ORIGINAL RESEARCH

Assessment of the Effectiveness of Desensitizing Dentifrices on Management of Dental Hypersensitivity: An *In Vitro* Study

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Received on: 12 March 2024; *Accepted on:* 16 April 2024; *Published on:* 05 August 2024

Abstract

Aim: The current study aimed to assess the efficiency of two desensitizing dentifrices on the management of dental hypersensitivity.

Materials and methods: For the purpose of this investigation, 60 extracted human sound premolar teeth that were removed for orthodontic purposes were collected. On the buccal cervical areas, an inverted-cone bur was used to create cavities that were 2 mm deep and 3 mm wide. The blocks were submerged in 17% ethylenediaminetetraacetic acid (EDTA) for 40 minutes in order to ensure the complete dentin tubule opening. Following preparation, all samples were split into three groups, each containing 20 samples, Group A: Control, Group B: Dentifrice containing calcium sodium phosphosilicate, Group C: Dentifrice containing casein phosphopeptide–amorphous calcium phosphate (CPP–ACP). Scanning electron microscopy (SEM) was used to assess the occlusion of dentinal tubules. One-way analysis of variance (ANOVA) was used to assess the desensitization efficacy of dentifrices. At a *p*-value less than 0.05, statistical significance was determined.

Result: Before application of different dentifrices, the maximum dentinal tubules opened in dentifrice containing CPP–ACP group (4.24 ± 0.10) followed by control group (4.18 ± 0.01) and dentifrice containing calcium sodium phosphosilicate (4.12 ± 0.06). And there was no significant difference between the different dentifrice groups ($p > 0.001$). After application of different dentifrices, the highest occlusion of dentinal tubules found in dentifrice containing CPP–ACP group (2.50 ± 0.05) followed by dentifrice containing calcium sodium phosphosilicate (2.84 ± 0.10) and control group (4.02 ± 0.07) and there was a highly significant difference between the different dentifrice groups ($p < 0.001$).

Conclusion: On conclusion, dentifrice containing CPP–ACP exhibited the highest level of dentinal tubule occlusion in comparison to the control group and dentifrice containing calcium sodium phosphosilicate.

Clinical significance: Dentinal hypersensitivity (DH) is a condition that is frequently experienced. With variable outcomes, a number of products are utilized in the management of DH. Need is felt in dentistry for a material that chemically reacts, physically occludes and adheres intimately to dentinal tubules to reduce the possibility of its recurrence.

Keywords: Dentifrice, Dentinal hypersensitivity, Occlusion of dentinal tubules, Scanning electron microscopy.

The Journal of Contemporary Dental Practice (2024): 10.5005/jp-journals-10024-3667

Introduction

One of the most prevalent painful diseases that impairs oral comfort and function is dentin hypersensitivity (DH). It is also one of the dental issues that is least likely to be fixed. Temporary pain or an excessive reaction in dentin subjected to stimuli, usually thermal, evaporative, tactile, osmotic, or chemical, that cannot be attributed to any other type of dental defect or pathology is known as DH. Without a doubt, the main goal of treatment plans should be to remove risk factors like abrasion, abfraction, or erosive elements in order to stop recurrence and to reduce the pain.[1]

The patient usually comes with a complaint of sharp, short, and transient pain which is spontaneous when triggered by a stimulus followed by a deep dull pain. This pain may be restricted to a small number of teeth or it may impact the entire surface of the teeth. The phrase "dentin sensitivity" refers to an unpleasant sensation that has emerged in the dentin that had previously responded normally. However, the phrase "hypersensitive dentin" refers to a situation in which a patient experiences an increased level of unpleasantness relative to their prior history of sensitivity.[2]

There are various concepts that explain the mechanisms of DH, but the hydrodynamic theory—which was developed by Brannstrom—is the most frequently accepted explanation.[3] According to this idea, exposed dentin to the oral cavity and

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How to cite this article: Pulipaka S, Ramanna PK, Samson A, *et al*. Assessment of the Effectiveness of Desensitizing Dentifrices on

patent dentinal tubules are the primary contributors to the pathophysiology of dental hygiene. In reaction to the stimuli, a rapid influx of dentinal fluid activates the pulpal nerve terminals, which in turn irritates the pulp.[4]

Reduction of dentin permeability and reduction of intradental nerves' response to fluid shift are two distinct methods that have been proposed for desensitizing dentin. It has been demonstrated that a variety of chemicals reduce dentin permeability and reduce tooth hypersensitivity. Many people believe that the best course of action for treating DH is to use desensitizing toothpaste.[5]

Casein phosphopeptide-amorphous calcium phosphate (CPP–ACP) is a component in MI paste; ACPs have the ability to remineralize tooth structure, and ACP serves as a salivary reservoir for phosphate and calcium ions. Remineralization solutions have been using CPP as a delivery system to deliver and maintain an ACP supersaturation state close to the tooth surface in recent years.[6] A novel substance called calcium sodium phosphosilicate (NovaMin®) reacts instantaneously to water or bodily fluids (saliva) by releasing billions of mineral ions that are then accessible to the mouth's natural remineralization process.[7]

Since chemical compounds can be used to desensitize tubules and reduce hypersensitivity, it is important to identify the best commercially available material for tubular occlusion-based hypersensitivity reduction. Therefore, the purpose of the current study was to assess the efficiency of two desensitizing dentifrices on the management of dental hypersensitivity.

Materials and Methods

Preparation of Samples

The present *in vitro* study was conducted in Kalinga Institute of Dental Sciences, Bhubaneswar, India, during the year of 2024. For the purpose of this investigation, 60 extracted human sound premolar teeth that were extracted for orthodontic purposes were collected. Teeth without coronal or root surface caries, without cracked/fractured teeth and absence of restoration were included. After teeth were completely cleansed, disinfected for 1 hour in a 5% sodium hypochlorite solution and they were preserved in artificial saliva. On the buccal areas of the cervical regions, an inverted-cone bur (Dia-bur, Zhengzhou, Henan, China) was used to create cavities that were 2 mm deep and 3 mm broad. For better dentinal surface exposure, the obtained samples were polished using abrasive paper (600–1200 grit, SS White, Gloucester, England). The blocks were submerged in 17% ethylenediaminetetraacetic acid (EDTA) for 40 minutes in order to ensure a complete dentin tubule opening. For the purpose of fully opening the dentinal tubules, blocks were left in place for 40 minutes. The samples were ultrasonicated in distilled water for a duration of 12 minutes in order to eliminate any remaining smear layer. In order to examine the dentinal tubular opening and reconstruct the cervical region's hypersensitive dentin, the sample teeth were processed and examined under a scanning electron microscope. After being analyzed under a scanning electron microscope, the samples were cleaned and then kept in artificial saliva.

Allotment of Groups

Following preparation, all samples were divided into three groups, each containing 20 samples.

Group A: Control

There was no application of treatment material.

Management of Dental Hypersensitivity: An *In Vitro* Study. J Contemp Dent Pract 2024;25(5):494–497.

Source of support: Nil

Conflict of interest: None

Table 1: Assessment of the opening of dentinal tubules before application of different dentifrices

Dentifrice used	*N*	*Mean ± SD*	*F value*	*p-value*
Group A: Control	20	4.18 ± 0.01		
Group B: Dentifrice containing calcium sodium phosphosilicate	20	4.12 ± 0.06	23.476	0.984
Group C: Dentifrice containing CPP–ACP	20	4.24 ± 0.10		

Group B: Dentifrice Containing Calcium Sodium Phosphosilicate

For 7 days, the calcium sodium phosphosilicate-containing dentifrice (NovaMin®, SHY NM™) was applied twice a day, at 12-hour intervals, to all 20 samples in the group. After every session, the samples were stored in artificial saliva.

Group C: Dentifrice Containing Casein Phosphopeptide–Amorphous Calcium Phosphate (CPP–ACP)

For 7 days, the samples in this group were treated with dentifrice (MI paste, GC, Melbourne, Australia) containing CPP–ACP twice a day (at 12-hour intervals for 3 minutes each time). After every session, the samples were stored in artificial saliva.

Evaluation of the Effectiveness of Desensitizing Dentifrices Using Scanning Electron Microscopy (SEM)

To fix the samples, each sample from each group was stored for 48 hours in a 10% formalin solution. For 10 minutes each, these materials were dehydrated in aqueous alcohol solutions with increasing concentrations of 70, 80, 90, and 100% alcohol. Samples were dehydrated, allowed to air dry, and then stored in a desiccator jar overnight. On SEM stubs, dried samples were mounted. Subsequently, a sputtering apparatus (JEOL 10 Nsputter JFC 1100) applied a fine coat of gold to the samples. Scanning electron microscope (JEOL 6100) was used to examine the mounted samples, and a ×1500 magnification was used to observe the occlusion of dentinal tubules.

Statistical Analysis

The SPSS software (version 20.0) was used to compute the mean and standard deviation. One-way analysis of variance (ANOVA) was used to compare the desensitization efficacy of dentifrices among the various groups. A *p*-value less than 0.05 was considered statistically significant.

Result

Table 1 shows the opening of dentinal tubules before application of different dentifrices. The maximum dentinal tubules opened in dentifrice containing CPP–ACP group (4.24 ± 0.10) followed by control group (4.18 ± 0.01) and dentifrice containing calcium sodium phosphosilicate (4.12 ± 0.06). And there was no significant difference between the different dentifrice groups ($p > 0.001$).

Table 2: Assessment of the occlusion of dentinal tubules after application of different dentifrices

Dentifrice used	*N*	*Mean ± SD*	*F value*	*p-value*
Group A: Control	20	4.02 ± 0.07		
Group B: Dentifrice containing calcium sodium phosphosilicate	20	2.84 ± 0.10	21.330	0.001
Group C: Dentifrice containing CPP–ACP	20	2.50 ± 0.05		

Table 3: Overall assessment of the occlusion of dentinal tubules after application of different dentifrices

Dentifrice	*Comparison with different groups*	*Difference of mean*	*p-value*
Group A	Group B	1.18	0.001
	Group C	1.52	0.001
Group B	Group A	−1.18	0.001
	Group C	0.34	0.792
Group C	Group A	−1.52	0.001
	Group B	−0.34	0.792

Table 2 shows the occlusion of dentinal tubules after application of different dentifrices. The highest occlusion of dentinal tubules found in dentifrice containing CPP–ACP group (2.50 ± 0.05) followed by dentifrice containing calcium sodium phosphosilicate (2.84 ± 0.10) and control group (4.02 ± 0.07) and there was a highly significant difference between the different dentifrice groups ($p < 0.001$).

Table 3 shows the overall assessment of the occlusion of dentinal tubules after application of different dentifrices. There was a statistically significant difference found between control v/s dentifrice containing calcium sodium phosphosilicate and control v/s dentifrice containing CPP–ACP. And there was no significant difference found between dentifrices containing calcium sodium phosphosilicate v/s dentifrice containing CPP–ACP.

Discussion

A quick, acute pain that is brought on by various stimuli, including tactile, thermal, osmotic, or chemical ones, is the characteristic of dentin hypersensitivity. It is among the most prevalent and unpleasant disorders affecting dental comfort. It is necessary to create inventive products or treatments that enable symptom relief. In order for dentin to be hypersensitive, exposed tubules must be open and patent to the pulp as well as the mouth cavity. Either nerve desensitization or blockage of exposed dental tubules are the ways most DH therapies work.[8]

As a persistent presenting feature of DH, pain has a negative impact on quality of life. The mechanism of DH has been explained by a number of concepts, although the hydrodynamic explanation is the most frequently accepted. According to this concept, fluid movement in the dentinal tubules induces distortion of nerve endings at the pulp-dentin junction, which in turn generates pain perception in the patient. It is commonly known that the medications that effectively cure dental hypersensitivity also have an affinity for dentin, occlude the tubules, and reduce tooth sensitivity.[9]

Because fluid flow velocity depends on the fourth power of radius, the dentinal tubule width is important. An increase in fluid flow of sixteen times occurs when the tubule diameter is doubled. Comparing sensitive teeth to nonsensitive teeth, the former have nearly twice as many tubules (about eight times) and a wider buccal cervical area. Because of the production and removal of smear layers, tubule patency is changed, leading to the episodic condition of DS.[10]

The dentifrice containing CPP–ACP (MI paste) group in the present investigation had the maximum dentinal tubule occlusion, followed by the dentifrice containing calcium sodium phosphosilicate (NovaMin) and the control group. Similar to this, Wang et al. used dentin tubule occlusion to assess the desensitizing toothpaste impact for treating dental hypersensitivity.[11] It turned out that CPP–ACP paste obstructed most of the dentin tubules in SEM examination, supporting its utility.

According to Tang and Millar, and Martinez-Mier, Sodium fluoride and CPP–ACP are combined in MI Paste at a 0.2% concentration.[12,13] The CPP stands for casein phosphopeptide, which is capable of stabilizing the insoluble CPP–ACP complex, or amorphous calcium phosphate. Dentin hypersensitivity and dental cavities are known to be prevented by MI Paste's ability to remineralize teeth through the deposit of calcium-phosphate precipitates containing fluoride. However, so far, the results published in the literature are inconsistent.

There was no significant difference between the dentifrice containing calcium sodium phosphosilicate (NovaMin) and the dentifrice containing CPP–ACP (MI paste) group in the current investigation. NovaMin adheres to an exposed dentin surface and reacts with it to generate a mineralized layer, according to Burwell et al.[14] It is hypothesized that the steady release of calcium over time will preserve the dentin's protective properties and ensure that the dentinal tubules remain continuously occluded.

When Bansal and Mahajan conducted a clinical study to assess the effectiveness of NovaMin desensitizing toothpaste, they discovered that, in comparison to other dentifrices, there was a substantial change in the mean VAS from 6.33 to 2.17 ratings for NovaMin.[15] Better reductions in hypersensitivity were demonstrated using NovaMin.

After comparison to a dentifrice containing 5% potassium nitrate, Satyapal et al. found that a dentifrice with 5% NovaMin offers quicker and greater alleviation from dentin hypersensitivity after 4 weeks.[16] This could be because to NovaMin's ability to obstruct tubules.

When exposed dentin reacted with NovaMin, Burwell et al. results indicated that a mechanically strong, mineralized layer that was resistant to acid challenge was created.[14] A gradual and continuous release of calcium was seen, indicating the maintenance of the protective effects on dentin.

One of the studies limitations was that the depth at which materials penetrated the dentin tubules was not precisely recorded, despite the fact that more penetration would help relieve pain caused by dentin hypersensitivity over an extended period of time. Additionally, the process by which these compounds work to seal the dentin tubules has not been examined. Future clinical trials with longer follow-up periods and larger sample sizes are advised to assess the products' long-term efficacy.

Conclusion

Within the limitation, the present study concluded that the two dentifrices that were used in this investigation consistently showed a significant reduction in dental hypersensitivity. But dentifrice

containing CPP–ACP exhibited the highest level of dentinal tubule occlusion in comparison to the control group and dentifrice containing calcium sodium phosphosilicate.

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