

# Comparative Evaluation of Hydroxyapatite, Potassium Nitrate and Sodium Monofluorophosphate as in Office Desensitising Agents – A Double Blinded Randomized Controlled Clinical Trial

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## Abstract

**Background:** The search for an agent that would predictably and permanently occlude the tubules, and blend with them led to the discovery of HYDROXYAPATITE (HAP). The present double blinded randomised controlled clinical trial aimed to compare the desensitizing effects of two forms of HAP with 2 other popular agents, potassium nitrate and potassium nitrate with sodium monofluorophosphate.

**Methods: Clinical study:** 716 hypersensitive teeth in 50 patients with hypersensitive symptoms, confirmed by visual analogue scale (VAS) and verbal rating scale (VRS), were randomly divided into 4 groups (A,B,C and D) treated with HAP dry sol gel and liquid precipitate form, potassium nitrate and sodium monofluorophosphate respectively. The responses were evaluated at 0, 1 day, 1, 2, 4 and 8 weeks respectively for all groups and later statistically analysed.

**Results:** HAP treated teeth showed statistically significant reduction in hypersensitive symptoms ( $p < 0.001$ ) requiring fewer applications compared to other groups at the end of 1<sup>st</sup> day, 2 and 8 weeks respectively. At the end of 8 weeks, all 4 groups showed significant change from baseline scores ( $p < 0.001$ ).

**Conclusion:** HAP showed definite potential as an effective permanent desensitizer when compared to potassium nitrate and sodium monofluorophosphate when used as an in-office procedure. However, its efficacy when used as part of dentifrice like the other 2 agents needs further research.

**Keywords:** Hypersensitivity; Pain measurement; Dentin desensitizing agents; Durapatite (HAP); Potassium nitrate; Sodium monofluorophosphate

## Background

Tooth hypersensitivity due to exposed dentinal tubules is a common finding in the adult population, with as many as 1 in 7 (8-57%) patients attending for dental treatment [1,2]. The subjects' evaluation of their own overall sensitivity, i.e. subject assessment, has been used frequently to measure hypersensitivity in clinical studies [3]. This assessment is done through various types of stimuli, which can be applied on the teeth to evoke a response from the patient. Patient's own perception of overall hypersensitivity, as experienced by them, following application of various stimuli, can be reported using either a verbal rating scale (VRS) [4], or a visual analogue scale (VAS) [5].

A number of treatment options are currently available for the treatment of hypersensitivity. Agents may bring about their therapeutic effects, either by partial or complete obturation of dentinal tubules (tubule occluding agents), by anti-inflammatory activity, protein precipitation, or sealing the tubules.

Research into the use of the mineral components of the inorganic portion of the tooth structure, i.e. calcium and phosphate has evoked considerable interest [6-11], and has inspired the preparation of hydroxyapatite (HAP), for occlusion of dentinal tubules [12]. Numerous studies have also reported the application of hydroxyapatite in various formulations, as dentifrices and gels in the treatment of tooth hypersensitivity [13-17]. Potassium nitrate [18-20] and sodium monofluorophosphate [21,22] are popular and proven desensitizing agents with worldwide usage and applications.

A pilot study evaluating the efficacy of Hydroxyapatite as an in-

office desensitizing agent found it to be very effective [12], therefore, the present study was undertaken with the primary objective of evaluating the clinical effectiveness of HAP, in comparison with potassium nitrate and sodium monofluorophosphate in treating hypersensitivity at 0, 1 day, 1 week, 2 weeks, 4 weeks and 8 weeks, following usage.

## Materials and Methods

### The clinical study

Following the approval of the Ethical Committee, Government Medical College, Nagpur, an experimental double blind randomized controlled clinical trial was carried out on 50 patients (22 males and 28 females) between the age group of 28 to 42 years, visiting the outpatient department, Government dental college, Nagpur, during the period between October 2001 and March 2002.

A special Performa was designed to have a systematic and methodical recording of all the observations and information, which included a detailed case history, clinical examination, relevant

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information related to the hypersensitivity, precipitating causes and past treatment received, along with a written consent of the patient for willingness to participate in the study.

### Patient selection

**Inclusion criteria:** 1. Presence of minimum of two hypersensitive teeth in each of the four quadrants.

2. Hypersensitivity of teeth to tactile, cold and air stimulation.
3. Teeth having hypersensitivity only on facial aspect (recession or abrasion)
4. Patients' willingness to participate in the study.

**Exclusion criteria:** 1. Patients who had taken any treatment for hypersensitivity within the last 6 months.

2. Patients having any form of restorations performed on the hypersensitive teeth within last 6 months.
3. Patients with clinical or radiographic evidence of pulp pathos's.
4. Teeth having carious lesions or restorations.
5. Patients with hypersensitivity due to attrition/erosion.

The subjects selected underwent thorough clinical examination, followed by oral prophylaxis, oral hygiene instructions and dietary counseling. Changes in dentin sensitivity to tactile stimuli (dental explorer), thermal stimuli (drops of melted ice) and air stimuli (blast from dental syringe) were evaluated, after the teeth were isolated with cotton rolls. Following application of these stimuli, responses were evaluated and assessed by the Verbal Rating Scale (VRS) and the Visual Analogue Scale (VAS).

At the outset, 68 patients fulfilled the criteria for selection, of which, 8 patients refused to sign the written consent to participate in the study. An additional 9 patients failed to keep up follow up appointments at the set time intervals, and 1 patient was deliberately excluded for statistical reasons to make it a even study sample size of 50.

716 hypersensitive teeth in the 50 patients were divided randomly into the 4 groups (A, B, C and D) to be treated by the four different agents (Table 1). Thus in each patient, the hypersensitive teeth in the 4 quadrants were randomly divided (by drawing lots) into the 4 groups as follows:

Group A–Hypersensitive teeth treated with HAP dry sol gel powder.

Group B–Hypersensitive teeth treated with HAP liquid precipitate.

Group C–Hypersensitive teeth treated with 5% potassium nitrate.

Group D–Hypersensitive teeth treated with 5% potassium nitrate with sodium monofluorophosphate.

The responses of the subjects to the various stimuli in each group

Age groups	Gender			Hypersensitive areas		
	males	females	Total	males	Females	Total
25-30	2	2	4	48	36	84
31-35	10	6	16	124	82	206
36-40	7	12	19	84	172	256
41-45	3	8	11	64	106	170
Total	22	28	50	320	396	716

**Table 1:** Basic demographic and clinical characteristics of the study groups.

were recorded as a sum of the VRS and VAS scores (after taking an average of 3 readings by different operators) at '0' day, preoperatively, and at 1 day, 1 week, 2 weeks, 4 weeks and 8 weeks, postoperatively.

Before application of the desensitizing agent, the areas to be treated were completely isolated with cotton rolls and saliva ejectors. The hypersensitive surfaces of groups A, B, C and D were etched with 37% phosphoric acid to remove the smear layer. Randomization was done by allotting 4 different operators designated A, B,C and D, for applying the 4 different agents randomly and at the same time ensuring that they were completely unaware of the agent they were administering. The hypersensitive scores at various time intervals for all the patients were recorded by other operators, who were in turn unaware of the agents applied. The patients were blinded by not letting them know which agent was applied where. The chief investigator, the first author in this study, coordinated the entire trial and recruited the various operators for the same.

### The desensitizing agents

Hydroxyapatite (HAP) is a recent innovation in the treatment of dentinal hypersensitivity, and even today happens to be the only in-office agent to be tested clinically [12]. The rationale behind the use of hydroxyapatite stems from the fact that it would permanently occlude the open dentinal tubules and blend with them, as it is similar to the inorganic composition of the tooth thereby bringing about permanent desensitization. It had been supplied as pre-sterilized packs in two forms [12]: HAP liquid precipitate and HAP dry sol gel powder.

HAP Liquid precipitate form [12] - For *in situ* precipitation of hydroxyapatite in dentinal tubules, two solutions were employed. The first solution was an aqueous solution of a calcium salt, and the second, an aqueous solution of sodium phosphate. These solutions were alternately applied on the tubule site for 1 minute each, and then repeated again after 5 minutes. Separate cotton swabs were used for applying the two solutions, so as not to allow mixing of the two solutions or cause turbidity. The gelatinous precipitate was then gently burnished into the open dentinal tubules.

The dry sol gel form of HAP [12] was a readymade powder. This fine powder was burnished onto the hypersensitive surface. Direct application of the fine powder was suggested, as it enhanced the direct penetration into the dentinal tubules.

Potassium nitrate# and sodium monofluorophosphate¶, containing dentifrices

#Thermoseal, ICPA, Mumbai, India.

¶Senquel F, Group pharmaceuticals, Mumbai, India.

Were directly burnished onto the hypersensitive tooth surfaces, uniformly for a period of 30 seconds. The patient was then made to rinse the mouth with plain water.

Applications of the agents were repeated every day for 1 week. Responses to the various stimuli were evaluated by using the same tactile and thermal stimuli used earlier, and the scores were recorded at 1 day, 1 week, 2 weeks, 4 weeks and 8 weeks, respectively, following their application. The number of applications of a particular desensitizing agent required to obtain a favorable response (score 0 or 1) were also recorded.

At the end of 8 weeks, all the data maintained separately by the various operators were compiled, and the results were statistically analyzed.

## Statistical analysis

The total scores (VRS+VAS) of all the patients recorded at 0 day, 1 day, 1 week, 2 weeks, 4 weeks and 8 weeks, respectively, on the basis of their responses to the 3 stimuli were statistically analyzed with SPSS V13 software and Microsoft excel 2007, using Kruskal-Wallis Chi-square test and Wilcoxon signed Ranks test.

## Results

### Comparison of change in scores (from baseline to other time intervals) within each group (intra group) (Table 2)

Mean scores in group A were 32.26 + 0.48(baseline), 10.9+ 0.28 (1<sup>st</sup> day), 11.78 + 0.41 (1<sup>st</sup> week), 10.98 + 0.29 (2<sup>nd</sup> week), 8.42 + 0.15 (4<sup>th</sup> week) and 8.94 + 0.18 (8<sup>th</sup> week), respectively.

Mean scores in group B were 32.38+0.43(baseline), 12.12+0.34(1<sup>st</sup> day), 12.92+0.44(1<sup>st</sup> week), 12.58+0.44(2<sup>nd</sup> week), 8.78+0.56(4<sup>th</sup> week) and 8.32+0.41(8<sup>th</sup> week), respectively.

Mean scores in group C were 31.84+0.41(baseline), 14.46+0.50(1<sup>st</sup> day), 12.66+0.49(1<sup>st</sup> week), 14.06+0.42(2<sup>nd</sup> week), 8.70+0.35(4<sup>th</sup> week) and 8.30+0.25 (8<sup>th</sup> week), respectively.

Mean scores in group D were 32.10+0.41(baseline), 16.88+0.52 (1<sup>st</sup> day), 13.12+0.47(1<sup>st</sup> week), 15.52+0.6(2<sup>nd</sup> week), 8.08+0.41(4<sup>th</sup> week) and 8.14+0.39(8<sup>th</sup> week), respectively.

The reduction in mean scores within each of the groups A, B, C and D (intra group) was found to be statistically significant from baseline to 1<sup>st</sup> day (P<0.001), 1<sup>st</sup> week (P<0.001), 2<sup>nd</sup> week (P<0.001), 4<sup>th</sup> week (P<0.001) and 8<sup>th</sup> week (P<0.001), respectively.

### Comparison of change in scores (from baseline to other time intervals) between groups (inter group) (Table 3)

The difference in mean scores between the groups was not

statistically significant at baseline (P>0.05), with mean difference in being 32.26+0.48 in group A, 32.38+0.43 in group B, 31.84+0.41 in group C and 32.10+0.41 in group D.

However, the difference in mean scores between the groups was found to be statistically significant (P<0.001) at day 1, with mean differences being 10.90+0.28 in group A, 12.12+0.34 in group B, 14.46+0.50 in group C and 16.88+0.52 in group D, respectively. In addition, the difference in mean scores was found to be statistically significant between Group a & Group B (P<0.05), Group A & Group C (P<0.001), Group A and Group D (P<0.001), Group B and Group C (P<0.01), Group B and Group D (P<0.001) and Group C and Group D (P<0.001).

Similarly, the mean differences in the 2<sup>nd</sup> week in group A (10.98+0.29), group B (12.58+0.44), group C (14.06+0.42) and group D (15.52+0.6), respectively, were also found to be statistically significant. (p<0.001) with significant difference between Group A and Group B (P<0.01), Group A and Group C (P<0.001), Group A and Group D (P<0.001) and Group B and Group D (P<0.01).

In the 8<sup>th</sup> week, the mean differences in group A(8.94+0.18), group B (8.32+0.41), group C (8.30+0.25) and group D(8.14+0.39), respectively, were also statistically significant( p<0.001) with significant difference between Group A and Group B (P<0.05), Group A and Group C (P<0.01), as well as Group A and Group D (P<0.01).

The difference in mean scores between the groups was not statistically significant (P>0.05) at the end of 1 week and 4 weeks.

### Comparison of the number of applications in each group (Table 4)

Chi-square test values revealed that the number of applications of the desensitizing agent needed to obtain relief in the different treatment groups showed statistical significance (P<0.001), with group A and

GROUPS	Time interval	Mean	Std dev	SE of Mean	Mean difference	Z	P-Value
GROUP A (N=50)	Baseline	32.26	3.40	0.48	---	---	---
	1st day	10.90	2.00	0.28	-21.360	-6.181	<0.001*
	1st week	11.78	2.89	0.41	-20.480	-6.161	<0.001*
	2nd week	10.98	2.03	0.29	-21.280	-6.162	<0.001*
	4th week	8.42	1.09	0.15	-23.840	-6.162	<0.001*
	8th week	8.94	1.28	0.18	-23.320	-6.170	<0.001*
GROUP B (N=50)	Baseline	32.38	3.05	0.43	---	---	---
	1st day	12.12	2.39	0.34	-20.260	-6.162	<0.001*
	1st week	12.92	3.10	0.44	-19.460	-6.161	<0.001*
	2nd week	12.58	3.09	0.44	-19.800	-6.168	<0.001*
	4th week	8.78	3.93	0.56	-23.600	-6.164	<0.001*
	8th week	8.32	2.87	0.41	-24.060	-6.169	<0.001*
GROUP C (N=50)	Baseline	31.84	2.89	0.41	---	---	---
	1st day	14.46	3.50	0.50	-17.380	-6.160	<0.001*
	1st week	12.66	3.47	0.49	-19.180	-6.162	<0.001*
	2nd week	14.06	2.96	0.42	-17.780	-6.161	<0.001*
	4th week	8.70	2.50	0.35	-23.140	-6.160	<0.001*
	8th week	8.30	1.76	0.25	-23.540	-6.160	<0.001*
GROUP D (N=50)	Baseline	32.10	2.88	0.41	---	---	---
	1st day	16.88	3.67	0.52	-15.220	-6.159	<0.001*
	1st week	13.12	3.33	0.47	-18.980	-6.160	<0.001*
	2nd week	15.52	4.26	0.60	-16.580	-6.163	<0.001*
	4th week	8.68	2.90	0.41	-23.420	-6.169	<0.001*
	8th week	8.14	2.73	0.39	-23.960	-6.176	<0.001*

Table 2: Comparison of change in scores from baseline to other time intervals in the groups: (wilcoxon signed ranks test).

Time interval	Groups	Mean	Std dev	SE of Mean	Min	Max	Kruskal-Wallis Chi-sq	P-Value	Significance
baseline	Group A	32.26	3.40	0.48	24	37	1.929	0.587	None
	Group B	32.38	3.05	0.43	24	37			
	Group C	31.84	2.89	0.41	24	36			
	Group D	32.10	2.88	0.41	24	36			
1 <sup>st</sup> day	Group A	10.90	2.00	0.28	7	14	75.397	<0.001*	AvsB, AvsC, AvsD
	Group B	12.12	2.39	0.34	8	16			BvsC, BvsD
	Group C	14.46	3.50	0.50	10	26			CvsD
	Group D	16.88	3.67	0.52	9	24			
1 <sup>st</sup> week	Group A	11.78	2.89	0.41	6	17	3.862	0.277	Not significant between any of the groups
	Group B	12.92	3.10	0.44	7	17			
	Group C	12.66	3.47	0.49	8	20			
	Group D	13.12	3.33	0.47	8	18			
2 <sup>nd</sup> week	Group A	10.98	2.03	0.29	7	14	42.542	<0.001*	AvsB, AvsC, AvsD
	Group B	12.58	3.09	0.44	6	18			BvsD
	Group C	14.06	2.96	0.42	10	22			
	Group D	15.52	4.26	0.60	10	28			
4 <sup>th</sup> week	Group A	8.42	1.09	0.15	6	10	1.053	0.789	Not significant between any of the groups
	Group B	8.78	3.93	0.56	3	21			
	Group C	8.70	2.50	0.35	4	17			
	Group D	8.68	2.90	0.41	3	16			
8 <sup>th</sup> week	Group A	8.94	1.28	0.18	6	12	12.841	0.005*	AvsB, AvsC, AvsD
	Group B	8.32	2.87	0.41	3	18			
	Group C	8.30	1.76	0.25	6	14			
	Group D	8.14	2.73	0.39	4	17			

\*denotes significant difference.

Table 3: Comparison of the groups at various time intervals.

No of applications	Treatment groups				Total	χ <sup>2</sup>	P-value
	A	B	C	D			
1	30	30	7	13	80	53.293	<0.001*
2	17	11	15	11	54		
3	3	4	18	19	44		
4	0	3	7	5	15		
> 5	0	2	3	2	7		
<b>TOTAL</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>200</b>		

\*denotes significant association.

The association between no. of applications and the treatment groups was found to be statistically significant (P<0.001), with group A and group B having lesser no. of applications, compared to group C and group D, which had higher no. of applications.

Table 4: Association between no. of applications and groups.

group B requiring lesser number of applications compared to group C and group D, which had higher number of applications.

## Discussion

Although most hypersensitive teeth are sensitive to more than one stimulus, not all teeth respond to the same stimulus [23]. Based on the recommendations of the Ad Hoc Advisory Committee on Dental Hypersensitivity (1986) [24] and American Dental Association, Council of Dental Therapeutics (1989) [25], three different stimuli—tactile, air and cold water were used to assess hypersensitivity in the study.

Currently no single method of eliciting and assessing cervical dentin sensitivity may be considered ideal [26], and hence, a combined assessment using two different methods seemed appropriate to eliminate the deficiencies of either one method, which was why the verbal rating scale (VRS) and the Visual analogue scale (VAS) were used in the present study. The VRS offers a restrictive choice of words, which may not represent the pain experience, with significant precision for all patients [27,28]. On the other hand, the validity and reliability of

the VAS for both experimental and clinical pain has been demonstrated by several investigators [29]. The VAS also appears to be more sensitive in discriminating between various treatments and changes in pain intensity [30].

Literature has shown that the transmission of pain stimuli across the dentin is by a hydrodynamic mechanism [30]. Logically, one approach to treatment would be the occlusion of the tubules, or based on Poisseuille's law, at least a reduction in tubule diameter [31].

Hydroxyapatite is a natural mineral constituent of teeth and bones, and hence, use of this material as a desensitizing agent to occlude dentinal tubules was highly desirable. Numerous efforts have been made towards precipitation of hydroxyapatite *in vitro* by calcium phosphate precipitation methods [6,10].

The motivation for synthesizing HAP by hydrothermal means has been to obtain nanosized particles for infiltration of dentinal tubules, for the alleviation of hypersensitivity. However, it was concluded that these crystallites were larger than dentinal tubule diameters, therefore, indicating that smaller, more equiaxed or spherical particles may be

desirable for dentine tubule infiltration [7]. The beneficial effects of HAP powder as an abrasive component of medical toothpaste and toothpowder in alleviation of hypersensitivity symptoms has also been confirmed [8]. Mechanical incorporation of HAP grains in the abraded dentine and obturation of some dentinal canaliculi was observed *in vitro* in SEM studies [8].

*In vitro* studies have also suggested that use of HAP containing dentifrices is better than fluoride 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 nano-structured HAP particles, which closely resemble mineral enamel constituents [13,16,17].

The use of the nano-HAP paste was associated with a statistically significant reduction in tooth sensitivity experienced during active bleaching [32], and also when used clinically to alleviate the symptoms of hypersensitivity [14,15].

The HAP used in the study was also prepared by hydrothermal methods and size of the particles was in microns that were ideal for dentinal tubule penetration, wherein the openings are 5-10 microns in diameter. Hydroxyapatite dispersed in a liquid had an effective concentration of 25% and Hydroxyapatite dry sol gel powder was 100% Hydroxyapatite. In the present study, both these forms were found to be equally effective in reducing hypersensitivity symptoms, giving highly significant results ( $p < 0.001$ ) in a very short period with limited number of applications, which was also statistically significant ( $p < 0.001$ ). Almost 60% of patients got relief within a day with the first application itself. In addition, no recurrences of symptoms were reported in both the HAP groups till the end of 8 weeks.

A recent study carried out with HAP containing dentifrice has shown that it has similar effect in reducing hypersensitivity as pre-existing benchmark tooth paste (strontium chloride) [9]. This could be due to the fact that when used as a dentifrice, the effects of HAP may have been minimized due to interference by the other ingredients in the dentifrice [33]. The burnishing that is done in the in-office procedure ensures thorough penetration of the agent into the tubules and a sustained desensitization, thereby preventing dislodgement from the tubules by mechanical factors, such as diet and tooth brushing, which may not be possible to be achieved with a dentifrice. SEM studies have also confirmed that the dentinal tubules were occluded predominantly with apatite mineral, not only on the dentin surface, but also deep inside the dentinal tubules to a depth of 10 to 15  $\mu\text{m}$  from the dentin surface [6,8,10].

In the present study, effective tubule occlusion by HAP could have possibly occurred, as evidenced by the pilot study [12], as chemically these agents are composed of calcium and phosphate, and the saliva in the oral cavity is supersaturated with respect to hydroxyapatite [9], thus, the chances of dissolution of these compounds by saliva are limited.

Potassium nitrate has been one of the oldest agents used in the management of hypersensitivity and has been considered a superior desensitizer by Hodosh in 1974, as it could cause rapid relief of symptoms. The group treated with 5% potassium nitrate in the present study showed significantly reduced scores ( $p < 0.001$ ) at the end of the 1<sup>st</sup> day, 2<sup>nd</sup> week and 8 weeks, respectively, which is in accordance with literature claiming the efficacy of the agent in reducing hypersensitivity over a period of 12 to 22 weeks [34,35].

However, although there was significant change in scores on day

1, 2 weeks and 8 weeks, no significant change was observed at 1 week and 4 weeks. This could possibly be explained if the exact mechanism of action of potassium nitrate is ascertained. On the one hand, it has been suggested that potassium nitrate may occlude the tubules and cause desensitization, [36] whereas on the other hand, it has been shown that high solubility of potassium nitrate in the oral fluids may preclude any long term effect [37]. This may in part explain the change in hypersensitivity scores, leading to recurrence of hypersensitivity symptoms in patients after a period of time. With repeated applications, however, the symptoms subsided.

The potassium nitrate- monofluorophosphate combination was used to encompass benefits of both aspects of densitisation-tubule occlusion and nerve inexcitation. The group treated with this agent showed statistically significant reduction in scores at the end of 8 weeks ( $p < 0.001$ ), as with other studies done with the agent [38,39].

In addition, the beneficial effects of monofluorophosphate in reducing hypersensitivity has also been reported [40], with suggestions that the desensitizing effects of the agent were long lasting in duration, at least for a 6 week period of time [41].

However, as with the potassium nitrate group, no significant change was observed at the end of 1 week and 4 weeks, as against the 1<sup>st</sup> day, 2 weeks and 8 weeks. This data is in accordance with the findings of Blunden et al. [42], who suggested that SEM studies on monofluorophosphate, *In vitro*, alone or in the presence of saliva produced no visual changes on the dentin surface and tubules remained patent. Furthermore, these agents were a constituent of a dentifrice, and the effects of other ingredients in the dentifrice vehicle may considerably interfere with the effects of monofluorophosphate [43].

Although it was observed that all 4 agents did not differ significantly in their desensitizing effects at the end of 8 weeks, there were considerable statistically significant differences ( $p < 0.01$ ) in the number of applications required by each of the agents in bringing about relief of hypersensitivity symptoms. HAP treated teeth required lesser number of applications to obtain a favorable response. Most patients obtained relief within the first or second application, which was sustained for a period of 8 weeks, which was not the case with the other agents, where 5 or more applications of the agent provided relief. This further reiterates the permanent desensitizing effects of hydroxyapatite due to its tubule occluding and blending capacity, as suggested by other studies leading to quicker and long lasting effect [6,10].

On the other hand, potassium nitrate and sodium monofluorophosphate probably required more time to exert their effects due to their high solubility rate in the oral cavity, leading to inadequate retention in the hypersensitive tooth area [37], or their inability to produce the desired effects due to the other ingredients in the dentifrice vehicle, which may have interfered with their activity as mentioned earlier [43].

In hypersensitivity studies, all three groups usually improve over a period of 4 to 8 weeks, although the rate of improvement may differ among groups [33], which were also observed in our study.

### Limitations of the Study

Larger sample size and a longer duration of the trial to ascertain sustained effects, along with comparison with other more popular commercially available agents and procedures, such as lasers, could have been attempted. In addition, the efficacy of HAP, when used as a part of a dentifrice, needs further research.

## Conclusion

Based on the results obtained in this randomized double blinded controlled clinical trial, Hydroxyapatite, no doubt shows definite potential, as an effective desensitizing agent, providing quick and sustained relief from symptoms, when compared to the other agents, although hypersensitivity symptoms were substantially reduced in all the treatment groups.

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## References

1. Oral care and Dentinal hypersensitivity: Prevalence (2010). Medscape.
2. Irwin CR, McCusker P (1997) Prevalence of dentine hypersensitivity in a general dental population. *J Ir Dent Assoc* 43: 7-9.
3. Gillam DG, Newman HN (1993) Assessment of pain in cervical dentinal sensitivity studies. A review. *J Clin Periodontol* 20: 383-394.
4. Ohnhaus EE, Adler R (1975) Methodological problems in the measurement of pain: a comparison between the verbal rating scale and the visual analogue scale. *Pain* 1: 379-384.
5. Carlsson AM (1983) Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. *Pain* 16: 87-101.
6. Ishikawa K, Suge T, Yoshiyama M, Kawasaki A, Asaoka K, et al. (1994) Occlusion of dentinal tubules with calcium phosphate using acidic calcium phosphate solution followed by neutralization. *J Dent Res* 73: 1197-1204.
7. Earl JS, Wood DJ, Milne SJ (2006) Hydrothermal synthesis of hydroxyapatite. *J Phys Conf Ser* 26: 268-271.
8. Anna S, Zofia KK, Ewa S, Zofia P (1998) Cracow hydroxyapatite ceramics-a product report. *Med Sci Monit* 4: 172-175.
9. Su HK, Jun BP, Chul WL, Ki TK, Tae IK, et al. (2009) The clinical effects of a hydroxyapatite containing toothpaste for dentin hypersensitivity. *J Korean Acad Periodontol* 39: 87-94.
10. Suge T, Ishikawa K, Kawasaki A, Yoshiyama M, Asaoka K, et al. (1995) Duration of dentinal tubule occlusion formed by calcium phosphate precipitation method: *in vitro* evaluation using synthetic saliva. *J Dent Res* 74: 1709-1714.
11. Suge T, Ishikawa K, Kawasaki A, Yoshiyama M, Asaoka K, et al. (1995) Effects of fluoride on the calcium phosphate precipitation method for dentinal tubule occlusion. *J Dent Res* 74: 1079-1085.
12. Shetty S, Kohad R, Yeltiwar R (2010) Hydroxyapatite as an in-office agent for tooth hypersensitivity: A clinical and scanning electron microscopic study. *J Periodontol* 81: 1781-1789.
13. Roveri N, Foresti E, Lelli M, Lesci IG (2009). Recent advancements in preventing teeth health hazard: The daily use of hydroxyapatite instead of fluoride. *Recent Pat Biomed Eng* 2: 197-215.
14. Hüttemann RW, Strübel G, Rzekpa-Glinder V, Dönges H (1989) Investigation of utility and mechanics of use of hydroxyapatite for therapy of hypersensitive tooth root. *ZWR* 98: 240-245.
15. Barone M, Malpassi M (1991) Clinical trial of a 15% supermicronized hydroxyapatite gel for dentin hypersensitivity. *G Ital Endod* 5: 43-47.
16. Terri Tilliss (2011) Calcium phosphate technology products treat demineralization, dental hypersensitivity. *Dentistry*.
17. Wang ZJ, Sa Y, Ma X, Wang YN, Jiang T (2009) The preparation of nano-hydroxyapatite and preliminary observation on its effects on the occlusion of dentinal tubule. *Zhonghua Kou Qiang Yi Xue Za Zhi* 44: 297-300.
18. Hodosh M (1974) A superior desensitizer--potassium nitrate. *J Am Dent Assoc* 88: 831-832.
19. Kim S (1986) Hypersensitive teeth: desensitization of pulpal sensory nerves. *J Endod* 12: 482-485.
20. Nagata T, Ishida H, Shinohara H, Nishikawa S, Kasahara S, et al. (1994) Clinical evaluation of a potassium nitrate dentifrice for the treatment of dentinal hypersensitivity. *J Clin Periodontol* 21: 217-221.
21. McFall WT Jr, Hamrick SW (1987) Clinical effectiveness of a dentifrice containing fluoride and a citrate buffer system for treatment of dentinal sensitivity. *J Periodontol* 58: 701-705.
22. Hernandez F, Mohammed C, Shannon I, Volpe A, King W (1972) Clinical study evaluating the desensitizing effect and duration of two commercially available dentifrices. *J Periodontol* 43: 367-372.
23. Trowbridge HO, Silver DR (1990) A review of current approaches to in-office management of tooth hypersensitivity. *Dent Clin North Am* 34: 561-581.
24. (1986) Recommendations for evaluating agents for the reduction of dentinal hypersensitivity. Ad Hoc Advisory Committee on Dentinal Hypersensitivity Council on Dental Therapeutics. *J Am Dent Assoc* 112: 709-710.
25. (1989) Safety of dental amalgam--an update. Council on Dental Materials, Instruments, and Equipment. Council on Dental Therapeutics. *J Am Dent Assoc* 119: 204-205.
26. Huskisson EC (1974) Measurement of pain. *Lancet* 2: 1127-1131.
27. Clark GE, Troullos ES (1990) Designing hypersensitivity clinical studies. *Dent Clin North Am* 34: 531-544.
28. Joyce CR, Zutshi DW, Hrubes V, Mason RM (1975) Comparison of fixed interval and visual analogue scales for rating chronic pain. *Eur J Clin Pharmacol* 8: 415-420.
29. Pashley DH (1990) Mechanisms of dentin sensitivity. *Dent Clin North Am* 34: 449-473.
30. Brannstrom M (1963) Dentin sensitivity and aspiration of odontoblasts. *J Am Dent Assoc* 66: 366-370.
31. Greenhill JD, Pashley DH (1981) The effects of desensitizing agents on the hydraulic conductance of human dentin *in vitro*. *J Dent Res* 60: 686-698.
32. Browning WD, Cho SD, Deschepper EJ (2012) Effect of a nano-hydroxyapatite paste on bleaching-related tooth sensitivity. *J Esthet Restor Dent* 24: 268-276.
33. Addy M (1990) Etiology and clinical implications of dentine hypersensitivity. *Dent Clin North Am* 34: 503-514.
34. Collins JF, Gingold J, Stanley H, Simring M (1984) Reducing dentinal hypersensitivity with strontium chloride and potassium nitrate. *Gen Dent* 32: 40-43.
35. Silverman G (1986) The effectiveness of 2 dentifrices in relieving dentin hypersensitivity. *J Dent Res* 65: 297.
36. Krauser JT (1986) Hypersensitive teeth. Part II: Treatment. *J Prosthet Dent* 56: 307-311.
37. Addy M, Dowell P (1983) Dentine hypersensitivity--a review. Clinical and *in vitro* evaluation of treatment agents. *J Clin Periodontol* 10: 351-363.
38. Chesters R, Kaufman HW, Wolff MS, Huntington E, Kleinberg I (1992) Use of multiple sensitivity measurements and logit statistical analysis to assess the effectiveness of potassium-citrate-containing dentifrice in reducing dentin hypersensitivity. *J Clin Periodontol* 19: 256-261.
39. Silverman G (1985) The sensitivity-reducing effect of brushing with a potassium nitrate-sodium monofluorophosphate dentifrice. *Compend Contin Educ Dent* 6: 131-133.
40. McFall WT Jr, Hamrick SW (1987) Clinical effectiveness of a dentifrice containing fluoride and a citrate buffer system for treatment of dentinal sensitivity. *J Periodontol* 58: 701-705.
41. Hernandez F, Mohammed C, Shannon I, Volpe A, King W (1972) Clinical study evaluating the desensitizing effect and duration of two commercially available dentifrices. *J Periodontol* 43: 367-372.
42. Blunden R, Howe S, Dowell P, Addy M, Adamas D, et al. (1981) The effects of compounds used clinically in the management of dentin hypersensitivity on some physical properties of dentin. *J Dent Res, IADR, British division: A* 130.
43. Addy M, Morgan T (1982) The effect of toothpaste on the electrical resistance and SEM appearances of dentin. *J Dent Res* 61: 547.