dentinal tubules would be an effective means of treating dentine hypersensitivity. In this study, SEM was used to compare occlusion effect of dentinal tubules between new desensitizing dentifrice containing Sodium metasilicate and existing desensitizing dentifrices. According to this study, size of dentinal tubules generally decreased after tooth brushing using all dentifrices. Especially, Na_2SiO_3 dentifrice showed increased dentinal tubules occlusion in comparison with BSI control group ($p < 0.05$). It is considered as a combination effect of abrasive agents and desensitizing ingredients. Abrasive agents in dentifrice might induce hypersensitive symptoms to partially stimulate to exposed dentine. Otherwise, some active components with a strong affinity for dentine could occlude dentinal tubules [2].

The sodium metasilicate which were new active ingredients for dentin hypersensitivity was known as alkaline and catalyst action. Even though Sodium metasilicate is insoluble in room temperature, it is possible to be melted under high temperature and pressure. Sodium metasilicate is

easily combined with various materials when making the dentifrice. It is assumed that Sodium metasilicate made a crystal structure in the dentinal tubules then we can find close to dentinal tubules.

Therefore, these results lead us to the conclusion that dentifrices containing Sodium metasilicate is able to be used effectively for dentine hypersensitivity. It is also necessary to develop the optimal combination of abrasive agents and desensitizing ingredients for maximum effect of tubule closing. In this study, there are some limitations of generalization and representation due to its small sample numbers. It will also be necessary to conduct a clinical trial for objective evaluation of reduction of dentin hypersensitivity *in vivo*.

Conclusion

New desensitizing dentifrice containing sodium metasilicate was effective on the occlusion of dentin tubules in comparison with existing desensitizing dentifrice.

Acknowledgement

This study was supported by grant No. R13-2003-13 from the Medical Science and Engineering Research Program of the Korea Science & Engineering Foundation. The new dentifrice containing Sodium metasilicate was supplied by Varowin Inc., South Korea.

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