Original Article

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Dentistry Section

Dentinal Tubule Occluding Effect of Potassium Nitrate in Varied Forms, Frequencies and Duration: An In vitro SEM Analysis

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ABSTRACT

Introduction: Dentinal hypersensitivity is an exaggerated response to non-noxious sensory stimuli (osmotic, thermal or mechanical changes). An inverse relationship between occluding open tubules and the intensity of sensitivity has been reported. Studies on the efficacy of potassium nitrate used in different forms and frequencies to occlude dentinal tubules are scarce.

Aim: To evaluate, in vitro the dentinal tubule occluding effect of potassium nitrate which differ in form, frequency and duration of application.

Materials and Methods: In an in vitro study, 45 extracted human maxillary and mandibular premolars were sectioned using diamond disc to obtain 90 samples which were treated with 6% citric acid and were randomly assigned to three groups: Group 1 was treated with potassium nitrate toothpaste (once and twice daily for two minutes); Group 2 with potassium nitrate mouthwash (once and twice daily for two minutes) and Group 3 served as control (distilled water). Post-treatment, the samples were immersed in distilled water. The samples were subjected to Scanning Electron Microscopy (SEM) at the end of 3, 7 and 14 days. SEM photographs were analysed based on extent of tubular occlusion. Chi-square test was applied to assess the significant difference between the groups.

Results: There was detectable difference in the dentinal tubule occlusion at the end of 3rd, 7th and 14th day between three groups. When compared to the mouthwash, toothpaste yielded better results. Twice daily application for a period of two minutes each was better when compared to once daily for two minutes.

Conclusion: Potassium nitrate is effective in occluding dentinal tubules when applied twice daily in toothpaste form than mouthwash form. However, randomised control trials are needed to confirm its efficacy in human subjects.

Keywords: Dentin hypersensitivity, Mouthwash, Toothpaste, Tubule occlusion

INTRODUCTION

Tooth hypersensitivity or dentin hypersensitivity is a symptom reported in vital teeth with areas of dentin exposed to the oral environment due to degradation of the enamel or cementum [1]. It is viewed by individuals as an important health problem, sometimes leading to an increased concern about their health status [2]. It is characterised by an intense, non-spontaneous, acute, transient, localized, short term pain of quick onset in response to mechanical, chemical, thermal or osmotic stimuli, without involvement of other pathological or structural defects in the teeth [3]. Despite its acute character, dentin hypersensitivity can be considered as a chronic pain condition [2].

Dentin hypersensitivity is characterized by a high prevalence of exposed cervical dentin which varies from 8% to 57% [4] which can affect different age groups with the majority of sufferers aged between 20 to 40 years. It has more of female predilection, though the sex difference rarely is statistically significant [5]. The teeth most commonly involved are maxillary premolars followed by maxillary first molars whereas least affected are the incisors [6]. The most commonly affected site is the buccal aspect of cervical area [7]. It compromises the quality of life and is one of the main complaints in the search for access to dental services [1]

The approaches that reduce or potentially eliminate hypersensitivity can be categorised into two classes: those that result in physical occlusion of tubules and those that block neural transmission at the pulpal tissues and chemically depolarizing the nerve synapse. Several active agents such as fluorides, strontium salts and potassium are present in desensitizing toothpastes. It is reported that the abrasive component of toothpaste can increase tubule occlusion in addition to the active agents. This additional blockage may occur either by direct occlusion of tubules with abrasive or indirectly by the formation of a smear layer during tooth brushing [8].

Studies have been reported on the effectiveness of different desensitising agents. Dentifrices containing potassium ions have been shown by several clinical studies to be effective in reducing dentin hypersensitivity. Potassium nitrate is used as a desensitising agent in mouthwash. Although, there exists a dilemma regarding the effectiveness in various forms, few studies have shown similar therapeutic potential among potassium nitrate dentifrice and mouthwash in reducing dentinal hypersensitivity [5]. However, studies regarding its dentin occluding effect in different forms, frequencies and duration of application are scarce in literature.

Hence, the present study aimed to evaluate and compare in vitro the efficacy of potassium nitrate as a dentinal tubule occluding agent in toothpaste and mouthwash form, applied once/ twice daily for a period of 3, 7 and 14 days. It was hypothesized that there was no difference in dentin occluding effects of potassium nitrate when used either in paste or mouthwash form once/twice daily over a period of 3, 7 and 14 days.

MATERIALS AND METHODS

An in vitro study was conducted from September 2016-October 2016 on dentin samples obtained from extracted human maxillary and mandibular both upper and lower premolars. The study was conducted at Government Dental College and Research Institute Bangalore and Indian Institute of Technology Bengaluru, Karnataka, India. Teeth with untreated or treated caries, hypoplasia, wear and trauma were excluded from the study.

A total of 90 dentin samples were obtained from 45 premolars which were sectioned mesio-distally using diamond disc to obtain two samples per tooth. The dentin specimen of 5*4*4 mm was obtained using airotar and long straight bur. All the specimens were treated with 6% citric acid for two minutes to facilitate removal of the smear layer and to disocclude the dentinal tubules. These treated specimens were washed thoroughly with distilled water to remove any remaining acid or debris present. The specimens were then randomly assigned to one of the following three groups [Table/Fig-1].

Groups	Subgroups	Method of application
Group 1:-5% potassium nitrate toothpaste	Group 1a (15 samples)	Once daily for 2 minutes
	Group 1b (15 samples)	Twice daily for 2 minutes
Group 2:-3% potassium nitrate mouthwash	Group 2a (15 samples)	Once daily for 2 minutes
	Group 2b (15 samples)	Twice daily for 2 minutes
Control (30 samples)	Distilled water	-

[Table/Fig-1]: Details of groups, subgroups and method of application of potassium nitrate in different forms and frequencies.

The intervention was manual application of toothpaste (rubbing of toothpaste on dentin with finger) and immersion of specimens in mouthwash for Group 1 and 2 respectively whereas Group 3 received no intervention (control). Samples in Group 1 and 2 after the intervention were placed in distilled water. At the end of 3 days, 7 days and 14 days, ten samples each from all group (five from each subgroups) were subjected to SEM to detect tubular occlusion. Equal samples were taken from subgroups.

Two blinded evaluators were trained and calibrated (inter and intra examiner reliability scores being 0.83 and 0.85 respectively) for the evaluation of dentin occlusion based on criteria in the previous literature [9].

Type 0: Open dentinal tubules without occlusion i.e., acid treated specimens without desensitising agent application.

Type 1: Partial dentinal tubule occlusion < 25% of dentinal tubule orifice.

Type 2: Partial dentinal tubule occlusion of > 25% up to75% of dentinal tubule orifice.

Type 3: Nearly complete dentinal tubule occlusion of >75% of dentinal tubule orifice.

At the time of analysis, Type 2 and Type 3 were considered in the same category as “partial dentinal tubule occlusion”.

Study armamentarium included gloves, mouth mask, diamond disc, straight airotar, burs, extracted teeth, citric acid, potassium nitrate toothpaste and mouthwash, dapen dish and distilled water. SEM (Zeiss sigma VP, Zeiss Oberkochen, Germany) was used for the analysis.

STATISTICAL ANALYSIS

Data obtained was entered in a MS Excel sheet. The descriptive statistics were computed with the Statistical Package of Social Sciences (SPSS) version 22.0 software. Chi-square test was applied to assess the significant difference between the groups. The p-value was considered as significant when less than 0.05 (confidence interval of 95%).

RESULTS

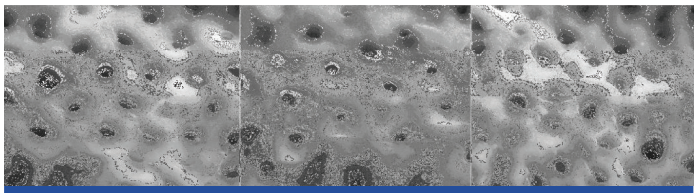
The present study evaluated the dentinal tubule occluding effect of potassium nitrate applied as toothpaste and mouthwash, once/twice daily for 3, 7 and 14 days.

SEM images of different groups at the end of each period are reproduced in [Table/Fig-2-6]. At the end of third day, dentinal tubules were partially occluded in Group 1 (subgroups a) and group 2 (subgroup b) [Table/Fig-7]. There was a statistically significant difference inthe tubular occlusion between the groups at the end of 3rd day (p<0.001).

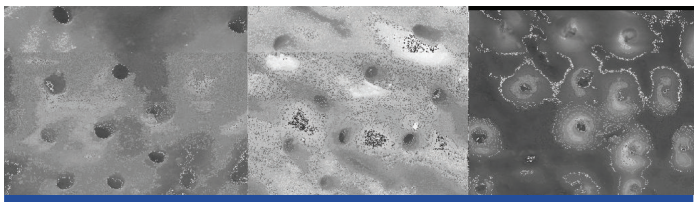
At the end of 7th day, dentinal tubules were either partially occluded (subgroup a) or both partially occluded and nearly complete occluded (subgroup b) in Group 1 whereas dentinal tubules were partially occluded in Group 2 (subgroups a and b) [Table/Fig-8]. A statistically significant difference was observed in the tubular occlusion between the groups at the end of 7th day (p<0.001).

At the end of 14th day, dentinal tubules were both partially occluded and nearly complete occluded (subgroup a) in Group 1 and nearly complete occluded (subgroup b) in group 1, whereas dentinal tubules were both partially occluded and nearly complete occluded (subgroup a and b) in Group 2 [Table/Fig-9] and the difference was found to be statistically significant (p<0.001).

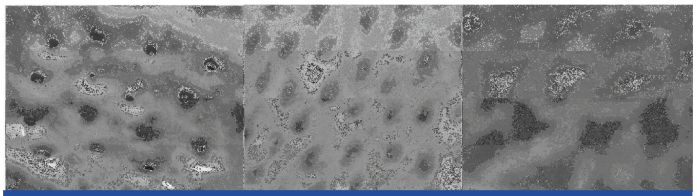
However, the proportion of samples which were nearly complete occluded in the decreasing order were Group 1 (subgroup b), group 1 (subgroup a), Group 2 (subgroup b) and Group 2 (subgroup a).



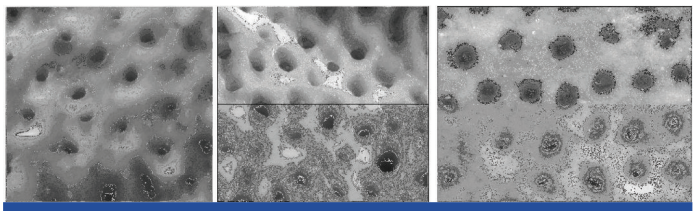
[Table/Fig-2]: Control group at the end of 3rd, 7th and 14th day.



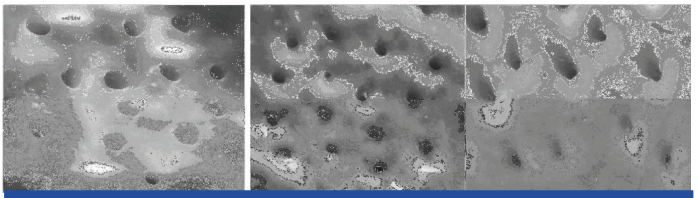
[Table/Fig-3]: Group 1a at the end of 3rd, 7th, 14th days.



[Table/Fig-4]: Group 1b at the end of 3rd, 7th, 14th day.



[Table/Fig-5]: Group 2a at the end of 3rd, 7th, 14th day.



[Table/Fig-6]: Group 2b at the end of 3rd, 7th, 14th day.

Level of occlusion*	Toothpaste group		Mouthwash group		Control group	p-value
	Group 1a	Group 1b	Group 2a	Group 2b	N=10	
	N=5	N=5	N=5	N=5		
Open dentinal tubules without occlusion	0%	0%	20%	0%	100%	<0.001 (Statistically significant)
Partial dentinal tubule occlusion	100%	100%	80%	100%	0%	
Nearly complete dentinal tubule occlusion	0%	0%	0%	0%	0%	

[Table/Fig-7]: Level of occlusion at the end of 3rd day. Chi-square test was applied.

Level of occlusion*	Toothpaste group		Mouthwash group		Control group	p-value
	Group 1a	Group 1b	Group 2a	Group 2b	N=10	
	N=5	N=5	N=5	N=5		
Open dentinal tubules without occlusion.	0%	0%	0%	0%	100%	<0.001 (Statistically significant)
Partial dentinal tubule occlusion	100%	60%	100%	100%	0%	
Nearly complete dentinal tubule occlusion	0%	40%	0%	0%	0%	

[Table/Fig-8]: Level of occlusion at the end of 7th day.
Chi-square test was applied.

Level of occlusion*	Toothpaste group		Mouthwash group		Control group	p-value
	Group 1a	Group 1b	Group 2a	Group 2b	N=10	
	N=5	N=5	N=5	N=5		
Open dentinal tubule without occlusion.	0%	0%	0%	0%	100%	<0.001 (Statistically significant)
Partial dentinal tubule occlusion	20%	0%	60%	40%	0%	
Nearly complete dentinal tubule occlusion	80%	100%	40%	60%	0%	

[Table/Fig-9]: Level of occlusion at the end of 14th day.
Chi-square test was applied.

DISCUSSION

The present study evaluated and compared the in vitro efficacy of potassium nitrate as a dentin tubule occluding agent in toothpaste and mouthwash form, applied once/ twice daily for 3, 7 and 14 days. Not many in vitro studies have been reported in literature on efficacy of potassium nitrate as a dentin occluding agent. Therefore comparisons are made wherever feasible.

An animal study on rats has demonstrated efficacy of potassium nitrate in tubular occlusion [10]. An in vivo demonstrated that the use of toothpaste containing 5% potassium nitrate on hypersensitive teeth was significantly more effective in immediate pain reduction than using placebo toothpaste [11]. Studies have found potassium nitrate to be inferior to calcium sodium phospho silicate [12] and Novamin [13]. However, studies have reported improved clinical effectiveness when potassium nitrate was combined with other agents like sodium fluoride and cetylpyridinium chloride [14] as well as with sodium monofluorophosphate, nano-hydroxyapatite, antioxidants phloretin, ferulic acid and silymarin [15]. In contrast to our results, an in vivo study demonstrated equal effectiveness of potassium nitrate toothpaste and mouthwash in reducing sensitivity when applied for four weeks [5].

Although, the effect of potassium nitrate mouthwash was lower as compared to toothpaste, tubular occlusion was seen in group 2a and 2b, with twice daily application showing better results. This is in line with another study where it was reported that potassium nitrate mouthwash is effective in alleviating dentinal sensitivity [16].

The result of our study showed that potassium nitrate in toothpaste form is more efficacious than mouthwash form in occluding the dentin tubules. Similarly, it was more efficacious when applied twice daily in both the groups. Maximum efficacy was observed at 14th day for toothpaste applied twice daily. The better tubular occluding effect of toothpaste form and the higher concentration of active ingredient (potassium nitrate) could be partly attributed to the better retention of the material and occlusion produced by abrasive components of toothpaste.

LIMITATION

However, the study has some limitations. This study employed in vitro design, hence limiting its ability to mimic oral health conditions. Secondly, after application, all the specimens were placed in distilled water. Hence, the impact of oral environment post application could not be reproduced in this study. Also, its efficacy when compared to other agents could not be as certained which was beyond the scope of the study. Since dentinal hypersensitivity is subjective in nature, the results need to be validated against patient's perception of sensitivity quality of life. Hence, further in vivo studies are required on effectiveness of potassium nitrate in different forms, frequency and duration in comparison with other agents.

CONCLUSION

The present in vitro study demonstrated maximum tubular occluding effects of potassium nitrate when applied in toothpaste form, twice daily for a period of two weeks. Further long term in vivo studies are suggested.

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