Received: 19th February 2015 Accepted: 17th May 2015 Conflicts of Interest: None

Source of Support: Nil

Original Research

Evaluation of Dentifrice Containing Nano-hydroxyapatite for Dentinal Hypersensitivity: A Randomized Controlled Trial

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How to cite the article:

Nithin G, John J, Nagappan N, Prabhu S, Senthilkumar E. Evaluation of dentifrice containing nano-hydroxyapatite for dentinal hypersensitivity: A randomized controlled trial. J Int Oral Heath 2015;7(8):118-122.

Abstract:

Background: This randomized, double-blind, parallel arm study was carried out to evaluate and compare the effectiveness between nano-hydroxyapatite (HAP) and a benchmark dentifrice in reducing dentin hypersensitivity.

Materials and Methods: About 36 patients were selected, randomly divided into two groups and was evaluated clinically using three different stimuli, i.e., tactile, air blast, and cold water test. The patient's responses to various stimuli were recorded using a visual analog scale at baseline and after 4 weeks.

Results: Statistical analysis was done using unpaired and paired *t*-tests. It was seen that patients treated in both groups showed significant reductions scores across all sensitivity measures at the end of 4 weeks.

Conclusion: The HAP containing toothpaste was effective in reducing dentin hypersensitivity with pre-existing benchmark toothpaste tested and hence can be advocated in the management of hypersensitivity.

Key Words: Clinical trials, dentinal hypersensitivity, hypersensitivity, nano-hydroxyapatite, NovaMin

Introduction

Tooth hypersensitivity is one of the most common problems encountered in clinical practice. Unlike dental caries and periodontal disease, it is one of the most painful and least successfully treated chronic problems of the teeth. It has been reported that 8-30%[1,2] of the adult are affected by dentin hypersensitivity with the greatest incidence being documented between 20 and 40-year-old groups.[1]

Most dentin hypersensitivity is a result of abrasion, attrition, erosion, abfraction, gingival recession, and improper brushing habits and the teeth most common affected are the canines and premolars.[3]

Numerous theories have been put forth to explain the mechanism of hypersensitivity, which include the direct stimulation theory, odontoblastic transducer mechanism, gate control theory, and the hydrodynamic theory. The later is the most accepted and according to this rapid shift in the fluid flow within the dentinal tubules appears to be responsible for causing odontoblastic pain.[4]

Several treatment methods have been tried to reduce dentinal hypersensitivity, ranging from home-use, over the counter products such as desensitizing mouthwashes, dentifrices or tray application forms to in-office application products such as varnishes, liners, restorative material, dentinal adhesives, iontophoresis procedures, and more recently, laser.[5]

Among these desensitizing dentifrices have established themselves as principal agents in the routine management of hypersensitivity, owing to the fact they are widely available, cost-effective, simple to use and the habit of tooth brushing being almost universal.[6] Many of these dentifrices contain potassium nitrate,[7] stannous fluoride,[8] sodium fluoride, sodium monofluorophosphate,[9] and strontium chloride[10] as an active ingredient and have proven to be effective leading it to be a frequent choice among both patients and dentists for the treatment of sensitive teeth.

Recently, research into the use of the mineral components of the inorganic portion of the tooth structure (i.e., calcium and phosphate) has gained considerable attention[11-16] and has inspired the preparation of hydroxyapatite (HAP) for occlusion of dentinal tubules.[17] Different forms of HAP have been tested in both *in-vitro* and *in-vivo* and have been found to effective in tubule occlusion.

However, particles of nano-HAP incorporated into dentifrices are the newer products available in the market. Since literature search revealed a paucity of studies conducted with this regard, the aim of this study was to compare and evaluate the effect of nano-HAP dentifrice with another standard product NovaMin, which has been widely used in reducing dentinal hypersensitivity.

Materials and Methods

This study was a single-center, randomized, double-blind, parallel group clinical trial. The protocols for the study were developed as per the guidelines for the design and conduct of clinical trials on dentinal hypersensitivity and in accordance with the Declaration of Helsinki and Guidelines for Good Clinical Practice. Prior to the start of the study patients were given both verbal and written information about the process and an appropriate signed informed consent form was obtained. The duration of the study was for 4 weeks.

This study was carried out on 36 patients (20 males and 16 females) between the age group of 18 and 60 years, visiting the outpatient department of Saveetha Dental College and Hospital, Chennai, during the period of March to July 2013.

Prior to the start of the study, ethical clearance was obtained from the Institutional Ethics Committee, Saveetha University. The participants for the study were selected according to the following inclusion and exclusion criteria.

Inclusion criteria were as follows: History of dentin hypersensitivity to hot or cold or sour stimuli, no history of any periodontal therapy in the past 1-year; and patient's willingness to participate in the study.

Patients with active cervical caries or attrited teeth with caries or chipped teeth; patients with history of chronic use of anti-inflammatory and analgesic medication and who have undergone periodontal surgery in the preceding 6 months; patients with any denture or bridge work that would interfere with the evaluation of hypersensitivity and pregnant and lactating women were all excluded.

Evaluation of hypersensitivity

The reported hypersensitive teeth in the subjects were verified by light strokes of dental explorer along the cervical areas of all teeth present. This study was explained to the subjects and signed informed consent was obtained.

Sensitivity was measured using a 10 cm visual analog scale (VAS) score, with the score of 0 being a no-pain response and a score of 10 being extreme pain or discomfort. The clinical examinations and sensitivity tests were carried out by a single examiner.

The enrolled patients were evaluated for three measures/tests of sensitivity; tactile test, air blast, and cold water. The adjacent teeth were isolated with cotton rolls before applying the stimuli.

Tactile examination

An explorer was gently run across the affected area, perpendicular to the long axis of the tooth. The test was repeated thrice before scoring by using VAS and then the reading was noted.[18]

Air blast test

For the air method, a blast of air at a pressure of 45-60 psi from a three-way dental syringe was directed toward the sensitive portion of the tooth perpendicular to the long axis of the tooth for a duration of 1 s at a distance of about 1 cm. The patient's response to the intensity of pain was recorded on a 10 cm VAS.

Cold water test

The cold water test was performed using 1 ml of freshly melted ice cold water, which was applied immediately to the buccal cervical region with the help of a disposable syringe (0.2 ml).[18]

All the three tests were applied in the ascending order of discomfort, i.e., tactile test (least disturbing) then air blast test and at last cold water test (most disturbing).[18] The stimuli were applied in the same order, at a time interval of 5 min each.[19]

Dentifrices tested

Two toothpastes containing following two components respectively as an active ingredient were used:

1. Nano-HAP containing (Aclaim™, Group Pharmaceuticals, Bangalore, India)
2. 5% calcium sodium phosphosilicate (Shy-NM™, Group Pharmaceuticals, Bangalore, India).

After the collection of baseline data, the subjects were randomly divided into two groups of 18 subjects each. Each group was provided with one of the either dentifrices. The present study employed a double blinding procedure to eliminate subjective bias. The identity of each dentifrice was masked by providing it in plain tubes. Each patient was provided with an adult soft bristled toothbrush and was advised to apply the dentifrice in an amount equal to about half the length of the bristle head, were also instructed to brush for two minutes and no more than a total of 2 times/day. They were recalled at 4th week for measurement of tooth sensitivity.

Data was entered in Microsoft Excel spreadsheet and analyzed using SPSS software (version 18). For test, a $P < 0.05$ is to be considered statistically significant. Mean VAS scores and mean ± standard deviation were calculated from individual scores from all subjects in a treatment group. Paired and unpaired *t*-test was used to assess the statistical significance.

Results

Figure 1 shows the distribution of study subjects based on age and gender.

A statistically significant reduction from baseline in tooth sensitivity was observed for both test products, for all three sensitivity parameters, at the end of 4 weeks.

Table 1 shows the comparison of mean VAS scores at baseline and after treatment with NovaMin dentifrice to various tests. The reduction in sensitivity score was maximum for the cold

test, followed by air blast and then the tactile for NovaMin treated group.

The difference in mean VAS score for various tests with NovaMin dentifrice was found to be statistically significant ($P < 0.001$) indicating a reduction in sensitivity scores at the end of 4 weeks.

Table 2 shows the comparison of mean VAS scores at baseline and after treatment with nano-HAP dentifrice to various tests. There was a considerable reduction in sensitivity scores with the maximum reduction for cold test followed by air blast and tactile. The difference in mean VAS score for various tests with nano-HAP dentifrice was found to be statistically significant ($P < 0.001$) indicating a reduction in sensitivity scores at the end of 4 weeks.

There were no statistically significant differences between the two study products in the reduction of sensitivity from baseline to 4 weeks, for any of the three sensitivity parameters, as shown in Table 3. No side effects occurred in all the subjects included in the study on the use of the active products.

Discussion

Much has been written on the subject of dentine hypersensitivity; yet, it would seem justifiable to agree that the condition is an enigma being frequently encountered, but poorly understood.[20]

Through the years, complaints of tooth sensitivity have resulted in the development of a variety of methods and substances, which have been intended for the reduction or elimination of this condition. There have been two basic approaches in the treatment of dentinal hypersensitivity, one is to seal and occlude the dentin tubules, thereby blocking the hydrodynamic mechanism; the other is to block neural transmission at the pulp level.

Most hypersensitive teeth are sensitive to more than one stimulus, and not all teeth respond to the same stimulus.[21] Based on the recommendations of the Ad Hoc Advisory Committee on Dentinal Hypersensitivity (1986)[22] and American Dental Association, Council of Dental Therapeutics (1989),[23] three different stimuli-tactile, air, and cold water were used to assess hypersensitivity in this study.

The sensitivity level of this study was determined by translating the subjective feedback scale into objective data using VAS scale. The validity and reliability of the VAS for measuring both experimental and clinical pain have been demonstrated by several investigators.[18,24]

HAP is considered as one of the most biocompatible and bioactive material on account of its similarity to the mineral composition found in teeth. *In vitro* studies have also suggested that use of HAP containing dentifrices is better than fluoride

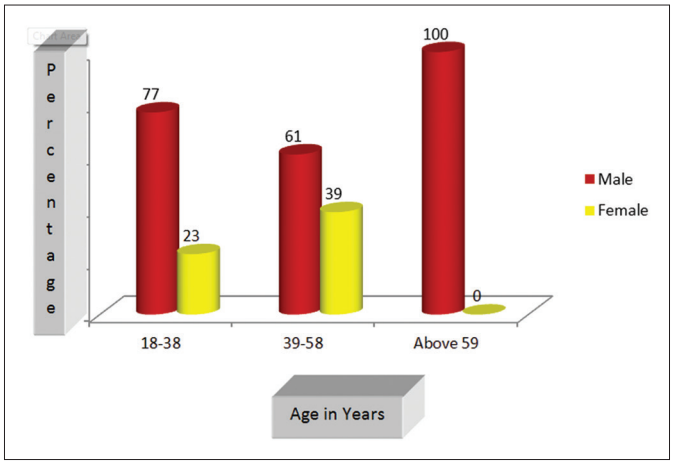

Figure 1: Distribution of subjects based on age and gender.

Table 1: Comparison of mean VAS scores at baseline and after treatment with NovaMin dentifrice to various tests.

Tests	NovaMin (mean±SD)		Mean difference	*P* value
	Baseline*	4 weeks*		
Cold	7.22±1.00	5.11±0.90	2.11	0.006
Air blast	6.89±1.18	4.83±1.09	2.05	0.004
Tactile	5.06±0.87	4.11±0.75	0.94	0.020

*Paired *t*-test, VAS: Visual analog scale, SD: Standard deviation

Table 2: Comparison of mean VAS score before and after treatment with nano-HAP dentifrice to various teats.

Tests	Nano-HAP (mean±SD)		Mean difference	*P* value
	Baseline*	4 weeks*		
Cold	6.72±1.01	4.94±1.05	1.77	0.003
Air blast	7.06±1.55	5.39±1.33	1.50	0.000
Tactile	4.67±1.08	3.78±0.94	0.88	0.004

*Paired *t*-test. HAP: Hydroxyapatite, VAS: Visual analog scale, SD: Standard deviation

dentifrices, as HAP induces a surface remineralization, forming a biomimetic apatite coating on enamel and dentin surface, which quickly occurs due to the chemical-physical characteristics of innovative nanostructured HAP particles, which closely resemble mineral enamel constituents.[25-27]

Occlusion of exposed dentinal tubules by nano-HAP, and by nano-HAP/protein complexes, helping to reduce hypersensitivity, has been studied in the recent years. However, until now there have not been many trials, making this one of the first such kind, in evaluating nano-HAP as a desensitizing dentifrice.

The results of the present study showed that use of nano-HAP dentifrice was associated with a statistically significant reduction in tooth sensitivity and was comparable to NovaMin. This finding was in accordance to a study done by Kim *et al.* in 2009[14] which shown a similar effect in reducing hypersensitivity to a pre-existing benchmark toothpaste (strontium chloride) when used after bleaching.

The effective tubule occlusion by nano-HAP in the present study could have possibly occurred, as chemically these agents

Table 3: Comparison of mean VAS scores at baseline and after treatment for both groups to various tests.

Group*	Various tests (mean±SD)					
	Cold test*		Air blast score*		Tactile score*	
	Baseline	4 weeks	Baseline	4 weeks	Baseline	4 weeks
NovaMinDentifrice	7.22±1.18	5.11±0.90	6.89±1.18	4.83±1.09	5.06±0.87	4.11±0.75
Nano-HAP dentifrice	6.72±1.01	4.94±1.05	7.06±1.55	5.39±1.33	4.67±1.08	3.78±0.94
P value	0.869	0.426	0.404	0.316	0.127	0.386

*Independent *t*-test. HAP: Hydroxyapatite, VAS: Visual analog scale, SD: Standard deviation

are composed of calcium and phosphate, and the saliva in the oral cavity is supersaturated with respect to HAP,[14] thus, the chances of dissolution of these compounds by saliva are limited. Similar findings were also reported by Hüttemann *et al*,[28] Barone and Malpassi[29] and Browning *et al.*[30] on using nano-HAP containing agents on hypersensitivity.

On the other, NovaMin is used widely in recent years in the management of sensitivity and has been considered as a superior desensitizer, as it could cause rapid relief of symptoms.

A review of the literature by Gendreau *et al.*,[31] based on randomized controlled clinical trials, supported the use of NovaMin in toothpaste formulations in providing relief of pain from dentin hypersensitivity. The results of the present study are in similar terms to studies conducted by Acharya *et al.*,[32] Rajesh *et al.*,[32] and by Litkowski and Greenspan,[34] which demonstrates that NovaMin dentifrice has the ability to reduce dentin hypersensitivity within 4 weeks.

Conclusion

Under the conditions of the clinical trial, NovaMin and nano-HAP showed significant reductions in dentine hypersensitivity at the end of 4 weeks. The data from this trial provides evidence of the therapeutic value of nano-HAP dentifrices, suggestive that it can be used in the reduction of and symptoms/pain due to dentine hypersensitivity in-comparable to other desensitizing agents.

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