JOURNAL OF DENTISTRY 43 (2015) 440–449

Available online at www.sciencedirect.com

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journal homepage: www.intl.elsevierhealth.com/journals/jden

# Effectiveness of various toothpastes on dentine tubule occlusion

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ARTICLE INFO

*Article history:*
Received 22 December 2014
Received in revised form
29 January 2015
Accepted 31 January 2015

*Keywords:*
Toothpaste
Dentine
Dentine tubules
Root dentine
Hypersensitivity

ABSTRACT

*Objective:* Dentine hypersensitivity is an increasing problem in dentistry. Several products are available that claim to occlude open dentine tubules and to reduce dentine hypersensitivity. The aim of this study was to investigate the effectiveness of several different products on dentine tubule occlusion using qualitative and quantitative methods.

*Materials and methods:* Dentine discs were prepared from extracted human premolars and molars. The dentine discs were brushed with 6 different experimental toothpastes, 1 positive control toothpaste and 1 negative control without toothpaste; the brushing simulated a total brushing time of 1 year. Half of the discs were etched with lemon juice after toothpaste application. Standardized scanning electron microphotographs were taken and converted into binary black and white images. The black pixels, which represented the open dentine tubules, were counted and statistically evaluated. Then, half of the dentine discs were broken, and the occlusion of the dentine tubules was investigated using energy dispersive X-ray spectroscopy (EDS).

*Results:* The number of open dentine tubules decreased significantly after brushing with 5 of the 6 tested toothpastes. A significant effect was observed after acid erosion for 3 of the 6 tested toothpastes. EDS revealed partly closed dentine tubules after brushing with 3 toothpastes; however, no partly closed dentine tubules were observed after acid erosion.

*Conclusions:* Some toothpastes are capable of partial dentine tubule occlusion. This occlusion is unstable and can be removed with acid erosion.

*Clinical significance:* Desensitizing toothpastes are the most common products that are used against dentine hypersensitivity, and these toothpastes affect dentine tubule occlusion.



## 1. Introduction

As the demographics of the human population change and as the human population ages, more teeth remain in the mouths of elderly people due to effective caries prevention and periodontal disease management. Thus, dentine hypersensitivity is becoming an increasing problem in dentistry.[1,2] Dentine hypersensitivity and a possible cause for this condition were described first by Gysi in 1900.[3] Since then, the mechanisms causing this type of pain have remained controversial. Pulpal nerves from the plexus of Raschkow extend into approximately 15% of the dentine tubule length.[4] These nerves do not innervate the peripheral dentine. Odontoblast processes may function as sensory receptors; however, odontoblast destruction does not cause insensitive

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http://dx.doi.org/10.1016/j.jdent.2015.01.014

dentine.[5,6] In addition, no synaptic contacts exist between the somatic nerves and odontoblasts.[7] In 1968, Brannstrom postulated the hydrodynamic theory, which hypothesizes that fluid movement from the pulp towards the outer dentine within the dentine tubules causes dentine sensation.[8–10] The hydrodynamic theory is now widely accepted as the cause of dentine sensitivity. Open dentine tubules may be the reason for the increased fluid movement that causes dentine hypersensitivity.[2,11–13] This possibility is supported by the observation that dentine hypersensitivity directly correlates with the number of open dentine tubules.[14]

Numerous home-use desensitizing products for the treatment of dentine hypersensitivity are currently available. These products are divided into two categories: products that block the pulp nerve response and products that occlude open dentine tubules.[1] The first group is composed of products that contain potassium salts. Potassium is thought to diffuse inside the dentine tubules and lower the excitability of the pulpal nerve fibres. Several arguments oppose this theory. One is that the diffusion distance in human teeth is greater than that in tested animals. Another argument is that the flow of dentinal fluid is outward from the pulp towards the tooth surface, which would hinder diffusion towards the pulp.[16] The majority of home-use desensitizing products belong to the second group and contain a wide variety of active components. These active components can be divided into several subgroups, which are summarized in Table 1.

The effect of strontium salts is thought to be attributable to their ability to absorb onto the connective tissue of dentine and to form strontium apatite, which may occlude the dentine tubules.[17–19] However, dentine tubule occlusion by strontium salts has not been proven. Clinical studies have demonstrated a reduction of pain perception in patients who used strontium salts.[20–22]

Recent investigations have demonstrated that arginine combined with calcium carbonate occlude dentine tubules and that this deposit converts to calcium phosphate.[13,23] However, many calcium phosphates are soluble in acidic environments and, therefore, unstable upon dietary acid challenge. Several randomized controlled clinical trials have demonstrated clear treatment effects of arginine and calcium carbonate toothpastes immediately and up to 8 weeks after treatment.[24–28]

In vitro studies have shown that stannous fluoride produces precipitates onto dentine; this precipitate is water- and acid-resistant.[29] These in vitro studies are supported by randomized controlled clinical trials that demonstrated the effective treatment of dentine hypersensitivity using stannous fluoride.[30,31]

Calcium sodium phosphosilicates precipitate onto dentine collagen as calcium phosphate and silicate, forming deposits on the dentine surface and in dentine tubules.[32–36] These precipitates are water- and acid-resistant. Randomized controlled clinical studies of calcium sodium phosphosilicates have shown the effective treatment of dentine hypersensitivity compared to controls.[37–40]

Oxalates form calcium oxalate crystals within the dentine tubules and act as desensitizing agents.[41] This effect is enhanced when combined with calcium chloride.[42] Some studies have demonstrated decreased hydrodynamic fluid flow within the dentine tubules upon oxalate treatment, thus reducing pain sensations.[41,43–46] Another study demonstrated that oxalates block dentinal fluid flow by forming precipitates within the dentine tubules.[47] However, a systematic review regarding the effectiveness of oxalates in the treatment of dentine hypersensitivity determined that that single treatments of oxalates had no effect on dentine hypersensitivity compared to placebos.[48]

The mechanisms of the action of fluorides in desensitizing dentine hypersensitivity remain unclear. Although most toothpastes contain fluorides in some form, the incidence of dentine hypersensitivity remain high. Fluorides, similar to other desensitizing agents, may block the dentine tubules. Fluorides enhance the mineralization of hydroxyapatite[49] and may enhance hydroxyapatite formation within the dentine tubules, which blocks fluid movement and reduces pain. However, this enhancement has not been demonstrated.

A novel approach in the development of desensitizing agents is the use of various combinations of nanoparticles.[50–52] The idea behind this approach is that nanoparticles may easily penetrate into dentine tubules and that these nanoparticles could act as mineralising agents that block fluid movement within the dentine tubules when combined with various agents.

Considering that almost all desensitizing agents claim to occlude open dentine tubules, the aim of this study was to investigate quantitatively the effectiveness of various substances on dentine tubule occlusion.

**Table 1 – Summary of substances that occlude dentine tubules.**

| Substance | Literature |
|---|---|
| Strontium (chloride, acetate) | 18,29,61 |
| Stannous fluoride | 30,31 |
| Calcium sodium phosphosilicate | 32,33,35,36 |
| Oxalates | 41,42,48 |
| Fluorides | 41 |
| Arginine and calcium carbonate | 2,15,23,24 |
| Nanoparticles with various functionalizing agents | 50–52,59,60 |

## 2. Material and methods

Seventy-eight caries-free extracted human molars were used for this experimental study. The collection of the teeth was approved by the ethical committee of Witten/Herdecke University (116/2013). Informed verbal consent was obtained from the patients before the use of the teeth. The teeth were stored in 0.9% NaCl containing 0.1% thymol until use.

### 2.1. *Experimental design*

Dentine discs with a thickness of 3 mm were cut from the teeth using a saw microtome (Leica 1600, Leitz, Wetzlar, Germany). Twelve dentine discs were used for each brushing experiment with the different toothpastes. The discs were