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Review Article

Review of Selected Over-the-Counter Toothpastes in the Management of Dentine Hypersensitivity

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Abstract

Desensitising products designed for use in the treatment of Dentine Hypersensitivity (DH) are available either through in-office procedures (professional products) or direct to the consumer (over the counter products [OTC]). This paper is an overview on selected OTC products available to the consumer and compares the reported effectiveness of the different active ingredients present in these products. Information was collected from several sources including direct observation of the toothpastes available in a UK supermarket and from online retailers (such as Amazon etc.,) as well as reviewing the published evidence from randomised control trials, systematic reviews, and meta-analyses as well as clinical studies. A comparison of the claims of effectiveness in reducing Dentine Hypersensitivity by toothpaste manufacturers on the toothpaste cartons (e.g., packaging and labelling) was compared with the results from these peer reviewed publications. Evidence from these publications would suggest that products containing potassium, stannous fluoride, calcium sodium phosphor-silicate, arginine, nano-hydroxyapatite, and fluoro-calcium-phospho-silicate ingredients have sufficient evidence to support their effectiveness in managing DH. There is, however, contradicting information on the effectiveness of potassium containing products in the published literature.

Introduction

Dentine Hypersensitivity (DH) is a somewhat puzzling clinical condition which may impact on the Quality of Life (QoL) of those who suffer from the problem [1,2]. The pain associated with DH has been described as 'rapid in onset, sharp in character and transient in nature', and will resolve once the offending stimulus has been removed [23]. The prevalence of DH varies depending on how data is collected, for example, questionnaire values range from 4% to 74% whereas clinical studies would suggest lower values in the region of 11.5% [3]. These higher values may suggest that self-reporting of DH may be exaggerated compared to clinical results as well as variations in the different populations that were assessed. From an epidemiological perspective, there was a slightly higher prevalence in females than in males which was not statistically significant. Evidence from clinical evaluation would suggest, in the main, a lower prevalence value compared to the self- reported values by participants which may be due in part to the participants being unable to distinguish the various conditions associated with dental pain (e.g., toothache etc.).The underlying mechanism of DH is hydrodynamic in nature and based on the Hydrodynamic Theory where minute fluid shifts in the dentinal tubules initiates a pain response [4]. Currently most treatment approaches are based on this theory and as such most desensitising products (In-office professionally applied and/or over the counter (OTC)) are based on their tubular occluding properties [5]. The choice of recommending a product will depend on a clinician's clinical judgement on the extent and severity of the clinical problem .The treatment of DH, however, is based on a correct diagnosis of the problem and by excluding all other possible causes of the individual's discomfort (essentially DH is a diagnosis of exclusion), the choice of product or technique based on the extent and severity of the condition, patient compliance, and successful monitoring/ management of the problem over time. The aim of this short overview is therefore to evaluate the claims of effectiveness of selected over the counter desensitising products (packaging claims) and compare these claims with evidence from the available published literature.

Methodology

A study was conducted by one of the authors (HS) to identify a range of home or consumer (over the counter) desensitising toothpaste products for the treatment of DH in a local supermarket store in the UKas well as online retail websites (e.g., Amazon). Information relating to the ingredients of the various selected toothpastes together with the claims made on the cartons (packaging/labelling) which subsequently included data from the internet (manufacturers' websites). A comparison was made on the various claims made by the manufacturers on their products with the available evidence from peer reviewed journals. This information was subsequently collated into tables as shown below (Tables 1 and 2). From the various desensitising products identified in the initial survey it was decided to concentrate on four selected products based a specific active ingredient namely: 1) Fluoro-Calcium-Phospho-Silicate (FCPS)(BioMin-F), 2) Stannous fluoride (Sensodyne Rapid Relief), 3) Arginine (Colgate Sensitive Instant Relief) and 4) Nano-hydroxyapatite (Curaprox Be you). A Potassium containing product with without other active ingredients (e.g., stannous fluoride or hydroxyapatite) together with a Calcium Sodium Phospho-silicate (CSP) product (e.g. Novamin based) was included when. discussing the results (Table 2).

Table 1: Selected over the counter desensitising toothpaste products available in the UK consumer market with their listed ingredients and their packaging claims.

Product and Claims	Ingredients
BioMin-F - **Claim:** Regular use with brushing at least twice daily will relieve sensitivity - Form fluorapatite in/around exposed dentine tubules (reduces sensitivity and strengthens/protects tooth structure)	Glycerin, Silica, PEG 400, Fluoro-Calcium-Phospho-Silicate, Sodium Lauryl Sulphate, Titanium Dioxide, Aroma, Carbomer, Potassium Acesulfame *Fluoride Content:* <600 ppm when packed
Colgate Sensitive Instant Relief - Pro-Argin technology that provides instant and long-lasting relief from the pain of sensitive teeth (up to 8 weeks) - Effectively occludes open dentinal tubules and builds a strong calcium-rich layer that ensures long-lasting relief from the pain of sensitivity	Calcium Carbonate, Aqua, Sorbitol, Aroma, Poloxamer 407, Sodium Monofluorophosphate, Cocamidopropyl Betaine, Zinc Oxide, Benzyl Alcohol, Cellulose Gum, Zinc Citrate, Sodium Bicarbonate, Tetrasodium Pyrophosphate, Xanthan Gum, Sodium Saccharin, Sucralose, Limonene, CI 77891. *Active Ingredient:* Arginine (8%) *Fluoride Content:* 1450 ppm
Corsodyl Gum + Breath and Sensitivity - Scientifically proven to target gum problems and bad breath, while creating a protective layer to help protect sensitive teeth	Glycerin, PEG-8, Hydrated Silica, Pentasodium Triphosphate, Aroma, Sodium Lauryl Sulfate, Titanium Dioxide, Carbomer, Stannous Fluoride (0.4540% w/w), Cocamidopropyl Betaine, Sodium Saccharin, Zinc Chloride, Carrageenan, Sodium Fluoride (0.0721% w/w), Limonene *Fluoride Content:* 1450 ppm
Curaprox Be you - Has hydroxylapatite (healing and protection) – strengthens enamel and creates a smooth surface. It: - Remineralises and recalcifies damaged tooth enamel - Heals tiny defects on tooth surfaces. - Reduces the sensitivity of exposed root surfaces. - Close openings that expose dentine – stops some painful stimuli from reaching the nerve. No SLS, no triclosan, no micro plastic (ingredients which are often debated)	Aqua, Glycerin, Hydrated Silica, Sorbitol, Xylitol, Panthenol, Aroma, Sodium Monofluorophosphate, Xanthan Gum, CocamidopropylBetaine, Microcrystalline Cellulose, Decyl Glucoside, Hydroxyapatite (nano), Glucose Oxidase, Mannitol, Maltodextrin, Mica, Sucralose, D-Limonene, Citric Acid, Sodium Hydroxide, Zea Mays Starch, Glucose, Echinacea Purpurea Root Extract, Titanium Dioxide, Sodium Chloride, Sodium Metabisulfite, Calcium Carbonate, L-Menthol, Centella Asiatica Extract, Citrus Aurantium Amara Fruit Extract, Potassium Thiocyanate, Polylysine, Cetyl Alcohol, Silica, Potassium Chloride, Tin Oxide, Harpagophytum Procumbens Root Extract, CI 77492 *Fluoride Content*: 950 ppm
Elmex Sensitive Professional - A toothpaste specially developed with Pro-Argin technology clinically proven to relieve the pains linked to sensitivity. - **Indication:** To relieve the pain instantaneously and durably	Calcium Carbonate, Aqua, Sorbitol, Bicarbonate, Sodium Lauryl Sulfate, Sodium Monofluorophosphate, Cellulose Gum, Sodium Bicarbonate, Tetrasodium Pyrophosphate, Sodium Saccharin, Benzyl Alcohol, Xanthan Gum, Limonene, CI 77891. *Active ingredient:* Arginine 8%. *Fluoride Content:* 1450 ppm
Oral B Sensitivity and Gum Calm Clinically proven to immediately relieve sensitivity pain and soothes gums for a feeling of in-mouth comfort.	Aqua, Sorbitol, Hydrated Silica, Sodium Lauryl Sulfate, Sodium Gluconate, Carrageenan, Aroma, Xanthan Gum, Cocamidopropyl Betaine, Zinc Citrate, Stannous Fluoride (0.61%), Sodium Hydroxide, Stannous Chloride, Sodium Saccharin, CI 77891, Sodium Fluoride, Cinnamal, Benzyl Alcohol, Sucralose, Eugenol, Sodium Benzoate, Citric Acid, Sodium Citrate, Potassium Sorbate *Fluoride Content:* 1450 ppm
Regenerate Hypersensitivity Toothpaste - Specially formulated medical device - Clinically proven to treat DH pain. - Acts on early invisible stages of enamel damage by restoring mineral content and micro hardness with regular use. - Contains NR-5+ technology. - Forms enamel minerals that wrap/ integrate onto teeth, activating enamel regeneration w/ hydroxyapatite formation	Glycerin, Calcium Silicate, PEG-8, Hydrated Silica, Trisodium Phosphate, Sodium Phosphate, Aqua, Sodium Lauryl Sulfate, PEG-60, Sodium Monofluorophosphate, Aroma, Sodium Saccharin, Polyacrylic Acid, Synthetic Fluorphlogopite, Tin Oxide, Limonene, CI 77891. *Fluoride Content:* 1450 ppm
Sensodyne Rapid Relief - Clinically proven DH relief in 60 seconds and provides long-lasting protection. - Creates a barrier over the sensitive areas + provides fast relief - also builds ongoing protection with every brush. - Also whitens enamel + prevents staining	Glycerin, PEG-8, Hydrated Silica, Pentasodium Triphosphate, Aroma, Sodium Lauryl Sulfate, Titanium Dioxide, Carbomer, Stannous Fluoride (0.454% w/w), Cocamidopropyl Betaine, Sodium Saccharin, Sodium Fluoride (0.0721% w/w), Limonene. *Fluoride Content*: 1450 ppm
Superdrug Procare Sensitive Toothpaste - Carefully cleans sensitive teeth. - Formulated to help people with sensitivity by providing maximum fluoride protection for sensitive teeth. - It also remineralises and strengthens tooth enamel	Aqua, Sorbitol, Hydrated Silica, Potassium Nitrate, Sodium Lauryl Sulphate, Aroma, Cellulose Gum, Cocamidopropyl Betaine, Sodium Fluoride (0.32% w/w), Sodium Saccharin, Sodium Hydroxide, Limonene, CI 77891, CI 73360-*Fluoride Content*: 1450 ppm

Products on the Market

The following selected products were identified in an initial survey (Table 1):

The following table (Table 2) highlights the purpose/aim and mechanism of action for each toothpaste and their main ingredient(s) together with the supporting evidence from the published literature.

Discussion

According to Vranić et al. [6] the main components of a toothpaste are abrasives, humectants, surfactants, binders, and flavouring agent together with any active ingredients. The formulation of toothpaste products is a complex procedure, and it is essential to ensure that any of the other ingredients within the formulation do not impact with the delivery of the active ingredient. According to Rathore and Gillam

Table 2: The purpose/aim and mechanism of action for each toothpaste and their main ingredient(s).

Active ingredient	Purpose/Effect	Mechanism of Action	Evidence of Effectiveness (selected references)
Potassium (may also be included with other active ingredients)	Helps remove surface stains and prevent sensitivity	Released potassium ions diffuse along the dentinal tubules to inactivate interdental nerves to inactivate the intradental nerves (in the dentine/pulp complex) by blocking the synapses between nerve cells, resulting in reducing nerve activity and sensitivity. (Nerve deactivation) (Mechanism is unconfirmed). Evidence of a desensitizing action was based on historical animal studies. No evidence of tubular occlusion when potassium ions were tested in vitro. There was, however, a transient depolarising effect when potassium ions were applied on exposed dentine (Ajcharanukul et al. 2007)	Orchardson & Gillam 2000, Poulsen et al. 2006, Pradeep & Sharma 2010, Karim and Gillam 2013
Stannous Fluoride	Can prevent cavities, protect against plaque regrowth, maintain healthy gums, and protect against sensitivity and bad breath.	Stannous fluoride produces calcium fluoride when it converts the calcium mineral apatite into fluorapatite. This calcium fluoride makes up a stable acid-resistant layer that is deposited on the tooth surfaces. This micro-thin shield protects against dietary acids + inhibits plaque production (Tubular occludent). Also promotes enamel mineralization	Parkinson et al, 2015, Hines et al. 2019 Arshad et al. 2023
Calcium Sodium Phosphosilicate	A bioactive material effective in occluding dentinal tubules which helps prevent sensitivity by reducing fluid flow within the dentinal tubules	It releases sodium, calcium, and phosphate ions, which interact with saliva resulting in hydroxycarbonate deposition over the exposed dentine as well as in the dentinal tubules (Tubular occludent)	Pradeep & Sharma 2010, Jones et al. 2015, Zhu et al. 2015, Hall et al. 2017, Arantes et al. 2019,
Arginine	Relieves tooth sensitivity pain by occluding dentinal tubules which helps prevent sensitivity by reducing fluid flow within the dentinal tubules	Arginine works with calcium (from calcium carbonate) and interacts (at a physiological pH) to form a positively charged complex that binds to the negatively charged dentine surface. Consequently, a calcium-rich layer forms on the cervical region of the tooth - this occludes, and seals open dentine tubules. Over time, a seal-like protective barrier is formed that prevents further sensitivity, following acid exposure (Tubular occludent).	Ayad et al. 2009, Hall et al. 2017, Arantes et al. 2019, Arshad et al. 2021
Fluoro-Calcium Phospho-Silicate (FCPS)	A bioactive glass which bonds to the teeth and enters the dentinal tubules which helps prevent sensitivity by reducing fluid flow within the dentinal tubules	Bioglass particles containing FCPS gradually dissolve in the dentinal tubules - this slowly releases calcium, fluoride + phosphate ions - which combine with saliva to form fluorapatite. This strengthens the teeth, aids effective remineralisation of the enamel, and prevents fluid flow through the dentinal tubules (which triggers sensitivity) (Tubular occludent)	Patel et al. 2019, Ali et al. 2020, Arshad et al. 2021
Nano-hydroxyapatite	Prevents demineralization, helps to strength tooth enamel, and can reduce tooth sensitivity by reducing fluid flow within the dentinal tubules	Nano-HA particles (between 20 - 80 nm) can penetrate the tooth enamel and replenish the minerals that have been lost through demineralisation. These particles can also occlude the exposed dentinal tubules and can help reduce sensitivity by reducing fluid flow within the dentinal tubules (Tubular occludent)	Shetty et al. 2010, Vano et al. 2014, Amaechi et al. 2021

[7] most manufacturers, make claims under the Cosmetic regulations rather than making a direct clinical claim such as 'prevents gingivitis' etc., which would require clinical evidence from well-conducted randomised clinical trials (RCT) to claim clinical efficacy [8]. For this selected overview on over the counter (OTC) desensitising products, examples of the various active ingredients (initially identified from the consumer brands in a UK supermarket and online retail websites), together with their respective claims of effectiveness were assessed from the available published literature (which included evidence from systematic, reviews, meta-analysis, reviews [including Cochrane Reviews] and clinical studies).

One of the problems in evaluating the evidence for these studies was 1) the lack of homogeneity between the studies particularly with view to the length of duration and assessment methodology of the selected studies for example reviews based a Cochrane type of review would only include studies of a minimum of six weeks duration as well as including similar ingredients in both control and test groups [9-11], 2) the likelihood that some of the active ingredients within the formulation may have changed over the decades and 3) the problems of the highly subjective nature when reporting Dentine Hypersensitivity.

Based on the evidence from the published literature it can be concluded that the active ingredients outlined in Tables 1 and 2 have been shown to be effective in reducing DH [12-16]. However, there is clearly a need to have well controlled clinical studies on a duration that is relevant to the claims being made. For example, if a short acting or immediate (rapid) effect is claimed than the time intervals in the study should reflect this (e.g., retesting within 5-10 minutes following application). Alternatively, if a long-lasting effect is claimed than the time intervals should reflect this (e.g., 3-6 months), furthermore if claims of protection against 'acid erosion' are made than evidence from in vitro or in situ studies should support this. It should be acknowledged, however that some toothpaste formulations may take longer to be effective in reducing DH. From a clinical perspective it may be reasonable for the clinician and patient to accept that the discomfort from DH may not be eliminated but there is some relief that enables them to enjoy a better Quality of Life (QoL). According to Rathore & Gillam [7] one of the advantages of publishing these claims on the packaging is that this may enable the consumer to identify an OTC product that is relevant to their specific needs such as a recommended toothpaste for 'sensitivity' with a degree of confidence that the product may actually help them in resolving their problem [17-32].

Conclusion

There appears that the conclusions from the published literature acknowledge the effectiveness of selected OTC desensitising toothpaste products e.g., potassium, stannous fluoride, calcium sodium phosphosilicate (CSP) and arginine have sufficient supporting evidence to justify their claims. Evidence to support the use of nano-hydroxyapatite (nano-HA) and Fluoro-Calcium-Phospho-Silicate (FCPS) is growing and some studies have shown that they have a similar or improved effect on reducing DH than the other ingredients. There is, however, contradictory evidence regarding the effectiveness of the potassium ion in potassium-based toothpastes.

Disclaimer

One of the Authors (DG) has several patents on oral care products and currently is a Director with Biomin Technology Limited, UK. There was, however, no commercial involvement in preparing and writing up the research undertaken in this study.

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