

Received: 2015.03.23
Accepted: 2015.04.30
Published: 2015.10.01

Assessment of Pain Intensity in Patients with Dentin Hypersensitivity After Application of Prophylaxis Paste Based on Calcium Sodium Phosphosilicate Formula

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Source of support: Departmental sources

Background: One of many functions of the pulp-dentin complex is sensory function. Acute, situated, receding pain after the cessation of the stimulus action is called dentin pain. Dentin hypersensitivity has been described as one of the most painful and least successfully treated chronic ailments of teeth. The aim of this research was the clinical evaluation of the effectiveness of professional polishing paste containing calcium sodium phosphosilicate formula (NovaMin) in eliminating dentin hypersensitivity after a single application.





Material/Methods: The study comprised 92 teeth with dentin hypersensitivity diagnosed on the basis of history and clinical examination. The pain reaction of exposed dentine was induced by tactile and dehydrating stimuli, asking patients to assess the severity of pain on the VAS scale. Clinical trial and survey were carried out twice: before and 1 week after the application of the polishing paste.

Results: After the application of the examined paste, the percentage of teeth reacting with a severe pain to the touch of the probe decreased from 16.3% to 4.3%, and with a moderate pain from 42.4% to 12%. Examination after applying dehydrating stimulus a week after carrying out the application showed a decrease in the proportion of teeth with strong pain from 28.3% to 0% and moderate pain from 38% to 15.2%. The lack of pain increased from 12% to about 50%.

Conclusions: The use of prophylactic professional paste with NovaMin formula in in-office procedure provides the reduction of dentin hypersensitivity noticeable by 1 week after application.

MeSH Keywords: **Calcium Sodium Phosphosilicate • Dentin Sensitivity • Visual Analog Scale**

Full-text PDF: <http://www.medscimonit.com/abstract/index/idArt/894189>

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Background

Sensory function is one of many functions of the pulp-dentin complex. Regardless of the type of stimulus, the only reaction of the pulp is pain [1]. Dentistry recognizes concepts of “pulp pain” and “dentin pain” [1]. A dull and difficult to locate pain lasting longer than the acting stimulus is pulp pain, caused by C-fibers activation and frequently confirming pulpitis. Acute, situated, receding pain after the cessation of the stimulus is dentin pain, caused by activation of nerve fibers A- δ [1] and is found in many different ailments, including dentin hypersensitivity [2–4].

In 1979, Merskey distinguished and characterized pain in several categories for the International Association for the Study of Pain (IASP) [5]. According to the current definition, pain is an unpleasant sensory or emotional experience, associated with actual or potential tissue damage or described in terms of such damage [5].

Because organs and tissues located in the oral cavity are well supplied with blood and nerve endings, all pathological processes in the region cause high-intensity pain [6]. The perception of pain originating in the mouth is perceived as disproportionately severe in relation to the actual cause of the pain, as compared to the rest of the body [1]. Pain, despite being a negative sensation, provides the physician with much information. Knowledge of the essence of pain, as well as its types or radiation, is often the basis for setting the correct diagnosis and treatment [5].

In physiological conditions, when the pulp-dentin complex is protected by enamel and root cementum, such stimuli as cold, hot, sweet and acid foods, and tooth brushing or touching, do not induce pain in the pulp [7]. When it comes to exposing the dentine and opening of outlets of dentinal tubules with maintaining their patency toward the pulp, harmless external stimuli (thermal, dehydrative, tactile, chemical or osmotic) cause excessive pain response in the pulp [8,9]. The described clinical condition, which cannot be attributed to another disease or tooth defect, has been defined as dentin hypersensitivity [3,9–11]. It has been described as one of the most painful and least successfully treated chronic ailments of the teeth [12].

Factors contributing to exposure of dentin are attrition, abrasion, erosion and abfraction, loss of cement in the cervical region following periodontal disease, or loss of organic matter of hard tissues of the tooth after teeth whitening [3,4,8–11,13]. According to the hydrodynamic theory explaining the formation of dentin hypersensitivity in pulp pain, the stimuli acting on the exposed dentine surface cause movement of the fluid in the dentinal tubules, stimulating pulp nerve receptors. The stimulation is transmitted to the central nervous system

and is experienced as pain [8,10,13]. The intensity of the pain varies from strong with high intensity to mild with moderate intensity, which may be because not all patients with hypersensitive dentin seek help from a dentist. The incidence of the disease in the adult population ranges from 8% to more than 50% [1,4,10,14].

Despite the presence on the market of many therapeutic agents to be used by patients at home and professional ones to be used in the dental office, there is no completely effective treatment that quickly and permanently eliminates dentin hypersensitivity [3,12,15–18].

A remedy for this still-current problem is a new product based on inorganic amorphous calcium and sodium phosphosilicates belonging to the group of materials known as bioactive glass, with the brand name NovaMin. The NovaMin concentration in NUPRO[®] Sensodyne[®] Prophylaxis Paste is 15% compared to 5% in a tooth paste.

The aim of the study was the clinical evaluation of the effectiveness of the professional polishing paste NUPRO[®] Sensodyne[®] Prophylaxis Paste in eliminating dentin hypersensitivity after a single application on the exposed, hypersensitive dentin.

Material and Methods

The research comprised 92 teeth with dentin hypersensitivity diagnosed based on history and clinical examination in 23 patients (14 women and 9 men) aged 21–66 years. Before starting treatment, patients responded to questions contained in a specially prepared questionnaire, including questions about the duration and severity of pain. The survey included the type of pain-inducing stimuli (cold, warm, touching, brushing, sweet, sour) and the intensity according to patient subjective assessment. In this aspect, history-taking was performed twice: in survey 0 (preliminary) and in survey 1 (1 week after the application of NUPRO[®] Sensodyne[®] Prophylaxis Paste, Dentsply). In addition, the survey included questions about hygienic habits of patients: frequency of tooth brushing, the hardness of toothbrush, and the use of assistive oral hygiene and dietary habits.

In the clinical trial, the number of lesions with exposed dentin on each tooth and their location, together with an indication of the likely causes and diagnosis, were assessed. Dentin hypersensitivity mostly occurred in abrasion (49 teeth), post-treatment hypersensitivity mostly occurred after scaling and orthodontic treatment (34 teeth), erosion occurred in 8 teeth, and in 1 tooth attrition was diagnosed. Hypersensitivity distribution by sex and diagnosis are presented in Table 1.

Table 1. Distribution of hypersensitivity by sex and diagnosis.

Cavities of non-carious origin and hypersensitivity of another origin	Women		Men		Total number of patients	Total number of teeth	
	Number of people	Number of teeth	Number of people	Number of teeth		(n)	%
Abrasion	10	32	5	17	15	49	53.3
Erosion	1	2	1	6	2	8	8.7
Attrition	–	–	1	1	1	1	1.0
Post-treatment hypersensitivity	3	21	2	13	5	34	37.0
Total	14	55	9	37	23	92	100.0

Table 2. Assessment of pain intensity in VAS scale before applying a NovaMin paste (test 0). Tactile stimulus.

Study groups	Sensation of pain intensity in VAS scale					Total
	0	1–3	4–6	7–9	10	
Abrasion	6	14	18	10	1	49
Erosion	4	2	0	2	0	8
Attrition	0	0	1	0	0	1
Post-treatment hypersensitivity	0	11	20	3	0	34
Total	(n) 10	27	39	15	1	92
	% 10.9	29.3	42.4	16.3	1.1	100.0

Table 3. Assessment of pain intensity in VAS scale after applying a NovaMin paste (test 0). Dehydrating stimulus.

Study groups	Sensation of pain intensity in VAS scale					Total
	0	1–3	4–6	7–9	10	
Abrasion	11	10	21	7	0	49
Erosion	0	5	1	2	0	8
Attrition	0	0	1	0	0	1
Post-treatment hypersensitivity	0	5	12	17	0	34
Total	(n) 11	20	35	26	0	92
	% 12.0	21.7	38.0	28.3	0.0	100.0

The pain reaction of exposed dentine, with patient consent, was induced by touching with a blunt probe (tactile stimulus) and by the air flow emitted from the blower for 1 s at a distance of 1cm (dehydrating stimulus), asking patients to assess pain intensity on the VAS scale. In each test before and 1 week after the application of paste, the assessment included the severity of induced pain according to the criteria: 0=no pain, 1–3 points=slight pain, 4–6 points=moderate pain, 7–9 points=strong pain, and 10 points=very severe pain.

The NUPRO® Sensodyne® Prophylaxis Paste was applied once onto the exposed sensitive dentin for 60 s using the preventive rubber cup on a low-speed handpiece as indicated by the manufacturer.

Results

In a preliminary study, before applying the NUPRO® Sensodyne® Prophylaxis Paste, the examined teeth reacted with pain when applying both stimuli. Tactile stimulus induced the highest

Table 4. Assessment of pain intensity in VAS scale after applying a NovaMin paste (test 1). Tactile stimulus.

Study groups	Sensation of pain intensity in VAS scale					Total
	0	1-3	4-6	7-9	10	
Abrasion	29	13	3	4	0	49
Erosion	6	2	0	0	0	8
Attrition	1	0	0	0	0	1
Post-treatment hypersensitivity	13	13	8	0	0	34
Total (n)	49	28	11	4	0	92
Total (%)	53.3	30.4	12.0	4.3	0.0	100.0

Tabela 5. Assessment of pain intensity in VAS scale after applying a NovaMin paste (test 1). Dehydrating stimulus.

Study groups	Sensation of pain intensity in VAS scale					Total
	0	1-3	4-6	7-9	10	
Abrasion	28	18	3	0	0	49
Erosion	4	4	0	0	0	8
Attrition	0	1	0	0	0	1
Post-treatment hypersensitivity	12	11	11	0	0	34
Total (n)	44	34	14	0	0	92
Total (%)	47.8	37.0	15.2	0.0	0.0	100.0

levels of pain (10 points) in 1.1% of cavities, in 16.3% strong pain (7-9 points), moderate pain in 42.4% (in the range of 4-6 points), small in 29.3% (1-3 points), and 10.9% of teeth did not respond with pain to tactile stimulus (Table 2). In case of dehydrating stimulus application in the initial test, no patient reported the highest level of pain. Severe pain was found (range 7-9 points) in 28.3% of studied cavities, in 38% moderate pain (4-6 points); in 21.7% slight pain I (1-3 points), and 12% felt no pain with the application of this stimulus (0 points) (Table 3).

One week after the application of the examined paste, the percentage of teeth reacting with a very strong pain decreased from 1.1% to 0, from 16.3% to 4.3% with severe pain, and 42.4% to 12% with moderate pain. In contrast, the percentage of teeth with a slight feeling of pain increased from 29.3% to 30.4%, and with no symptoms of pain from 10.9% to over 50% of studied teeth (Table 4).

A study using dehydrating stimulus 1 week after carrying out the application showed a decrease in the proportion of teeth reacting with strong pain from 28.3% to 0%, by a moderate pain from 38% to 15.2%, an increase in the percentage of people experiencing little pain from 21.7% to 37%, and the absence of pain from 12% to about 50% (Table 5). The reallocation in

these groups is caused by moving the percentage of people experiencing pain from the 7-9 interval into the 1-3 interval according to the VAS scale.

Prior to the study, the subjects responded to the questions included in the questionnaire. In 73% of respondents experiencing dentin hypersensitivity, the causative agent of pain onset was cold, in 55% it was tooth brushing, and 18% of patients reported that sweet or sour foods caused a pain response. All the respondents feeling hypersensitivity characterized the pain as short-term pain and 41% as acute pain.

In 68% of respondents, all those ailments lasted longer than 1 month. Of all respondents, 59% had not used before any measures to terminate hypersensitivity. Sixty-four percent of the respondents reported tooth brushing twice a day, using a manual toothbrush in most cases (only 3 people used a power toothbrush).

In response to a question about eating habits, 45% of respondents indicated they had fresh fruit or fruit juice once a day, 32% had fresh fruit or fruit juice several times a day, 41% occasionally drank cola beverages, and 55% drank wine.

Discussion

Contemporary reports show that the treatment of dentin hypersensitivity involves interruption of the neural response to pain stimulus by topical application of preparations containing potassium salts, because potassium ions cause depolarization of nerve receptors and reduce the conductivity. A second approach is by mechanical occlusion of outlets and the lumen of open dentinal tubules, and then the formation of insoluble precipitates with the participation of compounds of calcium, fluoride, strontium, arginine, the adhesive resins or lasers [2–4,10,13,15,17–21].

Researchers interested in the problem of elimination of dentin hypersensitivity suggest, among other things, that the treatment of this problem should mimic the natural process, leading to spontaneous occlusion of open dentinal tubules [21,22]. In the natural process of tubule occlusion, saliva provides calcium and phosphorus ions, which gradually occlude the tubules by forming a superficial protective layer consisting of salivary glycoprotein aggregates, calcium, and phosphates [2,20]. This process is favored by factors that maintain a high alkaline pH *in vivo*. The natural process does not cause rapid occlusion of dentinal tubules and the elimination of pain occurring in the dentin hypersensitivity [4,22]. To speed this process, additional amounts of calcium and phosphates must be delivered to the oral environment. The easiest and most natural way to do this is to use toothpaste that provides calcium and phosphates in a form providing clinical efficacy, despite the fact that saliva is a supersaturated solution of calcium and phosphate ions in relation to the hard tissue. For this purpose, compositions are applied that contain amorphous calcium phosphate, biphasic pastes with calcium sulfate, ammonium phosphate, sodium fluoride, di-potassium phosphate, and sodium bicarbonate and “biomaterials” containing phosphoro-silicate-calcium mixtures and bioactive glass particles [15,23,24].

Studies on the mechanism of closure of dentinal tubules have led to the development of a new formula based on bioactive glass particles, called NovaMin. Originally, it was intended for the regeneration of bone tissue and recently was used in dentistry. The mechanism of elimination of dentin hypersensitivity by NovaMin technology is based on the formation of a mechanically and chemically resistant calcium phosphate layer, which gradually crystallizes as hydroxyapatite [25]. In contact with a moist environment (water and saliva), NovaMin releases particles of calcium and phosphorus ions protected by the glass particles so that they can be delivered to a specific location, but not into the liquid medium. The next reaction step is the exchange of sodium ions from the bioactive glass particles with hydrogen cations, which increases pH to 8–8.5 [26]. Alkaline pH promotes the release of calcium and phosphate ions, which, in the form of calcium phosphate, precipitate on

the surface of the exposed dentine and in the light dentinal tubules gradually crystallize into a stable hydroxyapatite layer [23] that is resistant to repeated action of extrinsic and intrinsic acids. The formula is modeled on the natural process of closing of dentinal tubules developed by Markowitz and Pashley [22].

There are currently 2 types of prophylactic pastes with NovaMin on the market: NUPRO® Sensodyne® Polish or Stain Removal versions, and pastes without fluoride content are also available. Studies have confirmed the efficacy of calcium and sodium phospho-silicate at various concentrations both *in vitro*, *in vivo*, and *in situ* [23,25,27–32].

Wang et al. [31] proved the clinical efficacy of pastes with NovaMin in an *in vitro* study. Samples of dentin with open dentine tubules were exposed to paste including bioactive glass (NovaMin). Occlusion of dentinal tubules and increase in mineral content after using NovaMin were demonstrated by scanning electron microscopy (SEM). The resulting layer of material also proved to be resistant to repeated attacks of extrinsic acids [27,31]. Earl et al. used modern imaging techniques, and analyses showed an *in vitro* conversion of 15% calcium and sodium phosphosilicate (NovaMin) with amorphous material to a crystalline material corresponding to hydroxyapatite, which occluded dentinal tubules in the environment of artificial saliva. Chemical analysis of dentin surface after applying the tested paste showed an increase in calcium and phosphorus content [28].

In independent studies, Pradeep et al. and Acharya et al. demonstrated a significantly higher reduction of dentine hypersensitivity reactions in patients using a toothpaste with 5% calcium and sodium phosphosilicate at home, compared to the paste containing 5% potassium nitrate [30,32]. NovaMin also proved to be effective in eliminating dentin hypersensitivity when it was used in a concentration of 7.5% as an ingredient in a toothpaste, and compared with other formulations (potassium nitrate, fluoride, and tin) reduced the pain in a shorter time [33]. This was also confirmed in other studies [34–36].

Neuhaus et al. also achieved a statistically significant reduction in pain sensation after a single prophylactic professional application of NovaMin paste (15% calcium and sodium phosphosilicate) with and without fluoride, compared to controls. In patients with dentine hypersensitivity after scaling and polishing of the root surface, the use of NovaMin paste resulted in immediate reduction of pain sensations continuing for 28 days after the treatment administration. Immediate reduction of pain caused by a standardized touch stimulus (Yeaple Probe) was 100.5% according to the average value in the group that used fluoride toothpaste and 119.1% in the group without fluoride. The average value immediately after the prophylactic treatment of the relative reduction of pain sensation from

blower air flow was 44.6% for both of the test groups and increased to about 50% after 4 weeks. The authors reported no statistically significant difference in pain reduction when comparing groups, which used professional NovaMin toothpaste with fluoride and without fluoride [29].

The results of the presented work confirm the effectiveness of the NUPRO® Sensodyne® Prophylaxis Paste after a single professional application on the exposed hypersensitive dentine. It was noticeable as an increase of percentage of tested teeth

without pain and with a slight pain after tactile and dehydrating stimulus. Feeling of pain expressed as the mean value in the VAS scale was reduced in the examined group by 94%.

Conclusions

In-office use of professional prophylactic paste with NovaMin formula noticeably reduces dentin hypersensitivity 1 week after application.

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