*J Dent Sci* 2009;4(4):173–177

ORIGINAL ARTICLE

# Clinical efficacy of toothpaste containing potassium citrate in treating dentin hypersensitivity

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Received: Aug 17, 2009
Accepted: Nov 20, 2009

**KEY WORDS:**
dentin hypersensitivity;
potassium citrate;
toothpaste;
visual analog scale

**Background/purpose:** Many adults suffer from sensitivity, and dentin hypersensitivity is most commonly the result of exposed dentin which can sometimes trigger pain or discomfort when eating, drinking or simply brushing. The purpose of this study was to evaluate the clinical efficacy of desensitizing toothpaste containing potassium citrate in treating dentin hypersensitivity.
**Materials and methods:** This study was performed at the Department of Periodontics, Chung Shan Medical University Hospital. In total, 172 volunteers who provided informed consent were included in the study. A visual analog scale (VAS) was used to indicate dentin sensitivity in response to an air stimulus. Participants who had a VAS score of 30–80 were qualified for the study and were provided with their assigned desensitizing toothpaste containing potassium citrate (Colgate Sensitive Multi Protection) and a soft-bristled adult toothbrush for home use. After 4 weeks, the hypersensitive teeth were examined again, and the VAS score was also recorded.
**Results:** In this study, 38% (65/172) participants were found to suffer from dentin hypersensitivity, 40 persons who reported VAS scores of 30–80 were qualified for the clinical trial. Among these, 34 (85%) participants reported reduced dentin hypersensitivity after using the desensitizing toothpaste containing potassium citrate for 4 weeks. The mean value of the VAS score prior to the use of the toothpaste was 50.72, while the mean value of the VAS score after use was 30.68. The use of Colgate Sensitive Multi Protection was found to significantly reduce dentin hypersensitivity after 4 weeks ($P<0.01$).
**Conclusion:** The prevalence of dentin hypersensitivity in this study was 38%. The use of desensitizing toothpaste containing potassium citrate with oral hygiene instruction can effectively reduce dentin hypersensitivity.

## Introduction

Dentin hypersensitivity is one of the most commonly encountered dental problems, and estimates of its prevalence in the adult dentate population range from 8% to 57%.[1,2] It was shown to peak in 20–30 year olds and then rise again when people are in their 50s.[3] When thermal, tactile, osmotic and mechanical stimuli, such as tooth brushing, sweet and sour foods, and hot or cold water, are applied to the exposed dentin, patients feel a short sharp pain which is termed dentin hypersensitivity.[4,5] Most

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dentin hypersensitivity is a result of abrasion, attrition, erosion, abfraction, gingival recession, and improper brushing habits. Sites of predilection in descending order are the canines, first premolars, incisors, second premolars, and molars.[6]

Several theories have been put forward to explain the mechanisms involved in dentin hypersensitivity. Several hypotheses have been proposed to explain it:[7,8] (1) odontoblasts and their processes act as dentinal receptor mechanisms; and (2) pulp nerves are stimulated by a hydrodynamic mechanism, and nerve impulses in the pulp are modulated by the release of certain polypeptides during pulp injury. Of these, the most widely accepted theory is the so-called hydrodynamic theory of sensitivity. This theory postulates that rapid shifts, in either direction, of fluids within the dentinal tubules following stimulus application result in activation of sensory nerves in the pulp/inner dentin region of the tooth.[9]

Treatment for dentin hypersensitivity may include mucogingival surgery, a pulpectomy, and application of resin, lasers, topical desensitizing agents, and desensitizing toothpaste.[7] Desensitizing toothpaste is considered the simplest and most cost-effective treatment for most patients. Toothpastes with ingredients that include stannous fluoride, strontium chloride hexahydrate, aluminum ferric oxalates, potassium ferric oxalates, and fluorides are designed to reduce flow in the dentin tubules by occluding or sclerosing the tubules.[7] The most widely and simplest available desensitizing toothpaste ingredients are potassium compounds.[10] Potassium ions are thought to block the action potential generated in intradental nerves.

A clinical examination to measure levels of pain responses to dentin hypersensitivity stimuli might include a subjective assessment of tactile and cold stimuli. Whatever methods are used, they should be reproducible and quantifiable. The Yeaple probe and a new mechanical probe which run over the area of exposed dentin represent the state of the art for tactile sensitivity testing. A blast of cold air from a triple syringe offers the potential for a well-controlled thermal stimulus. Care should be taken to ensure, as much as possible, that neither stimulus interferes with the other stimulus used in the measuring procedure.[11]

The visual analog scale (VAS) offers the advantage of being a continuous scale, thus providing quantitative measurements. The validity and reliability of the VAS for measuring both experimental and clinical pain are well demonstrated.[11,12] The purpose of this study was to investigate the effects of a toothpaste containing potassium citrate (Colgate Sensitive Multi Protection; Colgate-Palmolive, Amphur Muang, Chonburi, Thailand) on dentin-hypersensitive teeth over a 4-week period to reduce hypersensitivity. Symptoms and signs of dentin hypersensitivity were measured using a VAS.

## Materials and methods

### *Patient selection*

This study was performed in the Department of Periodontics, Chung Shan Medical University Hospital. In total, 172 volunteers (99 males and 73 females) were recruited after informed consent was obtained. The inclusion criteria were: (1) patients must have good general health with no known allergies to commercial dental products; (2) patients must not have used desensitizing toothpaste within the last 3 months; (3) the study teeth must be decay-free and have no restorations; (4) the study teeth had to have clinical mobility of = grade 1; (5) the study teeth had to show signs of facial/cervical erosion, abrasion, and/or gingival recession; and (6) patients had to be able to read and understand the consent form and be willing to sign it.

Exclusion criteria included: (1) teeth which had undergone periodontal surgery within the past 6 months or been scaled/root planed within the past 3 months; (2) pregnant or lactating women; (3) individuals demonstrating gross oral neglect or requiring extensive dental therapy; (4) teeth used as abutments for fixed or removable partial dentures, or teeth with full crowns or obvious cracks in the enamel; (5) subjects who were unable to strictly adhere to product use; (6) subjects who had taken certain medications (anti-inflammatory drugs or antibiotics) on a daily basis during the previous 7 days; and (7) subjects suffering from a chronic medical disease or conditions which are associated with intermittent episodes or constant daily pain, such as arthritis.

### *Measurements*

A VAS is commonly used to assess dentin hypersensitivity.[13,14] A VAS consists of a 100-mm line with *0* at one end indicating not painful at all and *100* at the other end indicating extremely painful. A participant was asked to draw a vertical line on the horizontal scale at a point that corresponded to his/her reaction to the air stimulus. Teeth identified by the subject were tested for thermal sensitivity using a 1-second air blast 1 cm from the study tooth after isolating the tooth from the adjacent teeth using cotton rolls. Volunteers were asked to place a vertical mark on the line that represented the intensity of their pain on the

100-mm scale. Volunteers who had VAS scores of 30–80 qualified for the clinical study. One tooth was tested in each subject.

### *Experimental procedures*

This was a single-blinded design study. The brand name of the toothpaste (Colgate Sensitive Multi Protection) was hidden, so that participants did not know what brand of toothpaste they were given. Participants who met the criteria (VAS scores of 30–80) were provided with their assigned dentifrice and a soft-bristled adult toothbrush for home use after receiving some basic oral hygiene instruction. Toothpaste was applied to the entire length of the brush. Participants were asked to brush their teeth twice a day. Four weeks later, participants returned for the final examination of their pre-selected sensitive teeth as described above.

### *Statistical analysis*

In order to determine the effect of Colgate Sensitive Multi Protection on hypersensitive teeth, VAS scores were analyzed using the Wilcoxon signed rank test. A level of significance of $\leq 0.05$ was used for each comparison.

## Results

As shown in Fig. 1, 107 participants (69 males and 38 females) did not respond to the air blast stimulus and had a VAS score of 0. Sixty-five (30 males and 35 females) participants reported VAS scores of $>10$. The prevalence of dentin hypersensitivity in this study was thus 38% (65/172).

Forty participants (20 males and 20 females) who met the criteria (VAS scores of 30–80) qualified for the clinical study. The VAS scores of each person at the baseline and 4 weeks later are shown in Table 1. Thirty-four of the 40 (85%) participants were found to have reduced dentin hypersensitivity after using Colgate Sensitive Multi Protection for 1 month (Table 2). The percentage of improvement was 90% in females and 80% in males. The sites examined in descending order were canines, first premolars, incisors, second premolars, and molars (Table 3). Table 4 illustrates changes in the mean VAS sensitivity scores for air stimuli after the 4-week period. Scores decreased after desensitizing toothpaste use, from 50.72 mm at the baseline to 30.68 mm at the end of the 4-week period. Desensitizing toothpaste containing potassium citrate was found to have significantly reduced dentin hypersensitivity ($P<0.01$).

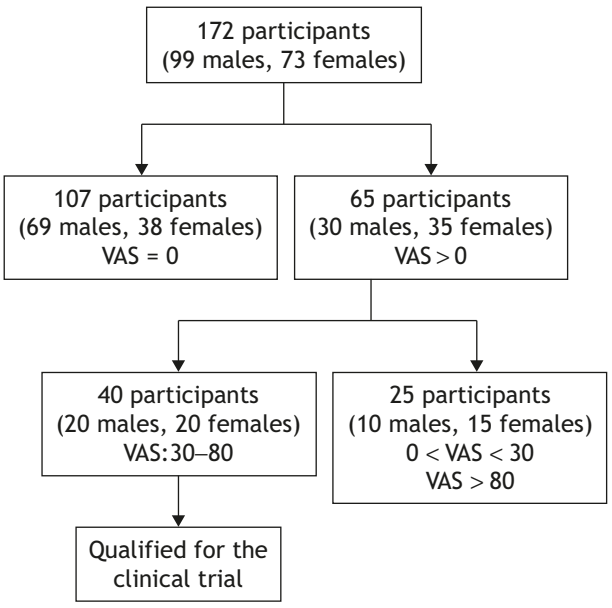


**Fig. 1** Distribution of participants in this study.

## Discussion

The prevalence of dentin hypersensitivity was widely reported previously. Graf and Galasse[15] reported a prevalence of 14.5%, while Irwin and McCusker[2] reported a prevalence of 57%. The study by Irwin and McCusker[2] was carried out using a sensitivity questionnaire with no subsequent clinical examination, so that it is likely to have overestimated the prevalence owing to inclusion of other causes of sensitivity. One report showed a prevalence of 32% in Taiwanese by evaluating the presence of cervical dentin hypersensitivity by means of a questionnaire and intraoral tests.[16] Consistently, our result showed that 38% of participants suffered from dentin hypersensitivity. This wide variation in prevalence may be due to certain factors, including different methods used to diagnose the condition, sensitivity questionnaire-based surveys probably exaggerating the true figure, and variations in the consumption of erosive drinks.

A clinical examination for dentin hypersensitivity includes objective assessments, such as a tactile or thermal stimulus.[11] Often individuals do not respond to all types of stimuli, but classically clinicians only use the air-blast stimulus.[17] Prolonged air blasts have an unknown and varying temperature effect, which can be avoided by using a short application time, usually 1 second. The 1-second air blast is easily controlled and is the best period for a dentin hypersensitivity assessment.[11,18] Those are the reasons why the teeth identified by subjects were tested using a 1-second air blast in the present study.

**Table 1.** Visual analog scale (VAS) scores at the baseline and after 4 weeks of using desensitizing toothpaste containing potassium citrate

| Patient no. | Sex | VAS I (baseline) | VAS II (4 weeks) |
|---|---|---|---|
| 1 | F | 71 | 53 |
| 2 | F | 37 | 26 |
| 3 | F | 44 | 29 |
| 4 | F | 32 | 16 |
| 5 | M | 52 | 29 |
| 6 | M | 78 | 37 |
| 7 | M | 57 | 26 |
| 8 | M | 42 | 23 |
| 9 | M | 43 | 28 |
| 10 | F | 55 | 43 |
| 11 | F | 49 | 11 |
| 12 | F | 36 | 39 |
| 13 | F | 43 | 18 |
| 14 | M | 41 | 18 |
| 15 | M | 59 | 26 |
| 16 | M | 44 | 29 |
| 17 | M | 73 | 75 |
| 18 | M | 26 | 12 |
| 19 | F | 61 | 41 |
| 20 | M | 74 | 29 |
| 21 | F | 42 | 12 |
| 22 | F | 38 | 0 |
| 23 | F | 26 | 27 |
| 24 | M | 26 | 29 |
| 25 | F | 60 | 34 |
| 26 | M | 76 | 80 |
| 27 | M | 64 | 36 |
| 28 | F | 58 | 37 |
| 29 | F | 32 | 16 |
| 30 | F | 54 | 32 |
| 31 | M | 44 | 47 |
| 32 | M | 51 | 23 |
| 33 | F | 30 | 15 |
| 34 | F | 49 | 33 |
| 35 | M | 63 | 47 |
| 36 | F | 57 | 39 |
| 37 | F | 58 | 27 |
| 38 | M | 55 | 23 |
| 39 | M | 66 | 24 |
| 40 | M | 63 | 38 |

F=female; M=male.

**Table 2.** Data on improvements after using the desensitizing toothpaste containing potassium citrate

| Sex | *n* | Improvement, *n* | Improvement (%) |
|---|---|---|---|
| Male | 20 | 16 | 80 |
| Female | 20 | 18 | 90 |
| Total | 40 | 34 | 85 |

**Table 3.** Sites examined for dentin hypersensitivity*

| Site | Male (*n*=44) | Female (*n*=42) | Total (*n*=86) |
|---|---|---|---|
| Canine | 14 (31.82) | 15 (35.71) | 29 (33.72) |
| First premolar | 14 (31.82) | 10 (23.81) | 24 (27.91) |
| Lateral incisor | 7 (15.91) | 6 (14.29) | 13 (15.12) |
| Incisor | 5 (11.36) | 4 (9.52) | 9 (10.47) |
| Second premolar | 3 (6.82) | 4 (9.52) | 7 (8.14) |
| Molar | 1 (2.27) | 3 (7.14) | 4 (4.65) |

*Data are presented as *n* (%).

**Table 4.** Summary of visual analog scale (VAS) scores at the baseline and after using desensitizing toothpaste containing potassium citrate for 4 weeks

| | VAS | | |
|---|---|---|---|
| | Median | Range | Mean±SD |
| Baseline | 51.5 | 26–78 | 50.72±14.39* |
| 4 weeks | 29 | 0–80 | 30.68±15.50* |

*Statistically significant between the baseline and 4 week, $P<0.01$. SD=standard deviation.

The VAS for dentin hypersensitivity has been measured using several methods, such as mechanical, thermal and air-blast stimuli.[12] VAS pain intensity can be shown either as a percent of the maximum or as an absolute score value.[11] Clark and Troullos[12] reported that the VAS is simple to understand and suitable for use in evaluating stimulus responses in dentin hypersensitivity studies. The validity and reliability of the VAS for measuring both experimental and clinical pain were demonstrated by several investigators.[11,12] Several studies compared the VAS with other pain scales, and the results indicated that the VAS correlated well with those methods and appeared to be more sensitive in discriminating between various treatments and changes in pain intensity.[11,19]

Toothpastes containing potassium ions are reported by several clinical studies to be effective in reducing dentin hypersensitivity, and the American Dental Association Council on Dental Therapeutics has granted a Seal of Acceptance to toothpastes containing 5% potassium nitrate.[20] Toothpastes which contain 3.75% potassium chloride[21,22] or 5.3% potassium citrate[23] are also reported to be clinically effective in treating dentin hypersensitivity. Potassium ions are thought to act by blocking synapses between nerve cells, thereby reducing nerve excitation and the associated pain.[24,25] Several clinical studies demonstrated that toothpastes containing potassium ions provide effective

desensitization. It was postulated that potassium ions released from toothpastes diffuse along the dentinal tubules to inactivate intradental nerves. A previous study reported that potassium citrate and potassium nitrate were more effective than other potassium salts in blocking nerve conduction and may be more effective dentinal desensitizing agents.[26] Similar results were found in this study: desensitizing toothpaste containing potassium citrate was effective in reducing dentin hypersensitivity after 4 weeks of use.

Taken together, the prevalence of dentin hypersensitivity in this study was 38%. It was also found that the desensitizing toothpaste which contains potassium citrate was effective in reducing dentin hypersensitivity with oral hygiene instruction. The improvement rate was as high as 85%.

## References


1. Addy M. Etiology and clinical implications of dentine hypersensitivity. *Dent Clin North Am* 1990;34;503–14.
2. Irwin C, McCusker P. Prevalence of dentine hypersensitivity in a general dental population. *J Ir Dent Assoc* 1997;43:7–9.
3. Curro F. Tooth hypersensitivity in the spectrum of pain. *Dent Clin North Am* 1990;34:429–37.
4. Ide M. The differential diagnosis of sensitive teeth. *Dent Update* 1998;25:462–6.
5. Berman LH. Dentinal sensation and hypersensitivity: a review of mechanisms and treatment alternatives. *J Periodontol* 1984;56:216–22.
6. Walters PA. Dentinal hypersensitivity: a review. *J Contemp Dent Pract* 2005;6:107–17.
7. Dowell P, Addy M. Dentine hypersensitivity—a review. *J Clin Periodontol* 1983;10:341–50.
8. Dababneh RH, Khouri AT, Addy M. Dentine hypersensitivity—an enigma? A review of terminology, epidemiology, mechanisms, aetiology and management. *Br Dent J* 1999;187:606–11.
9. Brannstrom M. *A Hydrodynamic Mechanism in the Transmission of Pain Producing Stimuli Through the Dentine*. Oxford: Pergamon, 1962:73–9.
10. Wara-aswapati N, Krongnawakul 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. *J Clin Periodontol* 2005;32:53–8.
11. Gillam DG, Newman HN. Assessment of pain in cervical dentinal sensitivity studies: a review. *J Clin Periodontol* 1993;20:383–94.
12. Clark GE, Troullos ES. Designing hypersensitivity clinical studies. *Dent Clin North Am* 1990;34:531–44.
13. Scott J, Huskisson EC. Graphic representation of pain. *Pain* 1976;2:175–84.
14. Pamir T, Ozyazici M, Baloğlu E, Onal B. The efficacy of three desensitizing agents in treatment of dentine hypersensitivity. *J Clin Pharm Ther* 2005;30:73–6.
15. Graf H, Galasse R. Morbidity, prevalence and intraoral distribution of hypersensitive teeth. *J Dent Res* 1977;56(Spec Iss A):162. [Abstract 479]
16. Liu HU, Lan WH, Hsieh CC. Prevalence and distribution of cervical dentin hypersensitivity in a population in Taipei, Taiwan. *J Endod* 1998;24:45–7.
17. Salvato AR, Clark GE, Gingold J, Curro FA. Clinical effectiveness of a dentifrice containing potassium chloride as a desensitizing agent. *Am J Dent* 1992;5:303–6.
18. West NX. Dentine hypersensitivity: preventive and therapeutic approaches to treatment. *Periodontol 2000* 2008; 48:31–41.
19. Pashley DH. Mechanisms of dentin sensitivity. *Dent Clin North Am* 1990;34:449–73.
20. Ohnhaus E, Adler R. Methodological problems in the measurement of pain: a comparsion between the verbal rating scale and the visual analogue scale. *Pain* 1975;1:379–84.
21. Silverman G, Gingold J, Curro FA. Desensitizing effect of a potassium chloride dentifrice. *Am J Dent* 1994;7:9–12.
22. Chesters R, Kaufman, HW, Wolff, MS, Huntington E, Kleinberg I. Use of multiple sensitivity measurements and logit statistical analysis to assess the effectiveness of a potassium-citrate-containing dentifrice in reducing dentinal hypersensitivity. *J Clin Periodontol* 1992;19:256–61.
23. Sowinski J, Ayad F, Petrone M, et al. Comparative investigations of the desensitizing efficacy of a new dentifrice. *J Clin Periodontol* 2001;28:1032–6.
24. Markowitz K, Bilotto G, Kim S. Decreasing intradental nerve activity in the cat with potassium and divalent cations. *Arch Oral Biol* 1991;36:1–7.
25. Peacock JM, Orchardson R. Effects of potassium ions on action potential conduction in A- and C-fibers of rat spinal nerves. *J Dent Res* 1995;74:634–41.
26. Peacock JM, Orchardson R. Action potential conduction block of nerves in vitro by potassium citrate, potassium tartrate and potassium oxalate. *J Clin Periodontol* 1999; 26:33–7.