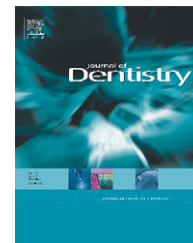


Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.intl.elsevierhealth.com/journals/jden

Efficacy in reducing dentine hypersensitivity of a regimen using a toothpaste containing 8% arginine and calcium carbonate, a mouthwash containing 0.8% arginine, pyrophosphate and PVM/MA copolymer and a toothbrush compared to potassium and negative control regimens: An eight-week randomized clinical trial

Augusto R. Elias Boneta^{a,*}, Karol Ramirez^a, Joselyn Naboia^b, Luis R. Mateo^c, Bernal Stewart^d, Foti Panagokos^d, William De Vizio^d

^a University of Puerto Rico, School of Dental Medicine, San Juan, Puerto Rico, USA

^b Calle Juan Bautista, Vicini #5, Condominio Delfin, Santo Domingo, Dominican Republic

^c LRM Statistical Consulting, Hoboken, NJ, USA

^d Colgate-Palmolive Technology Center, Piscataway, NJ, USA

ARTICLE INFO

Article history:

Received 25 June 2012

Received in revised form

16 November 2012

Accepted 17 November 2012

Keywords:

Efficacy

Dentine

Hypersensitivity

Mouthwash

Tactile

Air-Blast

ABSTRACT

Objective: Evaluate the efficacy of three regimens integrating toothpaste, toothbrush and mouthwash in reducing dentine hypersensitivity.

Methods: Eight-week single-centre, three-cell, double-blind, randomized study was conducted in the Dominican Republic. Subjects entered one of the three regimens: (1) toothpaste containing 8% arginine and 1450 ppm mono-fluorophosphate, in a calcium carbonate base, a soft-bristle toothbrush followed by a mouthwash containing 0.8% arginine, PVM/MA copolymer, pyrophosphates, and 0.05% sodium fluoride; (2) toothpaste containing 5% potassium nitrate and 1450 ppm sodium fluoride, a soft-bristle toothbrush, followed by a mouthwash containing 0.51% potassium chloride and 230 ppm sodium fluoride; and (3) toothpaste containing 1450 ppm mono-fluorophosphate, a soft-bristle toothbrush followed by a fluoride/arginine free mouthwash. Tactile and Air-Blast dentine hypersensitivity measurements were performed at baseline, two, four, and eight weeks. For treatment group comparisons, ANCOVA and post hoc Tukey's pair-wise ($\alpha = 0.05$) were used. Kaplan–Meier survival analysis was performed to evaluate Time to Treatment Improvement.

Results: 120 subjects were enrolled, 118 completed the study. The Tactile hypersensitivity mean scores showed statistically significant improvement at two, four and eight ($p \leq 0.001$) weeks in the arginine regime; the potassium regime did not show significant ($p \geq 0.05$) improvement. Air-Blast Hypersensitivity scores had a statistically significant decrease at two ($p = 0.006$), four ($p = 0.006$) and eight ($p = 0.002$) weeks in arginine and potassium regimes ($p \leq 0.05$). The most effective treatment proved to be arginine ($p \leq 0.05$) compared to the potassium regime.

* Corresponding author at: 1928 Calle Orquidea, Santa María, San Juan, Puerto Rico 00927, USA. Tel.: +1 787 758 3919.

E-mail address: Augusto.Elias@upr.edu (A.R. Elias Boneta).

0300-5712/\$ – see front matter © 2013 Published by Elsevier Ltd.

<http://dx.doi.org/10.1016/j.jdent.2012.11.011>

Conclusion: Arginine regimen provided the greatest reduction in Tactile and Air-Blast dentine hypersensitivity compared to potassium and negative control regimens; and provides faster dentine hypersensitivity relief than potassium regimen.

© 2013 Published by Elsevier Ltd.

1. Introduction

Dentine hypersensitivity is described as a short, sharp pain caused when exposed dentine responds to stimuli.¹ Predominantly, this sharp pain occurs when the root surface becomes exposed through gingival recession uncovering the dentine tubule orifices.² It usually results as a consequence of thermal, evaporative, tactile, osmotic, or chemical stimulus; and it cannot be attributed to other dental conditions.³

The prevalence of dentine hypersensitivity has been reported from 4 to 57%, in adults.⁴ This condition is more common in adults from 20 to 49 years old, with highest prevalence in ages 30–39.¹ In addition, the prevalence of dentine hypersensitivity has been described to be higher in females than males.⁵ Other risk factors include: gingival recession, removal of the tooth's enamel, as well as, consumption of certain foods or drinks.^{6–8} Chemical or physical forces such as a change in temperature and air movement stimulus have been associated with dental hypersensitivity.⁹ Brännström's Hydrodynamic Theory¹⁰ suggests that external stimuli cause movement of the dentine fluid in the tubules, resulting in a pressure change across dentine.¹¹ This stimulates intra-dental nerve response signals that are ultimately interpreted by the brain as pain.¹²

The most common oral health care products for the management of dentine hypersensitivity are toothpastes and mouthrinses. Toothpastes containing potassium salts are frequently used for dentine hypersensitivity.¹³ The mechanism of action of these products is not clear, but it has been proposed that the use of toothpastes leads to a depolarization of the membrane of nerve fibres that prevent repolarization; thus inhibiting the pain sensation.¹⁴ Potassium-based toothpastes may contain additional ingredients such as fluoride, antibacterial ingredients, crystal inhibitors and high cleaning abrasives that can reduce hypersensitivity.¹⁴ A recent review summarizes the inconsistent evidence of efficacy of potassium-based toothpastes in the hypersensitivity reduction compared to fluoride toothpaste.¹³

Clinical studies have assessed the efficacy of potassium salt and sodium fluoride mouthrinses for the treatment of dentinal hypersensitivity.^{15–17} Gillam and his coworkers compared the effectiveness of a 3% potassium nitrate and sodium fluoride mouthrinse with a control sodium fluoride mouthrinse to treat cervical dentine sensitivity.¹⁸ These authors demonstrated that the mouthrinse containing potassium nitrate significantly reduced cervical dentine sensitivity two and six weeks after product use compared to the control mouthrinse. Pereira and Chava compared the effectiveness of dentinal hypersensitivity in the treatment of a 3% potassium nitrate and sodium fluoride mouthrinse to a control mouthrinse containing sodium fluoride, using tactile and cold air sensitivity.¹⁹ At six weeks, the dentine

hypersensitivity of the test mouthrinse was significantly reduced compared to the control mouthrinse that used only the cold air technique. An arginine-calcium carbonate desensitizing toothpaste has proven to be an effective method for the management of dentinal hypersensitivity in vitro and clinical studies.²⁰ Arginine and calcium work together to deposit a dentine-like material (calcium and phosphate) forming a plug and a protective layer on the surface of the dentinal tubules.^{21–23} Several studies have demonstrated the effect of the arginine-calcium carbonate-containing toothpaste on dentine hypersensitivity. A clinical trial using 8.0% arginine, calcium carbonate, and 1450 ppm fluoride toothpaste reduced dentinal hypersensitivity in response to Tactile and Air-Blast dentinal hypersensitivity after two, four and eight weeks of product use compared to a toothpaste containing 2% potassium ions.²¹ In addition, three other studies have observed the same results.^{22–24}

Recently, an arginine-based mouthwash has been developed for the treatment of dentine hypersensitivity base (Colgate-Palmolive Co., New York, NY). This mouthwash has been evaluated in several clinical studies that demonstrate the positive effect on reducing dentine hypersensitivity.^{25–28} There is no evidence that an arginine-based regimen reduces dentine hypersensitivity. The objectives of this study were (1) to evaluate three home care regimens, each comprising the use of a dentifrice, toothbrush and mouthwash on dentine hypersensitivity over an eight-week period; and (2) to determine whether an arginine-based regimen provides faster relief for dentine hypersensitivity than potassium-based and sodium fluoride regimens. Our hypothesis was that an arginine-containing regimen is more effective, thereby providing faster relief for dentine hypersensitivity compared to potassium and negative control regimens.

2. Materials and methods

This clinical study used a randomized, double blind, three-treatment, parallel design. Adult subjects from a private dental clinic in Santo Domingo, Dominican Republic area were enrolled in the study.

Sample size was based on estimates of the standard deviation of 0.527 for Air-Blast and 10.18 for Tactile sensitivity scores. With a sample size of $n = 120$ (40 per group), this test is capable of detecting a change of 7.2 (35%) for Air-Blast and Tactile scores, respectively with 95% confidence, and 80% power.

Prospective study subjects reported to the clinical facility having refrained from all oral hygiene procedures and from chewing gum for 8 h, and from eating and drinking for 4 h prior to their examination.

3. Inclusion and exclusion criteria

1. Subjects ranged between 18 and 70 years old, and in good health.
2. Subjects possessed at least two hypersensitive teeth, which were anterior to the molars, with demonstrated cervical erosion, abrasion or gingival recession; and with tactile sensitivity stimuli scores of 10–30 g of force (Yeaple Probe), and Air-Blast stimuli scores of 2 or 3 (Schiff Cold Air Sensitivity Scale) present and measured at the baseline examination.
3. Subjects were available to participate during the eight-week duration of the study, and agreed to sign an informed consent form.
4. Subjects presenting gross oral pathology, chronic disease, advanced periodontal disease, those who had undergone treatment for periodontal disease (within the last 12 months), or had hypersensitive teeth with mobility greater than one were excluded from the study.
5. Subjects with teeth that had extensive/defective restorations (including prosthetic crowns), suspected pulpitis, caries, cracked enamel or that were used as abutments for removable partial dentures were also excluded from the study.
6. Subjects were excluded from the study if they began taking anticonvulsants, antihistamines, antidepressants, sedatives, tranquilizers, anti-inflammatory drugs or daily analgesics within one month prior to the start of the study, or if they start taking them during the course of the study.
7. Pregnant or lactating women, individuals who were participating in any other clinical study or who had participated in a desensitizing dentifrice study or had used a desensitizing dentifrice within the last three months, were not allowed to participate in the study.
8. Subjects with a history of allergy to the test products, or allergies to oral care/personal care consumer products or their ingredients, or subjects with existing medical conditions, which precluded them from eating and drinking for periods up to 4 h were also excluded from the study.

For each subject who qualified for participation in the study, two hypersensitive teeth that satisfied the Tactile and Air-Blast hypersensitivity enrollment criteria were identified for evaluation throughout the study. Qualifying subjects were sequentially randomized using a list of random numbers. The subjects in the study were evaluated for Tactile and Air-Blast hypersensitivity criteria at baseline, two, four and eight weeks.

To maintain the blinding of the study participants, examiners and all study personnel, all toothpastes and mouthwashes were over-wrapped. All test products were distributed in sealed opaque bags in an area separate from the examination room by site personnel not involved in the clinical evaluations. The three product regimens were letter coded.

The three regimens for treatment consisted: of brushing with the assigned soft-bristle toothbrush and toothpaste for 1 min twice a day, during the morning and evening. It was followed by rinsing with regimen's mouthrinse:

1. An arginine regimen: brushing with a toothpaste containing 8% arginine and 1450 ppm fluoride, as sodium monofluorophosphate, in a calcium carbonate base; and rinsing with 20 ml of a mouthwash (for 30 s), containing 0.8% arginine, PVM/MA copolymer, pyrophosphates, and 0.05% sodium fluoride, in an alcohol-free base (Colgate-Palmolive Co., New York, NY).
2. Potassium regimen: brushing with a toothpaste containing 5% potassium nitrate and 1450 ppm fluoride, as sodium fluoride, in a silica base; and rinsing with 15 ml of a mouthwash (for 1 min) containing 0.51% potassium chloride and 230 ppm sodium fluoride, in an alcohol base (GlaxoSmithKline Co., UK).
3. Negative control regimen: brushing with a toothpaste containing 1450 ppm fluoride in a di-calcium phosphate base; and rinsing (for 30 s) with 20 ml of a mouthwash without fluoride or arginine (Colgate-Palmolive Co., New York, NY).

For this study, the subjects were not allowed to employ any additional oral hygiene procedures, such as flossing or using inter-dental stimulators. In addition, subjects were instructed to refrain from chewing gum for eight hours and from eating and drinking for four hours prior to their follow-up hypersensitivity evaluations. There were no other restrictions regarding diet or smoking habits during the course of the study.

4. Clinical scoring procedures

4.1. Tactile hypersensitivity assessment

Tactile hypersensitivity was assessed using the Model 200A Electronic Force Sensing Probe developed by Yeaple Research of Pittsford, NY. The application of this probe for dental hypersensitivity testing utilizing #19 explorer tip at a pre-set force measured in grams was used.

The tactile hypersensitivity²⁹ was evaluated as described below:

- 1) The explorer tip of the probe was applied to the buccal surface of each hypersensitive tooth at the CEJ.

The explorer tip was stroked perpendicular to the tooth beginning at a pre-set force of 10 grams (0.01 kg) then increased by 10 g (0.01 kg) increments until the subject experienced discomfort, or until 50 grams of force (0.05 kg) was applied.

Subject scores were calculated by averaging the values measured on the two baseline-designated study teeth.

4.2. Air-Blast hypersensitivity assessment

The Air-Blast hypersensitivity was assessed as mentioned below:

- 1) The sensitive tooth was isolated from the adjacent teeth (mesial and distal) by the placement of the examiner's fingers over the adjacent teeth.
- 2) Air was delivered from a standard dental unit air syringe at 60 psi (4.22 kgf/cm²) (± 5 psi) (0.35 kgf/cm²), and 70 °F

Table 1 – Summary of age & gender: for subjects who completed the eight-week clinical study.

Treatment	Age (years) ^a Mean (range)	Gender ^a		Total N
		Male n (%)	Female n (%)	
Arginine regimen	39 (19–58)	20 (50.0%)	20 (50.0%)	40
Potassium regimen	33 (20–59)	22 (55.0%)	18 (45.0%)	40
Negative control	39 (18–61)	13 (34.2%)	25 (65.8%)	38

^a No statistically significant difference was indicated between the three treatment groups with respect to either gender or age ($p > 0.05$).

(21) ± 3 °F (–16). The air was directed at the exposed buccal surface of the hypersensitive tooth for 1 s from a distance of approximately 1 cm.

3) The Schiff Cold Air Sensitivity Scale²⁹ was used to assess subject response to this stimulus. This scale was scored as follows:

- 0 – Subject did not respond to air stimulus.
- 1 – Subject responded to air stimulus, but did not request discontinuation of stimulus.
- 2 – Subject responded to air stimulus and requested discontinuation or moved from stimulus.
- 3 – Subject responded to air stimulus, considered stimulus to be painful and requested discontinuation of the stimulus.

4.3. Oral soft and hard tissue assessment

The dental examiner visually examined the oral cavity and peri-oral area using a dental light and dental mirror. This examination included an evaluation of the soft and hard palate, gingival mucosa, buccal mucosa, mucogingival fold areas, tongue, sublingual and submandibular areas, salivary glands, and the tonsillar and pharyngeal areas.

Oral soft and hard tissue assessments, as well as Tactile and Air-Blast hypersensitivity follow-up evaluations of baseline-designated study teeth, were conducted after two, four and eight weeks of product use. The same trained and standardized dental examiner performed all examinations, using the same procedures as employed at baseline.

4.4. Adverse events

Adverse events were obtained from an interview with the subjects and from a dental examination by the investigator.

5. Statistical methods

Analysis of variance (ANOVA) and an analysis of covariance (ANCOVA) were performed to assess a reduction in hypersensitivity. The baseline Tactile and Air-Blast mean scores were compared using an (ANOVA). Then, (ANCOVA) was done to compare the mean Tactile and Air-Blast hypersensitivity scores of the different regimens after two, four, and eight weeks of products use. Post hoc pair-wise mean comparisons of the study regimens were performed using Tukey's test. All statistical tests of hypotheses were two-sided at significance level of $\alpha = 0.05$.

A Kaplan–Meier survival analysis was used to compare treatment groups with respect to the time required to

accomplish time treatment improvement (TTI). A threshold of 50% improvement in hypersensitivity score, defined as 50% of the difference between the baseline score and the “terminal” score (Air-Blast = 0, tactile = 50) was used to assess TTI.³⁰ If a subject crossed the threshold by first post-treatment visit, the subject's TTI was “interval censored” between day 0 and 14. Similarly, subjects with threshold crossings, which occurred after the first visit, but before the second and after the second, but before the third visit, were interval censored between days 14 and 28 and days 28 and 56, respectively. If a subject did not cross the threshold by the third visit, the TTI time for that subject was considered “right censored.” To determine the statistical significant difference between arginine containing regimen and potassium regimen groups a log rank and Wilcoxon tests were performed. A level of significance of $\alpha = 0.05$ was used.

6. Results

One-hundred and twenty (120) subjects were enrolled during the second week of October, 2011; and randomized in three study groups of forty (40) participants. One hundred and eighteen (118) participants completed the eight-week clinical study during the second week of December, 2011. As depicted in Table 1, gender ($p = 0.1601$) and age ($p > 0.05$) distribution in the three regimen groups did not differ significantly statistically.

As depicted in Table 2, there were no statistically significant differences among Tactile hypersensitivity mean scores at baseline in the three regimens ($p > 0.05$). After two weeks of product use, subjects in the arginine-containing regimen showed a statistically significant improvement in baseline-adjusted mean tactile hypersensitivity scores compared to potassium or negative control regimens of 61.2%, and 92.5% ($p < 0.001$), respectively. After four weeks of product use, subjects in the arginine-containing regimen also exhibited a statistically significant improvement in baseline-adjusted mean Tactile hypersensitivity scores compared to potassium and negative control regimens of 54.5%, and 121% ($p < 0.001$), respectively. After eight weeks of product use, subjects in the arginine-containing regimen demonstrated a statistically significant improvement in baseline-adjusted mean Tactile hypersensitivity scores relative to the potassium and negative control regimens of 68.6%, and 135.7% ($p < 0.001$), respectively. There was no statistically significant difference between subjects in the potassium and negative control regimens, after two ($p = 0.430$), four ($p = 0.072$), and eight ($p = 0.146$) weeks.

Table 2 – Summary of the tactile hypersensitivity scores for subjects who completed the eight-week clinical study.

Treatment	Baseline ^a (mean ± sd)	Two-week (mean ± sd)	% Difference two-week		Four-week (mean ± SD)	% Difference four-week		Eight-week (mean ± SD)	% Difference eight-week		n
			Potassium regimen	Neg. control regimen		Potassium regimen	Neg. control regimen		Potassium regimen	Neg. control regimen	
Arginine regimen	10.13 ± 0.79	19.75 ± 10.37	61.2% (<i>p</i> < 0.001)	92.5% (<i>p</i> < 0.001)	25.88 ± 12.5	54.5% (<i>p</i> < 0.001)	121% (<i>p</i> < 0.001)	32.88 ± 14.23	68.6% (<i>p</i> < 0.001)	135.7% (<i>p</i> < 0.001)	40
Potassium regimen	10.25 ± 1.10	12.25 ± 4.52	–	19.4% (<i>p</i> = 0.430)	16.75 ± 8.96	–	0.43% (<i>p</i> = 0.072)	19.50 ± 11.42	–	39.8% (<i>p</i> = 0.146)	40
Neg. control regimen	10.00 ± 0.00	10.26 ± 1.13	–	–	11.71 ± 4.10	–	–	13.95 ± 7.46	–	–	38

^a Regimens are not statistically significantly different from each other at baseline (*p* > 0.05).

Table 3 – Summary of the Air-Blast hypersensitivity scores for subjects who completed the eight-week clinical study.

Treatment	Baseline ^a (mean ± SD)	Two-week (mean ± SD)	% Difference two-week		Four -Week (mean ± SD)	% Difference Four-Week		Eight-Week (mean ± SD)	% Difference Eight-Week		N
			Potassium regimen	Neg. control regimen		Potassium regimen	Neg. control regimen		Potassium regimen	Neg. control regimen	
Arginine regimen	2.44 ± 0.44	1.25 ± 0.79	32.4% (<i>p</i> < 0.001)	44.4% (<i>p</i> < 0.001)	0.90 ± 0.72	32.8% (<i>p</i> = 0.006)	58.5% (<i>p</i> < 0.001)	0.61 ± 0.82	49.6% (<i>p</i> = 0.002)	70.2% (<i>p</i> < 0.001)	40
Potassium regimen	2.39 ± 0.40	1.85 ± 0.61	–	17.8% (<i>p</i> = 0.016)	1.34 ± 0.68	–	38.2% (<i>p</i> < 0.001)	1.21 ± 0.79	–	41% (<i>p</i> < 0.001)	40
Neg. control regimen	2.43 ± 0.42	2.25 ± 0.55	–	–	2.17 ± 0.62	–	–	2.05 ± 0.75	–	–	38

^a Regimens are not statistically significantly different from each other at baseline.

Table 4 – Analysis of Time to Improvement for Subjects Who Completed the Eight-Week Clinical Study.

Measurement	Threshold	p-Value for differences in TTI distributions between products		Mean (days)		Median (days)	
		Log rank	Wilcoxon	Arginine regimen	Potassium regimen	Arginine regimen	Potassium regimen
Tactile	50% Improvement	$p = 0.001$	$p = 0.002$	43.4	50.1	56	n/a [†]
Air-Blast	50% Improvement	$p = 0.001$	$p \leq 0.001$	24.5	37.8	14	28

[†] n/a indicates that the median could not be calculated due to the treatment group not crossing the 50th percentile threshold.

As depicted in Table 3, there were no statistically significant differences among Air-Blast hypersensitivity mean scores at baseline in the three regimens of treatments ($p > 0.05$). After two weeks of product use, subjects in the arginine-containing regimen showed a statistically significant reduction in baseline-adjusted mean Air-Blast hypersensitivity scores compared to the potassium and the negative control regimens of 32.4%, and 44.4% ($p < 0.001$), respectively. Furthermore, the subjects in the potassium regimen showed a statistically significant reduction in baseline-adjusted mean scores compared to the negative control regimen of 17.8% ($p = 0.016$), after two weeks. After four weeks of product use, subjects in the arginine-containing regimen showed a statistically significant reduction in baseline-adjusted mean Air-Blast hypersensitivity scores relative to the potassium or negative control regimens of 32.8% ($p = 0.006$), and 58.5% ($p < 0.001$), respectively. Subjects in the potassium regimen also exhibited a statistically significant reduction in baseline-adjusted means relative to the negative control regimen of 38.2% ($p < 0.001$), after four weeks. After eight weeks of product use, subjects in the arginine-containing regimen presented statistically significant reduction in baseline-adjusted mean Air-Blast hypersensitivity scores relative to the potassium regimen and negative control regimen of 49.6% ($p = 0.002$) and 70.2% ($p < 0.001$), respectively. In addition, subjects in the potassium regimen exhibited a statistically significant reduction in baseline-adjusted means relative to the negative control regimen of 41% ($p < 0.001$), after eight weeks.

Table 4 presents the results of the Tactile and Air-Blast Kaplan–Meier Time Treatment Improvement Analysis (TTI). A comparison of the mean TTI times for the two regimens showed that the arginine-containing regimen group had lower mean TTI for both tactile (24.5 vs. 37.8 days) and Air-Blast (43.4 vs. 50.1 days) sensitivity. The log rank and Wilcoxon test analysis showed that the arginine-containing regimen group had faster sensitivity relief compared to subjects in the potassium regimen group for both Tactile ($p = 0.001$ and $p = 0.002$), respectively) and Air-Blast ($p = 0.001$ and $p < 0.001$, respectively) sensitivity.

7. Discussion

The objectives of this study were to evaluate the efficacy of three dental regimens of toothpaste, toothbrush, and

mouthwash in reducing dentine hypersensitivity after an eight-week period; and to determine whether the arginine-containing regimen provides faster relief than the regimen based on Potassium in dentine hypersensitivity. We hypothesized that the arginine-containing regimen is more effective, and provides dentine hypersensitivity relief significantly faster than the potassium and negative control regimens. Indeed, in this study the arginine-containing regimen was shown to be more effective than a regimen consisting of potassium-based toothpaste and mouthwash and to negative control regime. Nevertheless, the potassium-based regimen provided inconsistent results in our study. The potassium-based regime provided dentine hypersensitivity relief compared to the negative control regimen when measured using the Air-Blast technique, but it did not provide dentine hypersensitivity relief when measured using tactile scores. Finally, the TTI analysis demonstrated that the dentine hypersensitivity relief provided by the arginine containing regimen was faster than the potassium regimen.

To the best of our knowledge this is the first clinical trial that reports the efficacy of an arginine-containing regimen for the relief of dentine hypersensitivity. However, previous clinical trials have established the efficacy of arginine-containing toothpastes against potassium-based and sodium fluoride toothpastes in the treatment of dentine hypersensitivity.^{21–24,31} Moreover, two additional studies have shown reduction in dentine hypersensitivity using arginine compared to potassium-based and negative control mouthwashes.^{16,17} Inconsistent results have been reported when comparing to potassium-based and sodium fluoride toothpastes in the relief in dentine hypersensitive.^{15–19,32} Similar results were found in our study.

8. Conclusion

This study demonstrated that an arginine-containing regimen significantly reduced Tactile and Air-Blast dentine hypersensitivity compared to potassium and negative control regimens. Also, the arginine-containing regimen provided significantly faster dentine hypersensitivity relief compared to the potassium-containing regimen.

The present study was approved and registered in “Concordia Clinical Research, Institutional Review Board” under IRB #175E.

This study was sponsored by Colgate-Palmolive, New York, NY.

Conflict of Interest Statement

Bernal Stewart, Fotinos Panagakos and William De Vizio are employees of the Colgate-Palmolive Company.

Acknowledgements

Jomar Díaz-Nicolás, DMD, Universidad Central del Este and University of Puerto Rico, School of Dental Medicine
Omar García-Rodríguez, University of Puerto Rico, School of Dental Medicine and Graduate School of Public Health.

REFERENCES

1. Addy M. Dentine hypersensitivity: new perspectives on an old problem. *International Dental Journal* 2002;52:367–75.
2. Canadian Advisory Board on Dentin Hypersensitivity. Consensus-based recommendations for the diagnosis and management of dentin hypersensitivity. *Journal of the Canadian Dental Association* 2003;69:221–6.
3. Pashley DH, Tay FR, Haywood VB, Collins MC, Drisko CL. Dentin hypersensitivity: consensus-based recommendations for the diagnosis and management of dentin hypersensitivity. *Inside Dentistry* 2008;4:1–35.
4. Dababneh RH, Khouri AT, Addy M. Dentine hypersensitivity—an enigma? A review of terminology, epidemiology, mechanisms, aetiology and management. *British Dental Journal* 1999;187:606–11.
5. Addy M. Dentine hypersensitivity: definition, prevalence distribution and aetiology. In: Addy M, Embery G, Edgar WM, Orchardson R, editors. *Tooth wear and sensitivity: clinical advances in restorative dentistry*. London: Martin Dunitz; 2000. p. 239–48.
6. Drisko CH. Dentine hypersensitivity. Dental hygiene and periodontal considerations. *International Dental Journal* 2002;52:385–93.
7. Zero DT, Lussi A. Etiology of enamel erosion. Intrinsic and extrinsic factors. In: Addy, Embery, Edgar, Orchardson, editors. *Tooth wear and sensitivity*. London: Martin Dunitz; 2000. p. 121–39.
8. Zero DT, Lussi A. Erosion – chemical and biological factors important to the dental practitioner. *International Dental Journal* 2005;5:285–90.
9. West NX. Dentine hypersensitivity. In: Lussi A, editor. *Dental Erosion*. Basel: Karger; 2006. p. 173–89.
10. Brännström M. A hydrodynamic mechanism in the transmission of painproduced stimuli through the dentine. In: Anderson DJ, editor. *Sensory mechanisms in dentine*. London: Pergamon Press; 1963. p. 73–9.
11. Brännström M, Johnson G. Movements of the dentine and pulp liquids on application of thermal stimuli. *Acta Odontologica Scandinavica* 1970;28:59–70.
12. Brännström M. Etiology of dentin hypersensitivity. *Proceedings of the Finnish Dental Society* 1992;88:7–13.
13. Cummins D. Dentin hypersensitivity. From diagnosis to a breakthrough therapy for everyday sensitivity relief. *Journal of Clinical Dentistry* 2009;20:1–9.
14. Orchardson R, Gillam DG. Managing dentin hypersensitivity. *The Journal of the American Dental Association* 2006;137:990–8. *Inside Dent* 2008; 4, 1–37.
15. Silverman G, Gingold J, Clark GE. The effectiveness of potassium nitrate and sodium monofluorophosphate dentifrices in reducing dentinal hypersensitivity. *Journal of Dental Research* 1988;67:247.
16. Ayad F, Berta R, DeVizio W, McCool JJ, Petrone ME, Volpe AR. Comparative efficacy of two dentifrices containing potassium nitrate on dentinal sensitivity: a twelve-week clinical study. *Journal of Clinical Dentistry* 1994;5:97–101.
17. Wara-aswapati N, Kringnawakul D, Jiraviboon D, Adulyanon S, Karimbux N, Pitiphat W. The effect of a new toothpaste containing potassium nitrate and triclosan on gingival health, plaque formation and dentine hypersensitivity. *Journal of Clinical Periodontology* 2005;32:553–8.
18. Gillam DG, Bulman JS, Jackson RJ, Newman HN. Efficacy of a potassium nitrate mouthrinse in alleviating cervical dentin sensitivity (CDS). *Journal of Clinical Periodontology* 1996;21:993–7.
19. Pereira R, Chava VK. Efficacy of a 3% potassium nitrate desensitizing mouthrinse in the treatment of dentinal hypersensitivity. *Journal of Periodontology* 2001;72:1720–5.
20. García-Godoy F. Dentin Hypersensitivity. The effects of an arginine-calcium carbonate and fluoride desensitizing dentifrice. *American Journal of Dentistry* 2010;23:2A.
21. Ayad F, Ayad N, Zhung YP, DeVizio W, Cummins D, Mateo LR. Comparing the efficacy in reducing dentin hypersensitivity of a new toothpaste containing 8.0% arginine, calcium carbonate, and 1450 ppm fluoride to a commercial sensitive toothpaste containing 2% potassium ion. *The Journal of Clinical Dentistry* 2009;20:10–6.
22. Schiff T, Delgado E, Zhang YP, Cummins D, DeVizio W, Mateo LR. Clinical evaluation of the efficacy of an in-office desensitizing paste containing 8.0% arginine and calcium carbonate in providing instant and lasting relief of dentin hypersensitivity. *American Journal of Dentistry* 2009;22: 8A–15A.
23. Docimo R, Montesani L, Maturo P, Costacurta M, Bartolino M, DeVizio W, et al. Comparing the efficacy in reducing dentin hypersensitivity of a new toothpaste containing 8.0% arginine, calcium carbonate and 1450 ppm fluoride to a commercial sensitive toothpaste containing 2% potassium ion: an eight-week clinical study in Rome, Italy. *The Journal of Clinical Dentistry* 2009;20:17–22.
24. Docimo R, Montesani L, Maturo P, Costacurta M, Bartolino M, Zhang YP, et al. Comparing the efficacy in reducing dentin hypersensitivity of a new toothpaste containing 8.0% arginine, calcium carbonate, and 1450 ppm fluoride to a benchmark commercial desensitizing toothpaste containing 2% potassium ion: an eight-week clinical study in Rome, Italy. *The Journal of Clinical Dentistry* 2009;20:137–43.
25. Mello SV, Arvanitidou E, Stanick M, Santana R, Kutes Y, Huey B. Mode of action studies of a new desensitizing mouthwash containing 0.8% Arginine, PVM/MA copolymer, pyrophosphates, and 0.05% sodium fluoride. *Journal of Dentistry* 2013;41S:S12–9.
26. Mello SV, Arvanitidou E, Vandeven M. The development of a new desensitizing mouthwash containing arginine, PVM/MA Copolymer, Pyrophosphates, and Sodium Fluoride – a hydraulic conductance study. *Journal of Dentistry* 2013;41S:S20–5.
27. Hu D, Mateo LR, Stewart B, Zhang YP, Panagakos F. Clinical investigation to evaluate dentin hypersensitivity reduction of a mouthwash containing 0.8% arginine, PVM/MA Copolymer, Pyrophosphates, and 0.05% Sodium Fluoride as Compared to a Negative Control Mouthwash Over an Eight-Week Period. *Journal of Dentistry* 2013;41S:S26–33.
28. Boneta AE, Galan RM, Mateo LR, Stewart B, Mello S, Arvanitidou E, et al. A clinical investigation to evaluate the efficacy of a mouthwash containing 0.8% arginine, PVM/MA copolymer, pyrophosphates, and 0.05% sodium fluoride as compared to a commercial mouthwash containing 2.4% potassium nitrate and 0.022% sodium fluoride and to a

- control mouthwash containing 0.05% sodium fluoride on dentin hypersensitivity: a six-week clinical study on adults in the Dominican Republic. *Journal of Dentistry* 2013;**41S**:S34-41.
29. Clark GE, Troullos ES. Designing hypersensitivity clinical studies. *Dental Clinics of North America* 1990;**34**:531-43.
 30. Bellamy N, Bell MJ, Goldsmith CH, Pericak D, Walker V, Raynauld JP, et al. Evaluation of WOMAC 20, 50, 70 response criteria in patients treated with hylan G-F 20 for knee osteoarthritis. *Annals of Rheumatic Diseases* 2005;**64**:881-5.
 31. Que K, Fu Y, Lin L, Hu D, Zhang YP, Panagakos FS, et al. Dentin hypersensitivity reduction of a new toothpaste containing 8.0% arginine and 1450 ppm fluoride: an 8-week clinical study on Chinese adults. *American Journal of Dentistry* 2010;**23**:28A-35A.
 32. Schiff T, Dotson M, Cohen S, De Vizio W, McCool J, Volpe A. Efficacy of a dentifrice containing potassium nitrate, soluble pyrophosphate PVM/MA copolymer, and sodium fluoride on dentinal hypersensitivity: a twelve-week clinical study. *The Journal of Clinical Dentistry* 1994;**5**:87-92.