Evaluation of Ferric Oxalate as an Agent for Use During Surgery to Prevent Post-Operative Root Hypersensitivity

Hom-Lay Wang, Chi-Tsai Yeh,† Frederic Smith,* Frederick G. Burgett,* Philip Richards,* Yu Shyr,‡ and Robert O'Neal**

THE AIM OF THIS STUDY was to evaluate the effectiveness of a 6% ferric oxalate solution applied during periodontal surgery to prevent post-operative tooth hypersensitivity. Twenty-five adult patients with similar bilateral periodontal defects participated in this study. Data were collected at baseline (1 week prior to surgery) and 1, 2, 4, and 6 weeks following surgery. Sensitivity level was determined using the visual analog scale (VAS) with the following stimuli: 1) mechanical stimulation with a No. 23 dental explorer; 2) water at 50°C; 3) ice; and 4) electric pulp tester (EPT). Teeth were randomly assigned to either test (6% ferric oxalate in 0.9% saline) or control (0.9% saline) groups. Solutions were applied to the exposed root surfaces for 1 minute during surgery. Data were analyzed by repeated measures ANOVA, paired *t*-test, and Pearson's correlation test. Results from this study demonstrated statistically significant reduction in the responses to thermal stimuli, especially cold, between groups treated with ferric oxalate as compared to those treated with saline. For the cold test the difference increased with time from baseline to 6 weeks. Statistically significant ($P < 0.05$) differences in sensitivity to heat between groups were also observed, but only at 2 and 4 weeks following surgery. There were no differences at any time period between the test and control groups when tactile or EPT techniques were used. In addition, there was no correlation between sensitivity and other clinical parameters. It was concluded from this study that 6% ferric oxalate was effective in reducing post-surgical cold sensitivity when applied during periodontal surgical procedures. *J Periodontol 1993; 64:1040–1044.*

Key Words: Dentin, sensitive/prevention and control; ferric oxalate/therapeutic use.

It has been reported that approximately 40 million adults in the United States have dentinal hypersensitivity at one time or another and more than 10 million have long-term or chronic hypersensitivity.[1] In addition, hypersensitive dentin is found in one out of seven adult patients receiving dental treatment. One type of dentinal sensitivity is iatrogenic root sensitivity following periodontal surgery.[2] Although the problem might exist prior to the surgery, it is usually aggravated afterward. During periodontal surgery gingival tissue and some of the cementum that originally covered the root surface are removed, resulting in the exposure of the root dentin. Tooth hypersensitivity may occur following thermal, mechanical, osmotic, or chemical stimuli. Uchida et al. reported that pain (hypersensitivity) scores more than doubled following periodontal surgery.[3]

Due to the discomfort involved in brushing hypersensitive root surfaces, patients tend to avoid these areas. Plaque and food debris are then allowed to remain on exposed root surfaces, which often leads to increasing sensitivity which may create a vicious cycle.[4-5] Therefore, dentinal hypersensitivity resulting from periodontal surgery may influence plaque control measures. Unsatisfactory postoperative supragingival plaque control is known to compromise the long-term success of surgical treatment.[6]

Numerous methods have been developed for the treatment of hypersensitive teeth. Agents such as ferric oxalate, which block dentinal tubules, are commonly used in the treatment of dentinal hypersensitivity. In an in vitro study, Pashley et al. found that ferric oxalate was able to reduce dentin permeability by 65%.[7] Recently, a 6% ferric oxalate solution has been made available to dentists for treatment

*Department of Periodontics/Prevention and Geriatrics, School of Dentistry, University of Michigan, Ann Arbor, MI.
†Private practice, Gaithersberg, MD.
‡Department of Biostatistics, School of Public Health, University of Michigan, Ann Arbor, MI.

of hypersensitive dentin. Favorable results have been reported with clinical use of this product.[8]

The use of these desensitizing agents has been limited to treatment of established tooth hypersensitivity. None of these products have been tested for use in preventing tooth hypersensitivity. Since root sensitivity is a common occurrence after periodontal surgery, a method to prevent this problem would be helpful. Therefore, the purpose of this study is to evaluate the effectiveness of 6% ferric oxalate solution applied during periodontal surgery for the prevention of post-operative tooth hypersensitivity.

MATERIALS AND METHODS

Twenty-five adult patients who were treated at the Graduate Periodontic Clinic of the University of Michigan, School of Dentistry were selected to participate in this double-blind study. The research protocol was approved by the Human Subjects Review Committee at the University of Michigan, School of Dentistry and patients signed appropriate informed consent forms. Patients who participated in this clinical trial had: good general health; no known allergy to ferric oxalate; similar bilateral periodontal defects which had been scheduled for periodontal surgery; no antibiotic or tooth hypersensitivity treatment within the last 6 months; no periodontal surgery in the areas to be studied within the last 3 years; no large carious lesions or cracked tooth structure; and no previous endodontic treatment on the selected teeth.

Gingival index (GI),[9] plaque index (PI),[10] clinical attachment level (AL), and probing depth (PD) as well as bleeding index (BI) were collected at baseline (1 week prior to the surgery) and 1, 2, 4, and 6 weeks following surgery. However, attachment levels and pocket depths were not reexamined until 4 weeks following surgery to avoid any interference with healing. Evaluations of the GI, PI, and BI were performed on the buccal aspect. Measurements of clinical attachment level (in mm from the cementoenamel junction to the apical extent of probing depth) and probing depth (in mm from the free gingival margin to the apical extent of probing depth) were performed at mesiobuccal, buccal, and distobuccal aspects of each tooth utilizing Michigan "O" calibrated periodontal probe. The BI was modified from the papillary bleeding index of Saxer and Muhlemann[11] as follows: 0 = no bleeding; 1 = single bleeding point occurs within 30 seconds after gentle probing; 2 = a fine line of blood observed at the gingival margin; and 3 = profuse bleeding or immediate bleeding following probing. Patients were evaluated for sensitivity level of the selected teeth by applying the following stimuli sequence to the buccal surface of each tooth: 1) mechanical stimulation with a No. 23 dental explorer (tactile test); 2) hot water which was preheated in a water bath[§] with the temperature set at 50°C; 3) ice water with the temperature maintained at 0°C; 4) electric pulp tester.[‖] By utilizing the Visual Analog Scale (VAS), the sensitivity level to mechanical and thermal stimuli on each selected tooth was established. The VAS is a straight line, 10 cm in length, with anchor words such as "no pain" and "severe pain" at either end of the line.[12] The subjects indicate with a mark a point on the line which corresponds to the pain/sensitivity level they perceive. The quantification is performed by measuring the distance from the first anchor word to the mark. The data from the electric pulp tester were obtained directly from the instrument in numerical form.

Surgical Procedures

Two similar periodontal flap procedures were performed in each patient with either a modified Widman or an apically positioned flap design. Teeth were scaled, root planed, and debrided, then irrigated with sterilized normal saline solution and dried with cotton pellets and air spray. Teeth in each surgical area were assigned to either the 0.9% saline solution (control) or 6% ferric oxalate in 0.9% saline solution (test) group by a coin flip. Either the test or control solution was applied to the buccal aspect of the exposed root surfaces with small cotton pellets for 60 seconds. Thereafter, tooth surfaces were irrigated with sterilized normal saline solution for 10 seconds and the flaps were then sutured. No periodontal dressing material was placed. Each patient received an analgesic[¶#] sufficient for 2 days. Data collection was performed by one person who was not involved in applying the agents during the surgery or in assigning control or test groups.

Statistical Analysis

Data were analyzed using the 6.03 statistical package** to obtain the means, standard errors, and the frequency distribution. Repeated measures ANOVA (analysis of variance) was used to evaluate changes in sensitivity levels within groups at different times. The paired *t*-test was used to compare the sensitivity levels between control and experimental groups at each time period. Both individual test and Bonferroni adjusted (for multiple comparisons) *P* values are used in Table 1. Pearson's correlation test was used to determine the correlation between the clinical indices and evaluate their influence on sensitivity.

RESULTS

Twenty-five patients including 15 males and 10 females with an age range from 25 to 63 years old participated in this study. Of the 233 teeth selected, 119 teeth were treated with 6% ferric oxalate solution and 114 teeth were used as control.

Post-surgical sensitivity to cold stimuli was significantly

[§]Meer Dental Co. Canton, MI.

[‖]2006 Vitality Scanner, Analytic Technology Co., Redmond, WA.
[¶]Advil, Whitehall Laboratory Inc., New York, NY.
[#]Tylenol with codeine, MacNeil Pharmaceutical, Fort Washington, PA.
**6.03 statistical package, SAS, Cary, NC.

Table 1. Results of Sensitivity Level to Different Stimuli

Stimulus	Weeks 0	1	2	4	6
Cold					
Control	3.04±0.32	5.81±0.40	6.21±0.61	5.94±0.41	5.35±0.34
Test	3.64±0.35	4.59±0.29	4.53±0.27	4.04±0.28	3.34±0.31
M.D±S.E.*	−0.60±0.36	1.22±0.47†	1.68±0.40‡	1.90±0.42‡	2.01±0.31‡
Hot					
Control	0.53±0.18	1.17±0.22	1.19±0.25	0.98±0.23	0.62±0.15
Test	0.36±0.10	0.69±0.18	0.51±0.12	0.34±0.08	0.34±0.12
M.D±S.E.	0.17±0.21	0.47±0.27	0.68±0.26†	0.64±0.24†	0.28±0.20
Tactile					
Control	0.81±0.17	1.19±0.17	1.10±0.22	0.98±0.22	0.78±0.19
Test	0.83±0.18	0.76±0.15	0.72±0.12	0.53±0.14	0.37±0.08
M.D±S.E.	−0.02±0.18	0.42±0.24	0.38±0.26	0.45±0.28	0.41±0.22
EPT					
Control	39.62±1.58	40.59±1.72	40.99±1.91	39.69±1.61	40.33±1.67
Test	39.83±1.66	41.69±2.17	40.51±1.80	40.13±1.91	39.82±1.92
M.D±S.E.	−0.21±1.48	−1.10±1.62	0.48±1.43	−0.44±1.55	0.51±1.52

The cold, hot and tactile data use the VAS scale; EPT values are read directly from the machine.
*M.D±S.E. = mean of difference ± standard error, M.d. = mean VAS (control) − mean VAS (test) and S.E. = standard deviation/$\sqrt{N}$, N=25.
†Statistically significant ($P < 0.05$) difference between control and test groups for the same stimulus.
‡Statistically significant ($P < 0.01$) difference between control and test groups for the same stimulus; $P < 0.05$, Bonferroni adjusted α − error = 0.05.

lower ($P < 0.01$) in the test group than in the control group. Table 1 demonstrates the results of the paired *t*-test comparing sensitivity to different stimuli between control and test groups. At baseline, there was no significant difference ($P < 0.05$) in the sensitivity to cold between control and test groups. However, the mean VAS value for sensitivity in the control group was greater than that of test group at 1 week following surgery with the difference being 1.21±0.47 cm which was statistically significant at the $P < 0.05$ level. At 2 weeks and thereafter, the differences between the two groups increased further, remaining significant at the $P < 0.01$ level. Sensitivity to cold stimuli increased in both groups one week following surgery with a more prominent increase in the control group than in the test group. The mean VAS value increased 91% (from 3.04 to 5.81) in the control group, while only increasing 26% (from 3.64 to 4.59) in the test group (Table 1).

The cold sensitivity level of the ferric oxalate-treated group decreased earlier than that of the control group. In the control group statistically significant differences ($P < 0.01$) in the sensitivity level to cold stimuli were noted between baseline and 1, 2, 4, and 6 weeks postsurgically. However, the test group showed statistically significant differences only between baseline/1 week ($P < 0.01$) and baseline/2 weeks ($P < 0.05$).

The responses to hot stimuli were consistently lower than those to cold stimuli. Statistically significant differences ($P < 0.05$) between responses of control and test groups to hot stimuli were seen only at 2 and 4 weeks postsurgically (Table 1). When the sensitivity levels to hot stimuli were compared across the time with the repeated measures ANOVA, statistically significant differences ($P < 0.05$) were observed between baseline/1 week and baseline/2 weeks only in the control group. No significant difference ($P < 0.05$) was demonstrated across time within the test group.

No statistically significant difference in the response to tactile or EPT stimuli was found between control and test groups following periodontal surgery (Table 1). The AL decreased (improved) postsurgically, especially during the first 4 weeks following the surgery (Table 2). This finding was observed consistently in both control and test groups. Furthermore, no difference in AL was found between the two groups during the entire experimental period. No statistically significant differences in PD, GI, PI, and BI scores were observed between groups throughout the entire experimental period. The highest score of GI and PI occurred at 1 week postsurgically in both groups and decreased with time thereafter. In addition, it was found that scores of BI decreased with time following surgery. No significant correlation ($P > 0.05$) between clinical parameters and sensitivity or among clinical parameters was observed.

DISCUSSION

Results from this study indicated that sensitivity to cold stimuli increased in both the control and test groups during the first week following surgery with a greater increase of sensitivity levels observed in the control group (91% vs. 26%). Statistically significant differences ($P < 0.01$) in the sensitivity level to cold stimuli were noted between baseline and 1, 2, 4, and 6 weeks postsurgically in the control group. On the other hand, statistically significant differences were only demonstrated between baseline/1 week ($P < 0.01$) and baseline/2 weeks ($P < 0.05$) in the test group. These results may indicate that ferric oxalate solution did not eliminate the postsurgical hypersensitivity completely. However, the increase of sensitivity postsurgically was less significant in

Table 2. Clinical Indices Comparison Between Groups

Index	Week 0	1	2	4	6
Clinical attachment level (mm)*					
Control	4.59±0.13	—,†	—	3.85±0.11	3.73±0.10
Test	4.52±0.17	—	—	3.70±0.13	3.77±0.12
Probing depth (mm)					
Control	3.80±0.11	—	—	2.78±0.09	3.73±0.10
Test	3.78±0.14	—	—	2.79±0.06	3.77±0.12
Bleeding index					
Control	0.73±0.12	—	—	0.19±0.06	0.11±0.04
Test	0.56±0.09	—	—	0.01±0.02	0.01±0.03
Gingival index					
Control	1.28±0.08	1.58±0.09	1.12±0.10	0.73±0.10	0.57±0.08
Test	1.21±0.11	1.43±0.10	0.89±0.10	0.68±0.06	0.46±0.07
Plaque index					
Control	0.91±0.08	1.41±0.10	1.03±0.10	0.75±0.09	0.61±0.08
Test	0.93±0.09	1.39±0.13	0.87±0.11	0.62±0.07	0.49±0.07

Values are mean ± standard error.
†Data not available; no significant differences at $P < 0.05$ level.

the test group than in the control group. This illustrated that 6% ferric oxalate solution, when applied to the root surface during periodontal surgery, is capable of reducing post-surgical sensitivity to cold stimuli. Uchida et al. evaluated 249 hypersensitive areas among 60 subjects before and after periodontal surgery comprised of either a gingivectomy or a flap procedure.[3] They found that there was over a 100% increase in the pain/hypersensitivity score following surgery. This is similar to the results of the cold test obtained in the present study.

In the present study, most of the patients in both groups experienced the highest level of sensitivity during the first week or 2 following surgery. This result is in agreement with that reported by Glickman in 1972.[13] Furthermore, Pashley also claimed that spontaneous remission of symptoms, which is observed in most instances, occurs somewhere between 7 and 14 days after surgery but may require several weeks to fully resolve.[14]

In a recent study performed by Kerns et al.,[15] dentin discs were treated with scaling/root planing, 0.5 M EDTA, or with 30% dipotassium oxalate followed by 3% monopotassium-monohydrogen oxalate. The discs were then incorporated into removable partial dentures worn by the donors. Evaluation of root planed samples revealed that the tubules had re-opened by 7 days. The samples which had been treated with potassium oxalate showed that few oxalate crystals remained and also revealed open tubules. Based on these observations, it seems that the creation of a smear layer or application of oxalate to occlude dentinal tubules, thereby reducing sensitivity, are relatively short-lived phenomena. However, if the hypothesis that plaque enhances hypersensitivity is correct, the earlier the patient begins to control plaque, the sooner he may be free from the associated sensitivity.

Similar trends were also observed in the results of the hot test as were seen in the cold test. However, the sensitivity level in the hot test was much lower than that of the cold test. This is because most of the subjects did not have as strong a response to hot stimuli as they did to cold stimuli. The overall low responsiveness to hot stimuli may render comparative evaluation and results less meaningful in terms of clinical significance. This observation is similar to the experience of several investigators who previously reported that cold was the most prevalent complaint presented by patients with dentin hypersensitivity.[16-18] Moreover, in a study performed by Ong and Strahan,[19] several types of stimuli were used to evaluate the desensitizing effect of a dentifrice containing 2% dibasic sodium citrate. The results indicated that of the stimuli used, cold was the most effective in eliciting a hypersensitive response, followed by chemical stimulation and an air blast. On the other hand, heat and toothbrushing caused the least discomfort.

The results of this study indicated that tactile stimuli did not elicit any remarkable responses. This finding was supported by Kanapka and Colucci, who evaluated responses to a variety of stimuli on 195 subjects, reporting that tactile stimuli elicited less discomfort or pain than cold and hot.[16] They indicated that 91.3% of the subjects responded to cold stimuli and 63.6% responded to hot stimuli, whereas only 32.3% of them felt discomfort or pain following stimulation with "touch."[16] Ong and Strahan used toothbrushing as one of the mechanical stimuli in their desensitizing study and found that toothbrushing evoked the least discomfort compared to other stimuli.[18]

No significant difference (at $P < 0.05$) in the EPT value was demonstrated between the two groups at any point during the experimental period. More importantly, it was found that the EPT value did not change significantly following periodontal surgery for either group. This is similar to that found in a study performed by Wallace and Bissada.[20] They reported that the pulpal threshold as determined by EPT was not altered significantly by periodontal therapy con-

sisting of scaling, root planing, and periodontal surgery within the treatment group.

There was also no strong correlation between sensitivity and the clinical parameters including PI, GI, BI, PD, and AL. It is possible that a 6-week postsurgical observation period was insufficient to detect any significant differences in clinical AL between groups. There has been a controversy regarding the role of plaque in the development of tooth hypersensitivity. Results of the present study did not reveal any close relationship between plaque and hypersensitivity. A correlation (although inconsistent) between plaque scores and dentin sensitivity has been reported by Addy et al.[6] Others have disagreed with him by saying that gingival recession caused by toothbrushing exhibited more influence on tooth hypersensitivity than plaque accumulation.[21-22]

No post-operative complications, such as disturbed wound healing or adverse systemic reactions, were reported by any of the subjects participating in this study. Based on these 6-week observations, application of 6% ferric oxalate solution on the root surfaces during periodontal surgery does not appear to interfere with the process of periodontal wound healing. However, further investigation regarding the influence of ferric oxalate solution on cell attachment and wound healing are needed.

REFERENCES

1. Kanapka JA. Current treatment for dentinal hypersensitivity. A new agent. *Compend Contin Educ Dent* 1982; 3(Suppl.):S118–S120.
2. Goldman HM. Dentinal sensitivity: A periodontist's perspective. *Compend Contin Educ Dent* 1982; 3(Suppl.):S110–S112.
3. Uchida A, Wakano Y, Fukuyama O, et al. Controlled clinical evaluation of a 10% strontium chloride dentifrice in treatment of dentin hypersensitivity following periodontal surgery. *J Periondontol* 1980; 51:578–581.
4. Everett FG, Hall WB, Phatak NM. Treatment of hypersensitive dentin. *J Oral Ther Pharmacol* 1966; 2:300–310.
5. Collins JF, Perkins L. Clinical evaluation of the effectiveness of three dentifrices in relieving dentin sensitivity. *J Periodontol* 1984; 55:720–725.
6. Addy M, Mostafa P, Absi EG, et al. Cervical dentin hypersensitivity: Aetiology and management with particular reference to dentifrices. In: Rowe NH, ed. *Proceedings of Symposium on Hypersensitive Dentine: Origin and Management.* Ann Arbor: The University of Michigan; 1985:43.
7. Pashley DH, Derkson GD, Tao L, et al. The effect of a multi-step dentin bonding system on dentin permeability. *Dent Mater* 1988; 4:60–63.
8. Salvato A, Troullos ES, Curro FA, et al. The effectiveness of ferric oxalate in relieving dentinal hypersensitivity. *J Dent Res* 1990; 69 (Spec. Issue):169 (Abstr. 482).
9. Löe H, Silness J. Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontol Scand* 1963; 21:533–551.
10. Silness J, Löe H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. *Acta Odontol Scand* 1964; 22:121–135.
11. Saxer UP, Muhlemann HR. Motivation und Aufklarung. *Schweiz Monatsschr Zahnheikd* 1975; 85:905–919.
12. Reading AE. A comparison of the McGill pain questionnaire in chronic and acute pain. *Pain* 1982; 13:185–192.
13. Glickman I. The gingivectomy technique. In: Glickman I, ed. *Clinical Periodontology,* 4th ed. Philadelphia: WB Saunders Co.; 1972:635–671.
14. Pashley DH. Mechanisms of dentin sensitivity. *Dent Clin North Am* 1990; 34:449–473.
15. Kerns DG, Scheidt MJ, Pashley DH, et al. Dentinal tubule occlusion and root hypersensitivity. *J Periodontol* 1991; 62:421–428.
16. Kanapka JA, Colucci SV. Clinical evaluation of dentinal hypersensitivity: A comparison of methods. *Endod Dent Traumatol* 1986; 2:157–164.
17. Harris R, Curtin J. Dentine hypersensitivity. *Aust Dent J* 1976; 21:165–169.
18. Orchardson R, Collins WJ. Clinical features of hypersensitive teeth. *Br Dent J* 1987; 162:253–256.
19. Ong G, Strahan JD. Effect of a desensitizing dentifrice on dentinal hypersensitivity. *Endod Dent Traumatol* 1989; 5:213–218.
20. Wallace JA, Bissada NF. Pulpal and root sensitivity rated to periodontal therapy. *Oral Surg Oral Med Oral Pathol* 1990; 69:743–747.
21. Gorman WJ. Prevalence and etiology of gingival recession. *J Periodontol* 1967; 38:316–322.
22. Volpe AR, Mooney R, Zumbrunmen C, et al. A long-term clinical study evaluating the effect of two dentifrices on oral tissues. *J Periodontol* 1975; 46:113–118.

Send reprint requests to: Dr. Hom-Lay Wang, University of Michigan, School of Dentistry, 1011 N. University Ave., Ann Arbor, MI 48109-1078.

Accepted for publication April 16, 1993.