NovaMin®: A promising antihypersensitivity agent

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ABSTRACT

NovaMin is the trade name of a particulate bioactive glass containing the active ingredient calcium sodium phosphosilicate (CSPS) (chemical formula: CaNaO₆PSi). CSPS materials were originally developed as bone regenerative materials. Considering the antibacterial and mineralizing effects of bioactive glasses, they have been used in dental products also. NovaMin has been used in various dental products for treating tooth sensitivity. Recent studies have proved that it also contains the potential to prevent demineralization or aid in remineralization of tooth surfaces, reduction in gingival bleeding and gingivitis, whitening of teeth and erosion. The present manuscript discusses the mechanism of action of NovaMin, reviews its potential uses, and also critically analyses it by enumerating its merits and demerits.

Keywords: Bioactive glass, calcium sodium phosphosilicate, dentinal hypersensitivity, NovaMin, remineralization

Introduction

Hydroxyapatite was believed to be the best biocompatible replacement material until Larry Hench brought a revolution by developing a material using silica (glass) as the host material, incorporated with calcium and phosphorous.[1] This material mimicked bone and stimulated the regrowth of new bone material. Thus, due to its biocompatibility and osteogenic capacity, it came to be known as “bioactive glass-bioglass.” It is now included, along with synthetic hydroxyapatite, in the field of biomaterials science known as “bioactive ceramics.” Bioglass is also reported to have antibacterial properties, most likely due to the change in pH induced by the dissolution of the ions from the surface of the glass and lack of bacterial adherence to the glass surface.[2]

In osseous defects bonding of glass to bone begins with the exposure of the glass to the aqueous solution. Na⁺ in the glass exchanges with H⁺ from the body fluids causing the pH to become more alkaline. Ca and P migrate from the glass forming a calcium phosphate (Ca-P) rich surface which will form an apatite layer. Underlying this Ca-P rich layer on the glass is an area which becomes increasingly silica rich due to the loss of Na, Ca, and P ions.[2]

NovaMin® (calcium sodium phosphosilicate [CSPS]) CSPS materials were originally developed as bone regenerative materials. In the early 1970’s, CSPS materials were a part of the broader class of bioactive ceramics which included Ca-P materials and calcium hydroxyapatite materials that had been developed for hard tissue repair and replacement by mainly due to their chemical similarity to bone mineral.[2]

Considering the antibacterial and mineralizing effects of bioactive glasses, they have found a wide range of applications in dentistry also. These glasses can be used as particulates or monolithic shapes and porous or dense constructs in different applications such as remineralization or hypersensitivity treatment.[3]

Composition

NovaMin® is technically described as an inorganic amorphous CSPS material that was designed based on a class of materials known as bioactive glasses. It comprises 45% SiO₂, 24.5% Na₂O, 24.5% CaO, and 6% P₂O₅.[4] The particular composition of NovaMin® is identical to that of the best known bioactive glass material, Bioglass® and contains only calcium, sodium, phosphate, and silica, all as an amorphous matrix. Its chemical formula is CaNa₆O₆PSi. NovaMin® delivers silica, ionic calcium, phosphorus, and sodium, which are necessary for bone and tooth mineralization. It was developed and patented by NovaMin Technology, Inc.[5]
Pathophysiology

Tooth hypersensitivity is a very common problem encountered in our daily practice. It is a sharp pain arising from exposed dentin, as a result of various stimuli such as heat, cold, or osmotic pressure and that cannot be ascribed to any other pathology.[6] Unfortunately, a very few epidemiological studies have highlighted its prevalence. Although the etiology of dentin hypersensitivity is multifactorial, it is seen that open dentinal tubules are a major cause in sensitivity. The currently accepted theory for tooth hypersensitivity is the hydrodynamic theory proposed by Brannstrom.[7] Open dentinal tubules allow fluid flow through the tubules that produce pressure changes which excite the nerve endings in the dental pulp. There are studies showing that in patients with dentin hypersensitivity, there is a greater number of tubules per area and the diameter of the tubules is greater than in patients with no sensitivity.[8] Usually, the dentinal tubules of the root are covered by a layer of cementum or by a smear layer of 2-5 μ thickness. When the smear layer is present, the fluid flow that occurs in dentin is only a few percent of that possible in its absence. Smear layer may be removed physically or by acids leading to the opening of dentinal tubules and thereby sensitivity.

In periodontitis, bacteria and their products also play a role leading to a higher percent of these patients reporting sensitivity.

Mechanism of Action

There have been 2 basic approaches to the treatment and prevention of dentinal hypersensitivity. The first approach is to treat the tooth with a chemical agent that penetrates into the dentinal tubule and depolarizes the nerve synapse, which reduces sensitivity by preventing the conduction of pain impulses, e.g., potassium nitrate. The second approach is to treat the tooth with a chemical or physical agent that creates a deposition which mechanically occludes dentinal tubules, thereby preventing pulpal fluid flow, e.g., strontium chloride and potassium oxalate. Although both approaches can significantly reduce or eliminate hypersensitivity, the duration of relief is highly variable. Hypersensitivity usually reappears due to toothbrush abrasion, presence of acid challenges in mouth, etc.[9]

The future of dentin hypersensitivity management lies in a material that will chemically react with the surface of dentin, intimately adhering to the tooth structure and significantly reducing the possibility of reopening the dentinal tubules either due to acidic food or overzealous brushing. That is what a material-like NovaMin can foster.[10]

It is indicated that when NovaMin comes in contact with saliva or any aqueous media, its active ingredient, inorganic chemical CSPS, binds to the tooth surface to initiate the remineralization process on the tooth enamel.[10]

This is performed by providing silica, calcium, phosphorous, and sodium ions to the tooth structure. A localized transient increase in pH occurs during the initial exposure of the mineral due to the release of sodium. This rise in pH helps the calcium and phosphate to form the NovaMin particles, followed by calcium and phosphorous found in saliva to form a Ca-P layer. As the particles’ reaction continues and deposition of Ca-P phase complex takes place, this layer crystallizes into a calcium hydroxyl apatite and also known as hydroxyl carbonate apatite.[11,12]

Thus, the combination of the residual CSPS particles and the hydroxycarbonate apatite layer results in the physical occlusion of dentinal tubules, which relieves hypersensitivity. The sodium ion is released for several days providing a long-term remineralization potential.

Discussion

CSPS products have received approval from the Food and Drug Administration. These materials are reactive when exposed to body fluids, and deposit hydroxy carbonate apatite, a mineral that is chemically similar to the mineral in enamel and dentin.[13] When incorporated into a dentifrice, particles are deposited onto the dentin surface to mechanically occlude dentinal tubules. NovaMin acts by remineralizing and increasing the hardness of the tissues. Hence, by virtue of its mechanism of action is not only an ideal ingredient for desensitizing dentifrices, rather it has also been documented to have many other advantages, thus promising its use as an indispensable ingredient in numerous dental products.

Kakodkar et al. did an in vitro study to evaluate the effect of NovaMin® desensitizing toothpaste mixed with 15% carbamide peroxide on tooth bleaching and tubule occlusion. It was found that the addition of NovaMin® to 15% carbamide peroxide occluded the dentinal tubules and that it did not affect the bleaching procedure. Its clinical relevance was thus proved in a dual advantage of desensitizing and bleaching with a single paste system.[14]

Recent studies have also demonstrated a potential for NovaMin® to prevent demineralization and/or aid in remineralization of white-spot lesions. NUPRO® NUSolution™ with NovaMin® is the newest Dentsply professional prophylactic paste. It is currently the only product powered by NovaMin, delivering the triple benefit of tooth desensitization, tubule occlusion, and stain removal.[15]

Golpayegani et al. compared the remineralization effect of topical NovaMin versus sodium fluoride (1.1%) on caries-like lesions in permanent teeth using scanning electron microscopy. NovaMin dentifrice appeared to have a greater effect on remineralization of caries-like lesions when compared to that of fluoride-containing dentifrice in permanent teeth.[16]

A similar study was carried out by Mony et al., who did a comparative evaluation of the remineralizing efficacy of CSPS agent (NovaMin) and fluoride-based dentifrice on quantitative and qualitative analysis. The samples were tested on the 15th and 30th day. It was found that Ca-P ratio and hardness in both the groups improved during the study period. However, the fluoride group showed higher values for Ca/PO4 and hardness but was not statistically significant. Scanning electron microscope pictures showed that the deposition of the
material over the decalcified enamel was more smooth and uniform
with NovaMin than with fluoride.\(^{[17]}\)

Milleman \textit{et al.} compared the effectiveness of NUPRO sensodyne
prophylaxis paste containing NovaMin with and without fluoride, to
a standard prophylaxis paste without fluoride (control). It was found
that the subjects having received the NovaMin containing prophylaxis
pastes showed statistically lower dentin hypersensitivity compared
to the control group immediately after the prophylaxis procedure.
NovaMin paste was found to be more than effective than the standard
prophylaxis paste.\(^{[13]}\)

Although NovaMin has been proved to be a better remineralizing agent
than many of the established formulations, the main drawbacks of
NovaMin are that it does not provide instant relief as apatite formation
and blocking of the dentine tubules by NovaMin may take several
weeks. Patients look for immediate relief from dentin hypersensitivity
and pain. Hence, tooth paste that acts more quickly to block the
dentine tubules is likely to be preferred. Moreover, the 45S5 glass
has a hardness of about 4.7 GPa while has a hardness of 3.5 GPa. It
would be desirable to have a glass that is similar to the hardness values
of natural enamel because a dentifrice containing an abrasive of more
hardness than enamel may result in abrasion or loss of enamel.\(^{[18,19]}\)

\textbf{Conclusion}

The uses of NovaMin for oral health-care applications have proven to
be beyond the treatment of tooth sensitivity. The potential of these
materials for remineralization of both enamel and dentin have been
studied \textit{in vitro} and \textit{in situ} and have been found to be really promising.
Novamin has also been found to have excellent desensitizing,
antibacterial and anti-inflammatory properties and hence proves to
be an attractive and dependable product for use in various dental
therapies. However, further longitudinal studies are necessary for a
systematic and meta-analysis review of NovaMin in all of its suggested
clinical indications.

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