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Desensitizing Toothpastes for Treatment of Dentin Hypersensitivity

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Abstract: Dentin hypersensitivity is a common condition characterized by short, sharp pain in response to external stimuli. Several over-the-counter treatment aids and clinical methods are available to manage the same. Desensitizing tooth pastes appear to be the most common method of management of dentin hypersensitivity. Potassium salts, strontium salts, stannous salts and fluorides have been evaluated as components of desensitizing pastes and commercial formulations are available. The latest in this regard are the bioglass technology (NovaMin) and arginine based toothpastes (ProArgin technology) which have shown good results in clinical trials. This review discusses the desensitizing toothpastes used for treatment of dentin hypersensitivity.
Key words: Dentin hypersensitivity, potassium, strontium, cations, fluoride, novamin, bioglass, ProArgin.

Introduction

The second most common dental condition of concern to patients is dentin hypersensitivity. Removal of cementum or enamel leaves the dentin exposed allowing various stimuli to produce fluid movement through the dentinal tubules. Dentin hypersensitivity is characterized by short, sharp pain arising from exposed dentin in response to external stimuli, typically thermal, evaporative, tactile, osmotic or chemical, and which cannot be ascribed to any other form of dental defect or disease. The fluid movements are believed to activate the sensory nerves of the pulp, leading to pain. This pain is typically a short burst for a short span of time and has been claimed to be due to stimulation of A-beta and A-delta nerve fibers.

Various therapeutic approaches have been investigated to treat this problem.There are a number of products that have been formulated for either in-office or over-the-counter (OTC) applications. These treatment options may be broadly classified into of the two major approaches: the interruption of the neural response to pain stimuli, or the occlusion of exposed and open tubules to block the hydrodynamic mechanism of pain stimulation (1). This review discusses the role of desensitizing toothpastes in managing dentin hypersensitivity.

Interruption of Neural Response to Pain Stimulus

Several clinical studies have concluded that only potassium based toothpastes are able to interrupt the neural response to pain stimulus. Atleast 10% of the toothpastes available in the market today for management of dentin hypersensitivity are based on potassium salts. The concentration of potassium ions used in most of these pastes is 2%, with potassium nitrate, potassium chloride and potassium citrate being the commonly used forms (2,3).These ions have a direct impact on nerve excitability. By increasing the potassium ion concentration adjacent to the dentinal nerve terminals, there is depolarization and activation of nerve fibres. A prolonged period of depolarization results in inactivation of the action potential. Divalent cation solutions stabilize the nerve membrane without changing the membrane potential (3). However, it has also been postulated that this claim cannot be made in humans who brush their teeth with these pastes only twice a day, which will only bring about a slight increase in potassium ion concentration in the saliva, and also for a short period of time. A Cochrane systematic review showed that there is no clear evidence is available for the support of potassium containing toothpastes for dentine hypersensitivity (4).

Some clinical trials have shown that potassium based desensitizing toothpastes are more effective in alleviating dentin hypersensitivity that fluoride based toothpastes (5-7). One of the most important points that was stressed in all these clinical trials is that, potassium based toothpastes must be used for a minimum of 2 weeks, twice daily to bring about a reduction of sensitivity; and for a period of 4-8 weeks to demonstrate significant pain relief. The cited reasons for this are that the potassium ions must diffuse from the oral cavity into the dentinal tubules, and further against dentinal fluid flow to the site of action, which is the nerve endings. The concentration of potassium ions must also build up to significant quantities to achieve depolarization and pain relief, which takes 4-8 weeks. Furthermore, when the use of these pastes is stopped, the potassium ions at the site of action are diffused, and the relief of sensitivity is lost (8). This is an important aspect that dentists must discuss with patients when recommending these pastes.

Occlusion of Exposed and Open Tubules to Block the Hydrodynamic Mechanism of Pain Stimulation

Open dentinal tubules create hypersensitivity because of hydrodynamic mechanism. This is based on Hagen-Poisuelle equation wherein, the fluid flow in dentinal tubules is directly proportional to the fourth power of the diameter of dentinal tubules. Achieving this occlusion will have benefits by decreasing the diameter of the dentinal tubule and hence reducing the dentinal fluid flow, thereby reducing dentin hypersensitivity. This can be done by creating a smear layer by burnishing of the tooth structure. Dentin bonding agents or other polymeric coatings can also be applied to seal these spaces. Fine abrasive particles, based on strontium, stannous and calcium phosphate also forms physical barriers and occludes dentinal tubules. A novel development in this regard are the ProArgin technology and NovaMin bioactive glass mediate the formation of biological minerals on the exposed dentinal surfaces. Tooth brushing can either create of remove a smear layer. This has been shown in in vitro studied wherein brushing with toothpaste could offer therapeutic action by mechanically forming a smear layer. Opposite to this contention is that brushing in the presence of dietary acids could cause smear layer removal (9).

A very effective method of dentin desensitization is the use of strontium based tooth pastes which occlude dentinal tubules by depositing fine particles. The mechanism applies to stannous salts based pastes and silica based abrasives. The most researched compound of this are the strontium chloride based toothpastes. The first commercial formulation, containing 10% of strontium chloride is Sensodyne. Over a period, strontium chloride based pastes have been replaced by potassium nitrate based pastes. Both strontium and stannous salts are believed to work by precipitating insoluble metal compounds on the dentin surface to occlude or partially occlude the open dentin tubules (10,11).

Present strontium based pastes also contain fluoride, and to make the strontium salt compatible with fluoride, strontium acetate in 8% concentration is used rather than strontium chloride. Nevertheless, studies on strontium based salts have not been particularly favorable, as shown by Zappa et al. (12) and Jackson et al. (13). Controversially, literature shows several studies wherein strontium based salts demonstrated superior results in patients with dentin hypersensitivity, compared to a placebo control (14). Pearce et al compared strontium

toothpastes; 8% strontium acetate and fluoride in a silica base and 10% strontium chloride in a diatomaceous earth base to a calcium- based fluoride-only control toothpaste. They showed that all three groups experienced reduced sensitivity, however, there were no significant differences between the two desensitizing toothpastes, or between the desensitizing toothpastes and the control product (15).

There is no conclusive evidence from clinical studies that strontium-containing toothpaste are more effective than regular fluoride based toothpaste in reducing dentin hypersensitivity. Also, strontium-based toothpaste is less effective in reducing dentin hypersensitivity than potassium-based toothpaste. Stannous fluoride formulations have been shown to provide significant reductions in dentin hypersensitivity after 4 or more weeks of twice daily use (16). A toothpaste containing 0.454% stannous fluoride and sodium hexametaphosphate was shown to significantly reduce sensitivity, on both tactile and air blast measures, compared to sodium fluoride toothpaste, after 4 and 8 weeks' use (17).

The Role of Novel Biomaterials in Tubular Occlusion

NovaMin technology (bioactive glass)

Present research focuses not just on simple means of treating dentin hypersensitivity like occluding tubules or blocking nerve conduction, rather, the focus is on treating and targeting the underlying causes and rendering the dentin resistant to mechanical and chemical attack. This may be achieved by two methods - increasing the mineral density of the dentin surface making it possible to improve its resistance to wear by both acid erosion and abrasion. Second, plugging and sealing open tubules with a calcium and phosphate containing dentin-like substance, which would block diffusion through the tubules into the dentin sub-surface, thereby increasing acid resistance (18). This "biomimetic: approach will make the dentin non-sensitive and sclerotic. The method of delivering such a calcium phosphate based material is also of interest. An anhydrous, single-phase fluoride toothpaste, containing calcium sulfate, dipotassium phosphate and baking soda, showed to modify the cosmetic appearance of enamel surfaces by filling surface defects and to occlude dentin tubules in vitro. This paste also reduced dentin hypersensitivity more effectively than a control toothpaste (19).

More recently, calcium phosphor silicates, have been shown to have the potential to release calcium and phosphate on exposure to an aqueous environment. Bioactive glass particles in a specially formulated dentifrice were also shown to occlude dentin tubules, offering substantial relief of sensitivity. The commercially available bioactive glass based toothpaste is NovaMin. NovaMin dentifrice was shown to be significantly more effective than both the strontium chloride and placebo control toothpastes after 6 weeks' use. Furthermore, when dentin surfaces treated with NovaMin were exposed to 6% citric acid for 1 minute, and artificial saliva for 24 hours, there was only partial loss in the occlusion, in contrast to potassion containing silica based pastes which showed complete loss.

ProArgin technology

This system, developed by Kleinberg et al., consists of 8% arginine with bicarbonate and calcium carbonate. The rationale behind this composition is that arginine, an amino acid is positively charged at physiological pH, bicarbonate is a pH buffer, and calcium carbonate is a source of calcium. This composition helps in maintaining the alkaline pH of salive and hence favors tubular occlusion by forming a glycoprotein on the surface. Initial studies on a commercial product called ProClude by Ortek Therapeutics, US have shown promising results. The effect is said to last for atleast 28 days following single treatment (20). Soon therafter Colgate- Palmolive improvised on this formula and introduced a toothpaste that contains 8% arginine, calcium carbonate, 1450 ppm fluoride. This material demonstrated significantly better relief of hypersensitivity than potassium ion based formulations. A major advantage of the ProArgin technology is its ability to offer instant relief. Most commercially available pastes for rapid relief of sensitivity are based on this technology. This may be considered a great breakthrough in the managememt of dentin hypersensitivity because for the first time, a desensitizing toothpaste clinically demonstrated significant relief of sensitivity instantly following topical direct application (21).

The mechanisms of action of the ProArgin technology have been elucidated by Kleinberg et al. Firstly, arginine physically adsorbs onto the surface of calcium carbonate, thereby forming a positively charged agglomerate. This agglomerate binds to the dentinal surface and tubuled. Secondly, the pH of this agglomerate is alkaline to allow mineral deposits of calcium and phosphate on the dentinal surface. The new dentifrice has been clinically proven to provide both significant instant and lasting dentin hypersensitivity relief and a whitening benefit (22). Three 8-week double blind, randomized clinical trials have demonstrated the superior clinical efficacy in reducing dentin hypersensitivity of this dentifrice relative to market-leading potassium based toothpastes when used twice daily during regular tooth brushing (23-25). This has also been confirmed by a systematic review, concluding that arginine-containing toothpastes are associated with the reduction of dentin hypersensitivity compared to both placebo and positive control toothpastes (26).

Conclusion

Dentin hypersensitivity may be considered an enigma. The pain is of a sharp nature and patients approach the dentist for permanent relief. Although the presently available commercial desensitizing toothpaste formulations do not offer permanent relief, the recent technologies based on bioglass and arginine appear promising. Further research should be performed to improve the composition of these dentifrices and clinical trials should concusively establish their role in the treatment of hypersensitivity.

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