Original Article

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Dentistry Section

An In vitro SEM Study on the Effect of Bleaching Gel Enriched with NovaMin on Whitening of Teeth and Dentinal Tubule Occlusion

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ABSTRACT

Introduction: Tooth whitening products enjoy substantial popularity. However, tooth hypersensitivity is invariably an undesirable consequence. Desensitizing toothpastes may be used for alleviating the symptoms. NovaMin, as an active ingredient in many dentifrices, has been shown to deliver significant therapeutic desensitising benefits.

Aim: To study the effect of NovaMin desensitising toothpaste mixed with 15% carbamide peroxide on tooth bleaching and tubule occlusion.

Material and Methods: This study was carried out in vitro, on extracted premolars which were bleached, using the above mentioned mixture and shade change was evaluated. They were then sectioned to be observed under a scanning Electron Microscope. The number of completely and partially blocked tubules as well as open tubules were counted for each specimen. Statistical analysis for shade change was done by using paired t-test. Mean and Standard deviation were calculated for the tubule counts and they were analyzed statistically.

Conclusion: The results of this study indicated that the addition of NovaMin to 15% Carbamide peroxide occluded the dentinal tubules and that it did not affect the bleaching procedure. They also emphasized its clinical relevance in a dual advantage of desensitizing and bleaching with a single paste system.

Keywords: NovaMin, Bleaching

INTRODUCTION

Bleaching is the most conservative treatment for discoloured teeth and despite the fact that bleaching systems have become increasingly popular, tooth-whitening procedures cause gingival irritation and tooth sensitivity [1]. Fifteen to sixty five percent of patients who have undergone 10% carbamide peroxide bleaching therapy, reported increased tooth sensitivity. This effect has been reported for virtually all delivery systems and peroxide concentrations. At-home bleaching achieves a high success rate and is the technique most widely used by clinicians for bleaching vital teeth, but it does not eliminate hypersensitivity [2,3]. This sensation can be felt both during and immediately after treatment. Unfortunately, the aetiology of bleaching-related tooth sensitivity has neither been well-understood nor easily measured; however, the hydrodynamic theory is a mechanism frequently cited to explain it. According to this model made by Branstrom in 1963, peroxide solutions introduced into the oral environment contact available dentinal surfaces and cause retraction of odontoblastic processes, resulting in rapid fluid movement inside the dentinal tubules. This ultimately manifests in stimulation of mechanoreceptors at the pulp periphery. As a result, patients can feel a clinically evident painful sensation when such teeth are exposed to cold or pressure or even when they are at rest [4].

AIM OF THE STUDY

Our aim was to study the effect of NovaMin desensitising toothpaste mixed with 15% carbamide peroxide on bleaching of teeth and dentinal tubule occlusion.

MATERIALS

The materials included the following:

- Thirty non–carious extracted premolars which were extracted for orthodontic reasons from patients aged 18-30 years were used. Teeth with cervical lesions were not used for the study. They were ultrasonically cleaned and their roots were coated with a nail varnish to avoid the effects of carbamide peroxide on root surfaces [Table/Fig-1]. The sample size was decided, based on data obtained from previous studies.
- A vitapan classic shade guide was used for shade matching.
- 15% Carbamide peroxide gel (Opalescence Tooth whitening systems, Ultradent Products Inc., USA) [Table/Fig-2].
- Desensitizing Toothpaste SHY-NM (Group Pharmaceuticals, Malur) [Table/Fig-2].
- Micromotor and a diamond disc (NSK products, Tochigi, Japan)
- Ion Sputtering machine and a Scanning Electron Microscope.

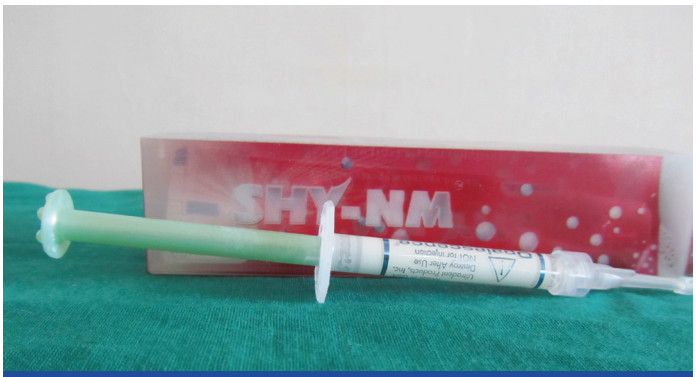
METHODS

- This study consisted of 30 extracted premolars which were ultrasonically cleaned and whose roots were coated with nail varnish. The shade was taken with a Vitapan Classic shade guide under normal daylight by three examiners.
- All the teeth were bleached by using 15% carbamide peroxide mixed with a desensitising toothpaste containing NovaMin in a 1:1 proportion. Bleaching was carried with this new formulation, with teeth immersed in disposable glass for 8 hours a day. This procedure was carried out for 2 weeks.
- Every day, a new solution was used by mixing a 1:1 propoartion of a desensitising toothpaste containing NovaMin and 15% carbamide peroxide, in order to replenish the bleaching agent.
- The specimens were then cleaned in normal water, a new shade was taken postbleaching by the same three examiners and 1mm thick sections were obtained using a micromotor and a diamond disc, just above the level of cementoenamel junction [Table/Fig-3].

These sections were then observed under a scanning electron-microscope and occlusion of dentinal tubules was studied [Table/Fig-4 and 5].

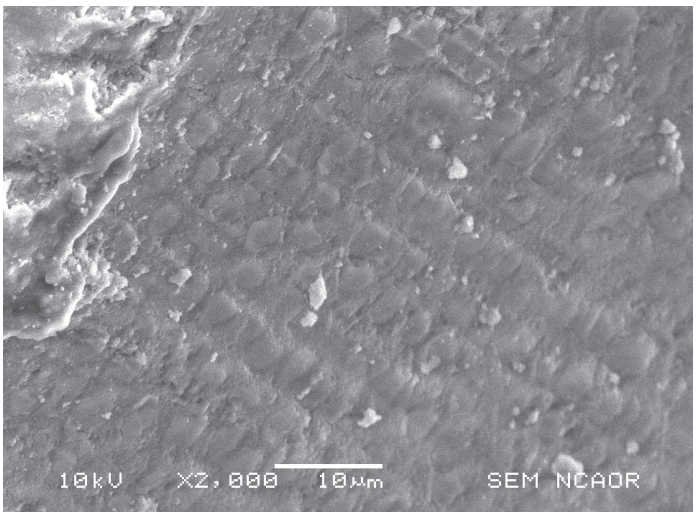
In between the sessions of bleaching , the samples of teeth were stored in another disposable glass and they were kept in a vaccumized jar.

[Table/Fig-1]: The extracted premolars coated with a nail varnish used for the study

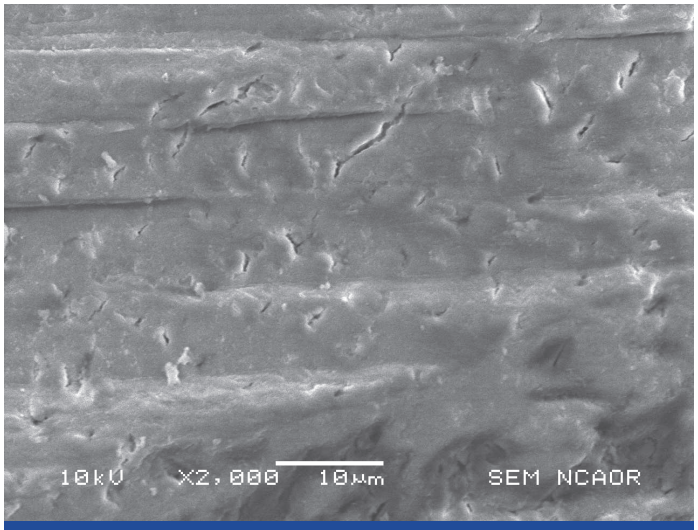


[Table/Fig-2]: Desensitizing toothpaste and a home bleaching agent

[Table/Fig-3]: Sections of the teeth 1mm thick



[Table/Fig-4]: Scanning electron microscope views of a section in Carbamide peroxide and NovaMin group showing occluded tubules



[Table/Fig-5]: Scanning electron microscope views of a section in Control group showing open tubules.

For Evaluation of Dentin Tubule Occlusion [Table/Fig-6]

- Tubule counting was performed on all SEM (Scanning Electron Microscope) images that were obtained at 2000X and 10KV. Three people separately examined each image and counted the number of completely blocked tubules, open tubules and partially occluded tubules.

Completely blocked in %	Partially blocked in %	Open tubules in %
84.7	11.76	3.52
86.25	12.50	1.25
92.80	7.14	0
86.70	9.63	6.02
92.04	7.95	0
84.28	14.28	1.42
76.25	18.75	5
87.80	12.19	0
86.90	11.90	1.19
88.37	11.62	0
86.25	10.71	3.75
89.28	10.7	0
96.25	2.5	1.25
90.24	9.75	0
93.75	6.25	0
97.36	2.63	0
89.74	10.25	0
96.25	2.5	1.25
84.61	10.25	5.12
87.80	12.19	0
89.13	10.86	0
93.77	2.22	0
98.88	0	1.1
90.90	9	0
93.18	4.54	2.27
92.85	7.14	0
93.02	6.97	0
91.48	8.51	0
94.56	5.43	0
90	8.88	1.11

[Table/Fig-6]: The number of tubules that were open, completely blocked and partially blocked expressed as percentage.

- Tubules that could not be fully visualized on the SEM images were not counted.
- For each SEM image, the tubule counts from the three people were averaged together to obtain the number of open, partially occluded, and total visible (open + partially occluded) tubules. This method was followed by Anora Burwell [5] [Table/Fig-4].

For Evaluation of Changes in the Shade of the Teeth: [Table/Fig-7]

- The shade guide's 16 tabs were arranged from the highest (B1) to the lowest (C4) values.
- We calculated tooth shade changes by calculating the shift in the number of shade guide units that occurred toward the lighter end of the scale.
- Three individuals carried out shade matching under daylight and an average of these observations was used for analysis. This method was followed by Lidia Yileng Tay [3].

Control Group

This group consisted of 10 teeth for which the same protocol was used, but they were bleached with 15% Carbamide peroxide without NovaMin and the tubule occlusion was studied [Table/Fig-5].

Sr. No	Shade before Treatment	Shade after Treatment
1	7	6
2	4	3
3	3	2
4	10	10
5	6	6
6	13	11
7	3	2
8	7	6
9	6	5
10	7	6
11	3	1
12	3	1
13	7	6
14	14	11
15	14	11
16	15	14
17	2	1
18	3	1
19	14	14
20	15	14
21	4	3
22	6	6
23	14	14
24	15	14
25	7	6
26	9	7
27	16	14
28	13	11
29	10	10
30	8	6

[Table/Fig-7]: Shade changes before and after treatment expressed in a numerical form

STATISTICAL ANALYSIS

The percentage occlusion of dentinal tubules was calculated and mean and standard deviation were calculated [Table/Fig-8]. For shade differences before and after treatment, paired t test was used for statistical analysis.

	Mean (Expressed as percentage)	Standard Deviation
Completely blocked tubules	90.31%	4.84
Partially blocked tubules	8.63%	4.11
Open tubules	1.43%	1.77

[Table/Fig-8]: Mean and Standard Deviation calculated from observations

Mean of tubules completely blocked =2709.39/ 30 =90.313

Standard Deviation= $\{ 679.642/29\}^{1/2} = 4.84$

Mean of tubules partially blocked = 259/30= 8.63

Standard Deviation= $\{492.29/29\}^{1/2} = 4.11$

Mean of open tubules = 34.26/30= 1.142

Standard Deviation= {91.35/29} ½ =1.77

For shade of the teeth, the Paired t test was performed and t=4.2962

RESULTS

The results of the paired t–test were found to be significant. In control group, 95% of the tubules were open and only 5% of the tubules were occluded.

DISCUSSION

The addition of 5% potassium nitrate (KNO3) to "sensitive formula" gels has been tried out and is the most typical way of creating an antihypersensitivity toothpaste. However, this strategy fails to take into consideration that a prolonged and sustained use is needed to cause a noticeable regression of pain [6,7]. The use of added fluorides is also not the answer. The problem with this approach is that the most effective anti–hypersensitivity fluoride formulations use 0.4% stannous fluoride. This approach, however, frequently causes products to be somewhat unstable and slow acting and this can result in significant tooth discolouration. Hence, this ingredient is not favoured for use in bleaching gels. Manufacturers do offer sodium fluoride formulations, but these are weak, slow acting alternatives [8,9]. Amorphous Calcium Phosphate (ACP) can be added to carbamide peroxide. ACP works via a unique method that uses amorphous calcium phosphate compounds in a carbonate solution, to crystallize and form hydroxyapatite. These crystals then reportedly fill in microscopic surface defects and repair early carious lesions, as well as they make teeth smoother, stronger and less sensitive. Interestingly, this agent also has been shown to minimize surface protein precipitation that can limit the ability of chromagens to bind to teeth over time, but it should be stored in dual-chambered containers that separate positive and negative ion interactions until the time of their introductions into the oral cavity [3].

NovaMin (Calcium Sodium Phosphosilicate) is an inorganic compound that reacts in aqueous environments to release calcium, sodium, and phosphate ions over time. Being originally developed as a bone regenerative material, this compound has been shown to be effective in occluding dentinal tubules physically, through the development of a hydroxyapatite-like mineral layer [10].

NovaMin, in aqueous environment, releases Sodium ions (Na+), which immediately begin to get exchanged with hydrogen cations (H+ or H3O+) .This rapid release of ions allows Calcium (Ca^{2}+) ions as well as Phosphate ($PO4^{3}$-) ions in the structures of particles, to be released from the material. This initial series of reactions occur within seconds of exposure, and the release of the calcium and phosphate ions continues as long as the particles are exposed to the aqueous environment. A localized, transient increase in pH occurs during the initial exposure of the material, due to the release of sodium. This

increase in pH helps in precipitating the calcium and phosphate ions from the Calcium Sodium Phosphosilicate particle, along with calcium and phosphorus found in saliva, to form a calcium phosphate (Ca-P) layer. As the deposition of calcium and phosphorus complexes continue, this layer crystallizes into hydroxycarbonate apatite, which is chemically and structurally equivalent to biological apatite [11]. Calcium Sodium Phosphosilicate products have received approval from the Food and Drug Administration. Numerous studies have focused on the decrease of sensitivity, following the occlusion of open dentinal tubules [12]. Most of these studies have used Scanning Electron Microscopes to show the patent tubules before treatment and the occluded tubules after treatment [13,14].

Current information supports blocking of dentinal tubules (either long term or short term), which results in relief of sensitivity. This is in concurrence with Brannstrom's theory of hydrodynamic fluid movement in the tubules, which causes sensitivity (Brannstrom, 1963). All studies done by using Calcium Sodium Phosphosilicate containing dentifrices consistently showed that they were capable of significantly reducing hypersensitivity.

An in vivo study carried out by Rajesh et al., on evaluation of NovaMin containing dentifrices for relief of dentinal hypersensitivity in 2012, revealed significant success in reduction of hypersensitivity [15]. Another study done by Milleman et al., reported no adverse effects of NovaMin which was used in vivo [16].

CONCLUSION

The results of this study indicated that the addition of NovaMin to 15% Carbamide peroxide occluded the dentinal tubules and that it did not affect the bleaching procedure. Though these results are promising, further clinical trials are necessary, to prove that Calcium Sodium Phosphosilicate is an ideal desensitizing agent in combination with carbamide peroxide.

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