Clinical Comparison: Fast-Acting and Traditional Topical Dental Anesthetic

Arthur C. DiMarco, DMD,*† and Ann O’Kelley Wetmore, RDH, MSDH‡

*RIDE Program Director, University of Washington School of Dentistry, Spokane, Washington, †Professor, Eastern Washington University, Department of Dental Hygiene, Spokane, Washington, and ‡Associate Professor and Director of BSDH Degree Completion Program, Eastern Washington University, Department of Dental Hygiene, Spokane, Washington

A randomized, nonblinded clinical trial compared the effectiveness of an application method of a fast-acting refrigerant topical agent to a 20% benzocaine gel topical. In a split-mouth design, right and left anterior middle superior alveolar injections ($N = 30$) were administered with a 27-gauge needle at least 24 hours apart with preinjection topicals. Using a cotton-tipped applicator, a refrigerant topical was applied for 5 seconds and 20% benzocaine gel for 2 minutes on opposite sides at 2 separate appointments. Subjects self-reported pain perception after each injection using a visual analog scale (VAS). The mean VAS ratings demonstrated no significant difference between the 5-second application of the refrigerant ($M = 16.2$, $SD = 17.7$) and the 2-minute application of 20% benzocaine topical gel anesthetic ($M = 17.9$, $SD = 18.2$). Fifty-seven percent of the subjects reported greater pain reduction with the refrigerant, 33% reported greater pain reduction with 20% benzocaine, and 10% reported no difference. Results suggest the described method of application of a refrigerant as an oral topical anesthetic has a faster onset and provides similar benefit in pain reduction compared with 20% benzocaine gel. The refrigerant was easy to accomplish and well received by subjects, indicating potential for routine use in dentistry.

Key Words: Refrigerant; Vapocoolant spray; Preinjection; Topical agents; Local anesthesia; Benzocaine.

Fear and anxiety surrounding dental appointments can present significant challenges when attempting to provide comfortable and appropriate dental treatment.^{1,2} It has been noted that at least 5% of the fear and anxiety experienced during dental care is due to fear of needles.² Some sources place that figure even higher especially when the word *injection* is combined with or substituted for the word *needle*.³ Fear and anxiety associated with needles and injections are often consequences of past painful experiences, and, given similar environments, both can quickly resurface.⁴

It has been reported that painless and/or less painful needle penetration, particularly at the beginning of an

injection, can reduce at least some of the fear and anxiety dental patients experience.^{2,4,5} A more effective topical anesthetic would have the potential for minimizing pain from injections, particularly at the beginning. Kosaraju and Vanderwalle⁶ investigated a dental application method for the placement of a refrigerant topical agent. They concluded the refrigerant “was more effective than the use of a topical anesthetic gel [20% benzocaine] in reducing the pain experienced by patients who received posterior palatal injections” but suggested “a larger sample in future studies would minimize”^{6(p71)} the effect of uncontrollable variables such as application of pressure, rate of injection, and refrigerant tissue temperature. To our knowledge, no subsequent study has been conducted with this refrigerant prior to this one.

While approved by the US Food and Drug Administration in 2004 for use on skin and oral mucosa, the refrigerant Kosaraju and Vanderwalle⁶ studied must be

Received August 19, 2014; accepted for publication June 22, 2015.

Address correspondence to Ms Ann O’Kelley Wetmore, Eastern Washington University, Department of Dental Hygiene, 310 N Riverpoint Blvd, Box E, Spokane, WA 99202; awetmore@ewu.edu.

Anesth Prog 63:55–61 2016

© 2016 by the American Dental Society of Anesthesiology

ISSN 0003-3006/16

SSDI 0003-3006(16)

sprayed directly from the container onto the mucosa per prescriptive guidelines.^{6,7} The aerosol delivers liquid refrigerant from a plastic nozzle. Vaporization occurs rapidly, cooling the tissues and rendering them temporarily unresponsive to pain. While the manufacturer states the current application method is useful for subcutaneous and intramuscular injections, the spray delivery method presents challenges for some dental local anesthetic techniques, particularly those located in posterior areas. Kosaraju and Vanderwalle⁶ investigated an alternate method of application that provides for placement of the refrigerant in specific locations in the oral cavity using a cotton-tipped applicator.⁶

As Kosaraju and Vanderwalle⁶ and others have noted, many strategies have developed in response to fear of needles and injections, all of which are designed to minimize the experience of pain during needle penetration and, in many cases, during entire injections. These include the applications of topical anesthetics and electrical stimulation, distraction techniques such as wiggling lips and cheeks, applying vibrations using mechanical devices, and, in some cases, applying vibrations along with cold temperatures.^{8,9} The application of pressure (with or without topical agents) is another frequently used strategy to preanesthetize tissue, particularly palatal tissue, which can be used as a stand-alone technique or in combination with any of the other methods.⁴

Topical anesthetics are used routinely in both medicine and dentistry to prepare injection sites prior to needle penetration. Some studies have demonstrated topical anesthetic effectiveness in reducing pain perception during injections; however, others have concluded topical anesthetics provide little more than placebo levels of effectiveness.^{10–14} Those finding little or no value in the use of topical preinjection anesthesia point to a lack of objective evidence that topicals reduce the experience of pain in intraoral injections.^{10–14} When viewed in this light, the disadvantages of topical anesthetics, including unpleasant taste, additional expense, collateral numbness, and lengthy waiting periods for optimal effectiveness, have encouraged some clinicians to either avoid topical anesthetics or to abbreviate manufacturer-recommended application times to periods that, even if somewhat effective, would not be expected to provide optimal benefit. While alternatives to topical anesthetics are preferred by some, evidence regarding the effectiveness of the alternatives has been described as limited.⁶ When evaluating topical anesthetic gel effectiveness prior to injections, it is important to note that single anesthetic gels typically anesthetize minimal thicknesses of mucosa (1–3 mm).¹⁵ In self-reports, it could be difficult for subjects to discriminate between sensations that occur within the affected tissue from those that occur

below the affected tissue.^{4,15} Despite questions of effectiveness, many authorities recommend the use of preinjection topical anesthetics, and most clinicians use them.^{4,11,16–21} In a 2001 survey of local and topical anesthetic use by pediatric dentists in which more than 1681 responded, 89% always used topical anesthetics and 98% always or sometimes used them.²² Rosivack et al²¹ compared the effectiveness of a flavored 20% benzocaine topical anesthetic with a similarly flavored placebo during 27-gauge needle penetrations and found 20% benzocaine to be significantly more effective compared with the placebo.

Of greater relevance to this study, Vongsavan and Vongsavan²³ reported that 20% benzocaine gel was more effective than a placebo in reducing the discomfort of palatal injections, as did Yaacob et al²⁴ when comparing pain from needle penetrations in the palate after applications of 5% lidocaine versus a placebo. Effectiveness in the palate remains even less clear, however, compared with effectiveness elsewhere in the oral cavity.²⁴ In a 2000 literature review of intraoral topical anesthetics, Meechan²⁵ discussed both positive and negative study results for a variety of application sites including the palate. There are more negative than positive studies cited for the palate, most having used placebos in addition to anesthetic agents for penetrations as well as injections of anesthetics.

Refrigerants, or vapocoolants, have been used extensively in medicine for providing comfort prior to procedures that involve needles, such as venipunctures, immunizations, and other types of injections, especially in children.^{26–30} Their use is much less widespread in dentistry; nevertheless, both ice sticks and refrigerants have been used in dental settings to provide preinjection anesthesia, and both have been described in the literature.^{26,31} Kosaraju and Vanderwalle⁶ described previous frozen ice stick and 5-second refrigerant applications using cotton pellets saturated with dichlorodifluoromethane on palatal penetration sites.³² They also described anecdotal evidence suggesting that off-label applications of 1,1,1,2 tetrafluoroethane have been used to provide preinjection anesthesia in dentistry; however, as they pointed out, no researchers to their knowledge have previously investigated the effectiveness of the refrigerant that was used in their study in reducing pain in dental applications.⁶

The refrigerant, 1,1,1,3,3-pentafluoropropane/1,1,1,2-tetrafluoroethane (Pain Ease, Gebauer, Cleveland, OH) “is intended for topical application to skin, intact mucous membranes (oral cavity, nasal passages and lips) and minor open wounds.”⁷ Oral biocompatibility studies using 5 doses of the refrigerant applied to the oral cavities of hamsters over 4 hours demonstrated only slight to no erythema.⁷ The histopathology report

classified Pain Ease as a nonirritant when applied to oral mucous membranes. In addition, the results of animal inhalation studies demonstrated no toxicity.⁷

The manufacturer cautions, “Do not use product on diabetics or persons with poor circulation or insensitive skin. Use of cold products on these patients may cause discomfort, skin irritation, and/or frostbite.”⁷ An additional adverse reaction includes the following statement: “Freezing of the skin can occasionally alter the skin pigmentation.”⁷ Postinflammatory hypopigmentation is possible because of the destruction of epidermal melanocytes; however, there are no comments listed regarding the potential for the development of mucosal hypopigmentation.

As a further investigation into the efficacy of the method of application of a refrigerant, this study compared it to a 20% benzocaine gel topical anesthetic during the administration of anterior middle superior alveolar (AMSA) injections.

METHODS

The subjects ($N = 30$) in this study ranged from 19 to 77 years of age. Their treatment plans required either dental hygiene therapy or routine restorative therapy with local anesthesia. All treatment was performed at Eastern Washington University, Riverpoint Campus, Spokane, Washington. Patients were screened for their desire to participate and enrolled based on satisfying the following inclusion criteria: American Society of Anesthesiologists Physical Status Classification System ASA I or ASA II, at least 18 years old, and intact oral mucous membranes. Subjects were excluded based on a history of diabetes, poor circulation, or insensitive skin. Informed consent was obtained from each of the 30 subjects. The Eastern Washington University Institutional Review Board approved the study's protocol.

Similar to the previous study, a randomized, crossover, or split-mouth design was used with responses recorded after both right and left palatal injections for each participant; however, instead of performing posterior palatal injections as in the previous study, AMSA injections were administered. The AMSA injection technique was selected because it more closely matched the needs of the patients in the Eastern Washington University clinics while providing similar palatal challenges to the previous study, including the penetration of tightly bound fibrous tissue, slow deposition rates, and a similarly painful reputation compared with most non-palatal injections locations.^{4,33} As recommended for AMSA injections, a penetration site midway between the midpoint of the palatal gingival crest between the premolars and the midpalatal raphe on the side to be

Figure 1. Placement of topical anesthetic for an anterior middle superior alveolar injection.

anesthetized was chosen for each side of the palate on each participant (see Figure 1).⁴ The 2 principal investigators administered all injections. Both were calibrated in the AMSA injection technique including a standardized preinjection application of either a 20% benzocaine gel for 2 minutes or a refrigerant agent for 5 seconds. Students were asked to assist only by filling a medicine cup to the 5-mL mark when the refrigerant was used, with the volume verified by the principal investigators in each instance. The principal investigators dried the tissue, soaked the cotton-tipped applicator in the refrigerant, and applied the refrigerant to the tissue with an applicator. No assistance was required when applying benzocaine gel topical.

The number of subjects ($N = 30$) was greater in this study compared with the 2009 study ($N = 16$), in order to satisfy the central limit theorem.⁶ The 5-minute interval between injections was increased to 24 hours to minimize bias from any aspect of the first injection that might affect pain perception during the second. A coin toss was used to randomize the selection of the preinjection topical agent. The side of the palate (right or left) selected first was determined by the preexisting

Table 1. Visual Analog Scale Score Differences of Self-Reports of Pain ($n = 28$)

Refrigerant, mm	20% Benzocaine, mm
0	7
0	15
1	6
1	15.5
2	4
2	1
3	4
5	9.5
5	4.5
5	5
7	38
7	71
10	10.5
11	57
12	13
13	5.5
14	42
15.5	32
16.5	46.5
18	33
23	28
33	4.5
38	4
39	15
45	8
49	11
53	31
58	15.5

treatment plan for each patient. Neither the selection of the topical agent nor the side of the palate injected first was influenced by either of the principle investigators.

With the exceptions of a greater volume of solution deposited (0.3 mL in the previous study versus 0.9 mL for the AMSA injections in this study), the increased time necessary for the deposition of these volumes, the depth of penetration for AMSA injections, and a larger needle size (27 gauge), the technique for the application of the refrigerant to prepare the tissue at the injection site was identical to that described by Kosaraju and Vanderwalle.⁶ A 5-mL liquid sample of the refrigerant was collected in a small medicine cup, the mucosa was dried with a 2- × 2-inch piece of gauze, and a cotton-tipped applicator was soaked in the refrigerant and placed on the palatal tissue site for 5 seconds. With the applicator in place, an injection of 0.9 mL (18 mg) of 2% lidocaine, 1:100,000 epinephrine was administered into the injection site via a 27-gauge short needle during a 90-second interval.⁶ The penetration depth was increased from 1–2 mm to 3–4 mm until bony resistance was encountered and subsequent negative aspiration was confirmed, as recommended when performing AMSA injections.⁴

Topical anesthetic gel (20% benzocaine) was used to prepare the injection site on the opposite side of the mouth. Except for the administration of AMSA injections

Table 2. Paired Sample Statistics ($P = .283$)

	M	N	SD	SEM
Refrigerant	16.20	30	17.682	3.228
20% Benzocaine	17.90	30	18.197	3.322

and the use of 27-gauge short needles, both principal investigators followed the same protocols as Kosaraju and Vanderwalle.⁶ Benzocaine gel was placed in a syringe, and 0.1 mL was injected on a cotton-tipped applicator. The mucosa was dried with a 2- × 2-inch piece of gauze. The applicator was applied to the mucosa for 2 minutes, and 0.9 mL (18 mg) of 2% lidocaine, 1 : 100,000 epinephrine was administered to the injection site via a 27-gauge short needle during a 90-second interval.⁶

A visual analog scale (VAS) was used to evaluate the subjects' self-reports of injection pain. The VAS was constructed using "a 100-mm horizontal line with descriptive anchors at each end. The left end was labeled 'no pain' and the right end was labeled 'worst pain possible.' The subjects were instructed to make a vertical mark within the 100-mm line to indicate the level of discomfort they experienced after receiving the injection."^{6(p70)} The VAS score was calculated by measuring the distance from the left end (no pain) of the scale in millimeters. The farther to the right end of the VAS that the mark was scribed, the greater the intensity of pain experienced.⁶ Both a mean and SD were determined for the group ($N = 30$). The data were analyzed with a paired t test ($P = .05$) using a software package (Excel 2013, Microsoft, Redmond, Wash).

RESULTS

The participant pool included 18 men and 12 women ($N = 30$), ages 19 to 77 years, with an average age of 48.7 years. Benzocaine anesthetic gel was used first in 16 subjects and the refrigerant was used first in the remaining 14 subjects. Right-side AMSAs were administered first in 19 subjects, and the remaining 11 subjects received left-side AMSAs first. Self-reported VAS measured from 0 mm to 58 mm for the refrigerant and 0 mm to 46.5 mm for the 20% benzocaine based on a 1-mm to 100-mm VAS with, 28 VAS showing a difference and 2 the same (see Table 1).

The mean VAS distance for the refrigerant group was 16.2 mm, with an SD of 17.7 mm. The mean VAS distance for the anesthetic gel group was 17.9 mm, with an SD of 18.2 mm (see Table 2). In all, 57% of subjects ($n = 17$) reported lower VAS scores with the refrigerant, 33% ($n = 10$) reported lower VAS scores with the

Figure 2. Number of patients whose visual analog scale scores indicated preference for refrigerant or benzocaine or no preference.

anesthetic gel, and 10% ($n = 3$) reported identical VAS scores for both (see Figure 2).

There were no adverse reactions reported for any of the AMSA injections. There was no statistically significant difference in pain reduction between a 5-second application of a refrigerant compared with a 2-minute application of a 20% benzocaine gel ($P = .283$, CI 95%).

DISCUSSION

The null hypothesis was accepted. There was no statistically significant difference between self-reported pain with a 5-second application of a refrigerant as a preinjection topical agent compared with a 2-minute application of a 20% benzocaine anesthetic gel in patients who received AMSA injections. Sixty-seven percent of the subjects ($n = 20$) reported better or similar pain control after refrigerant application compared with 43% ($n = 13$) after a 20% benzocaine gel application.

There are many alternatives to topical anesthetic gels, but most lack more than limited clinical substantiation.⁶ The use of a computer-controlled local anesthetic delivery device (CCLAD) is an exception because it has been demonstrated to provide less painful injections, and for that reason, CCLADs were not used in this study.^{34–36} In addition to a number of studies verifying a statistically significant reduction in pain experienced when CCLADs are used, the manufacturer of one of the most common CCLAD devices describes an anesthetic pathway technique that it claims produces its own topical anesthetic effect, which likely would have affected the results if used in this study.³ Significantly, several reports in the literature concerning pain experience with CCLADs are based on palatal injections, and some focus specifically on AMSA injections.

A significant limitation in this study is the lack of placebo topical applications. Gill and Orr,¹⁰ in a double-blind trial using several topical anesthetic agents and a placebo before penetration into palatal mucosa, found no significant difference in pain reduction of the topical anesthetics versus the placebo. In a similarly designed study, Keller³⁷ also noted no significant difference in reported pain reduction. Vongsavan and Vongsavan,²³ on the other hand, reported that 20% benzocaine gel was more effective than a placebo in reducing the discomfort of palatal injections, as did Yaacob et al²⁴ comparing pain from needle penetrations in the palate after applications of 5% lidocaine versus a placebo. Meechan²⁵ performed a review of intraoral topical anesthetics and included slightly more negative results compared with positive results regarding reduction of pain following topical anesthetic placement in the palate.

Future studies would benefit from placebo penetrations and injections to demonstrate that either or both of the topical agents used were inferior to, superior to, or no more effective than placebos administered prior to needle penetrations and anesthetic administration. Prospective research would also benefit from separating pain reduction during needle penetration from pain reduction during anesthetic administration.

In addition, limitations of this study include a variety of confounding variables that are beyond the investigators' control. While attempts were made with every injection to hold the cotton-tipped applicators in position without exerting additional pressure, a variable amount of pressure was likely exerted, and the degree of pressure was likely inconsistent. Generally, the rate of injection and needle depth were consistent but not identical because of the variable anatomy encountered. The refrigerant tissue temperature varied with individual oral temperatures and the ambient temperatures in the clinic on any particular day, morning, or afternoon. While it would have been ideal to have the patient blinded, it was not possible for several reasons:

- A sensation of cold temperatures may be obvious.
- Application times between the refrigerant and the benzocaine were significantly different (5 seconds vs 2 minutes).
- The topical gel has a taste and aroma, and the vapocoolant does not.

Finally, considering these and the differences in handling of the 2 agents prior to application, there is little confidence in a future ability to perform a similar study that is truly blinded. However, other studies with a larger sample size, which compare other topical agents and other dental local anesthetic techniques, may be warranted.

CONCLUSIONS

Traditionally, gel anesthetics are preferred as preinjection topicals. Recognizing the importance of time management in clinical practice, a fast-onset topical agent can be of benefit. This study suggests that a brief, 5-second application of a vapocoolant has similar preinjection benefits to slower-onset gel anesthetics. The method investigated in this study of a vapocoolant agent as a preinjection protocol has potential for routine use in dentistry.

ACKNOWLEDGMENTS

The Gebauer Company, Cleveland, Ohio, funded this project. The authors thank the study participants, students, faculty, and staff in the Department of Dental Hygiene, Eastern Washington University, Cheney, Washington.

The authors declare no potential conflicts of interest with respect to the authorship and/or publication of this article.

REFERENCES

- De Jongh A, Muris P, Schoenmakers N, Ter Horst G. Negative cognitions of dental phobics: reliability and validity of the dental cognitions questionnaire. *Behav Res Ther*. 1995; 33:507–515.
- Milgrom P, Coldwell SE, Getz T, Weinstein P, Ramsay DS. Four dimensions of fear of dental injections. *J Am Dent Assoc*. 1997;128:756–762.
- Hill KB, Chadwick B, Freeman R, O'Sullivan I, Murray JJ. Adult dental health survey 2009: relationships between dental attendance patterns, oral health behaviour, and the current barriers to dental care. *Br Dent J*. 2013;214:25–32.
- Bassett KB, DiMarco AC, Naughton DK. *Local Anesthesia for Dental Professionals*. 1st ed. Upper Saddle River, NJ: Pearson Education; 2010.
- Masaru K. Initial injection pressure for dental local anesthesia: effects on pain and anxiety. *Anesth Prog*. 2005; 52(3):95–101.
- Kosaraju A, Vanderwalle KS. A comparison of a refrigerant and a topical anesthetic gel as preinjection anesthetics. *J Am Dent Assoc*. 2009;140:68–72.
- Gebauer's Pain Ease: topical aerosol skin refrigerant [technical data document]. Available at: http://www.gebauer.com/Portals/150313/docs/pets_eng.pdf. Accessed September 3, 2013.
- Hutchins HS Jr, Young FA, Lackland DT, Fishburne CP. The effectiveness of topical anesthesia and vibration in alleviating the pain of oral injections. *Anesth Prog*. 1997; 44(3):87–89.
- Meechan JG. Effective topical anesthetic agents and techniques. *Dent Clin North Am*. 2002;46:759–766.
- Gill CJ, Orr DL. A double-blind crossover comparison of topical anesthetics. *J Am Dent Assoc*. 1979;98(2):213–214.
- Jeske AH, Blanton PL. Misconceptions involving dental local anesthesia part 2: pharmacology. *Texas Dent J*. 2002; 119:310–314.
- Martin MD, Ramsay DS, Whitney C, Fiset L, Weinstein P. Topical anesthesia: differentiating the pharmacological and psychological contributions to efficacy. *Anesth Prog*. 1994; 41(2):40–47.
- Meechan JG, Winter RA. A comparison of topical anaesthesia and electronic nerve stimulation for reducing pain of intra-oral injections. *Br Dent J*. 1996;181:333–335.
- Roghani S, Duperon DF, Barcohana N. Evaluating the efficacy of commonly used topical anesthetics. *Pediatr Dent*. 1999;21:197–200.
- Blanton PL, Jeske AH. Dental local anesthetics: alternative delivery methods. *J Am Dent Assoc*. 2003;134: 228–234.
- Blanton PL, Jeske AH. Misconceptions involving dental local anesthesia. Part II: pharmacology. *Texas Dent J*. 2002; 119:310–314.
- Dionne RA, Phero JC, Becker DE. *Management of Pain & Anxiety in the Dental Office*. 1st ed. Philadelphia, Penn: W. B. Saunders Company; 2002.
- Evers H, Haegerstam G. *Introduction to Dental Local Anesthesia*. 2nd ed. Fribourg, Switzerland: Mediglobe SA; 1990.
- Jastak JT, Yagiela JA, Donaldson D. *Local Anesthesia of the Oral Cavity*. 1st ed. Philadelphia, Penn: W. B. Saunders Company; 1995.
- Malamed SF. *Handbook of Local Anesthesia*. 6th ed. St Louis, Mo: Elsevier Mosby; 2013.
- Rosivack RG, Koenigsberg SR, Maxwell KC. An analysis of the effectiveness of two topical anesthetics. *Anesth Progr*. 1990;37:290–292.
- Kohli K, Ngan P, Crout R, Linscott CC. A survey of local and topical anesthesia use by pediatric dentists in the United States. *Pediatr Dent*. 2001;23:265–269.
- Vongsavan K, Vongsavan N. Comparison of topical anesthetic gel and TENS in reducing pain. *J Dent Res*. 1996; 75:248.
- Yaacob HB, Noor GM, Malek SN. The pharmacological effect of xylocaine topical anesthetic: a comparison with placebo. *Singapore Dent J*. 1981;6:55–57.
- Meechan JG. Intra-oral topical anaesthetics: a review. *J Dent*. 2000;28:3–14.
- Abbot K, Fowler-Kerry S. The use of a topical refrigerant anesthetic to reduce injection pain in children. *J Pain Symptom Manage*. 1995;10:584–590.
- Armstrong P, Young C, McKeown D. Ethyl chloride and venipuncture pain: a comparison with intradermal lidocaine. *Can J Anesth*. 1990;37:656–658.
- Cohen Reis E, Holubkov R. Vapocoolant spray is equally effective as EMLA cream in reducing immunization pain in school-aged children. *Pediatrics*. 1997;100(6):E5.
- Fetzer SJ. Reducing the pain of venipuncture. *J Perianesth Nurs*. 1999;14:95–101, 112.

30. Mawhorter S, Daugherty L, Ford A, Hughes R, Metzger D, Easley K. Topical vapocoolant quickly and effectively reduces vaccine-associated pain: results of a randomized, single-blinded, placebo-controlled study. *J Travel Med.* 2004; 11:267–272.
31. Duncan JD, Reeves GW, Fitchie JG. Technique to diminish discomfort from the palatal injection. *J Prosthet Dent.* 1992;67:901–902.
32. Harbert H. Topical ice: a precursor to palatal injections. *J Endod.* 1989;15:27–28.
33. Meechan JG, Howlett PC, Smith BD. Factors influencing the discomfort of intraoral needle penetration. *Anesth Prog.* 2005;52(3):91–94.
34. Anderson ZN, Podnos SM, Shirley-King R. Patient satisfaction during the administration of local anesthetic computer controlled local anesthetic delivery system. *J Dermatol Nurs Assoc.* 2003;15:329–330, 392.
35. Feda M, Al Amoudi N, Sharaf A, et al. A comparative study of children's pain reactions and perceptions to AMSA injection using CCLAD versus traditional injections. *J Clin Pediatr Dent.* 2010;34:217–222.
36. Gibson RS, Allen K, Hutless S, Beiraghi S. The wand vs. traditional injections: a comparison of pain related behaviors. *Pediatr Dent.* 2000;22:458–462.
37. Keller BJ. Comparison of the effectiveness of two topical anesthetics and a placebo in reducing injection pain. *Hawaii Dent J.* 1985;16:10–11.