

# Injection pain and postinjection pain of the palatal-anterior superior alveolar injection, administered with the Wand Plus® system, comparing 2% lidocaine with 1:100,000 epinephrine to 3% mepivacaine

John Nusstein, DDS, MS,<sup>a</sup> Yvette Burns, DDS, MS,<sup>b</sup> Al Reader, DDS, MS,<sup>c</sup> Mike Beck, DDS, MA,<sup>d</sup> and Joel Weaver, DDS, PhD,<sup>e</sup> Columbus, Ohio  
OHIO STATE UNIVERSITY

**Purpose.** The purpose of this prospective, randomized, double-blind study was to compare injection pain and postinjection pain of 2% lidocaine with 1:100,000 epinephrine and 3% mepivacaine using the computer-assisted Wand Plus® injection system to administer the palatal-anterior superior alveolar (P-ASA) injection. Additionally study was done to determine if the use of topical anesthetic decreased the pain of needle insertion with the P-ASA injection.

**Study design.** Using a crossover design, 40 subjects randomly received, in a double-blind manner, P-ASA injections of 1.4 mL of 2% lidocaine with 1:100,000 epinephrine and 1.4 mL of 3% mepivacaine, at 2 separate appointments. The P-ASA injection was administered, utilizing the Wand Plus® system, 6 to 10 mm into the incisive canal located lingual to the central incisors. The pain of needle insertion, needle placement, solution deposition and postinjection pain were recorded on a Heft-Parker visual analog scale for the 2 P-ASA injections. Eighty injections were randomly administered in the study, 40 using topical anesthetic gel and 40 using a placebo gel.

**Results.** For needle insertion, 30% of the subjects reported moderate/severe pain with the lidocaine solution and 43% reported moderate/severe pain with the mepivacaine solution. There was no significant difference ( $P > .05$ ) between the topical and placebo groups. For needle placement into the incisive canal, 54% of the subjects reported moderate/severe pain with the lidocaine solution and 58% reported moderate/severe pain with the mepivacaine solution. For anesthetic solution deposition, 8% of the subjects reported moderate pain with the lidocaine solution and 12% reported moderate pain with the mepivacaine solution. There were no significant differences ( $P > .05$ ) between the lidocaine and mepivacaine solutions. Regarding postinjection pain, when anesthesia wore off on the day of the injection, 20% of the subjects reported moderate/severe pain with the lidocaine solution and 14% reported moderate/severe pain with the mepivacaine solution. Pain ratings decreased over the next 3 days. There were no significant differences ( $P > .05$ ) between the lidocaine and mepivacaine solutions. Postinjection, 12% and 18% of the subjects experienced temporary numbness/paresthesia of the incisive papilla with the lidocaine and mepivacaine solutions, respectively. Twenty percent and 28% of the subjects had incisive papilla swelling or soreness with the lidocaine and mepivacaine solutions, respectively. There were no significant differences ( $P > .05$ ) between the lidocaine and mepivacaine solutions.

**Conclusions.** The P-ASA injection of 1.4 mL of 2% lidocaine with 1:100,000 epinephrine or 3% mepivacaine, administered with the Wand Plus®, has the potential to be a painful injection. The use of topical anesthetic did not significantly reduce pain of needle insertion when compared to a placebo. The incidence of postinjection pain, temporary numbness/paresthesia, and incisive papilla swelling or soreness would indicate that some pain and problems occur with the P-ASA technique, regardless of whether 2% lidocaine with 1:100,000 epinephrine or 3% mepivacaine is used.

(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;97:164-72)

Traditionally, maxillary anterior teeth have been anesthetized by administering an infiltration injection near

the apex of the target tooth. Recently, a site-specific injection for anesthetizing anterior maxillary teeth has been introduced—the palatal-anterior superior alveolar (P-ASA) injection.<sup>1,2</sup> Friedman and Hochman<sup>1</sup> state that bilateral pulpal anesthesia of the maxillary incisors and usually the canines, for an expected duration of

This study was supported by Graduate Endodontic Research Funds and The Steven Goldberg Memorial Fund.

<sup>a</sup>Assistant Professor, Department of Endodontics, Ohio State University.

<sup>b</sup>Former Graduate Student in Endodontics, Ohio State University.

<sup>c</sup>Professor and Program Director, Department of Endodontics, Ohio State University.

<sup>d</sup>Associate Professor, Department of Oral Biology, Ohio State University.

<sup>e</sup>Associate Professor and Program Director of Anesthesiology, De-

partment of Oral and Maxillofacial Surgery, Oral Pathology, Anesthesiology, Ohio State University.

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doi:10.1016/j.tripleo.2003.09.012

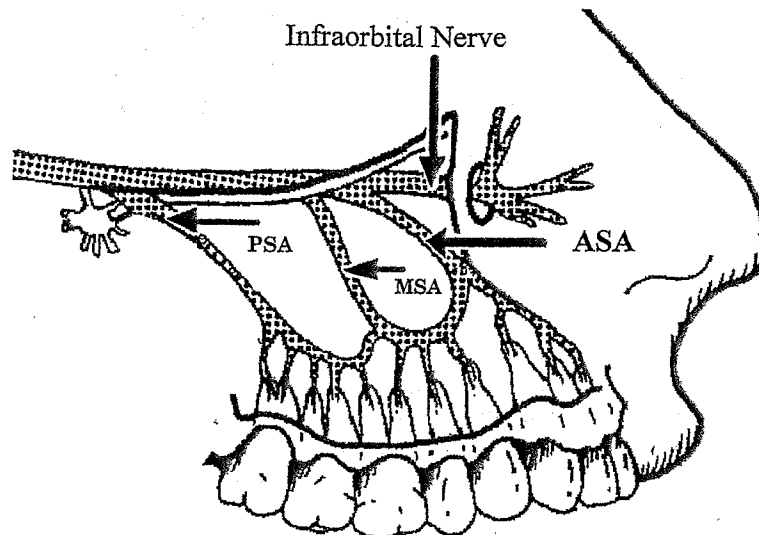


Fig 1. Distribution of the maxillary division of the trigeminal nerve showing the infraorbital nerve and anterior superior alveolar nerve (ASA). The posterior superior alveolar (PSA) and middle superior alveolar (MSA) nerves are also identified.

approximately 60 minutes, will be achieved with the P-ASA injection of 0.9 to 1.4 mL of anesthetic solution. Additionally, the authors<sup>1</sup> state that soft tissue of the anterior third of the palate and facial gingiva are achieved without anesthesia of the lips and face, or interference with the muscles of facial expression. The P-ASA injection differs from the nasopalatine injection in that the needle penetrates more deeply and more volume of anesthetic solution is injected than for the traditional nasopalatine injection. Basically, the nasopalatine injection is intended to anesthetize the soft tissues of the anterior palate.<sup>3</sup> The P-ASA injection uses a palatal injection into the incisive canal and derives its name for the injection's ability to supposedly anesthetize both the right and left anterior superior alveolar nerves.

The right and left anterior superior alveolar (ASA) nerves branch from their respective infraorbital nerves approximately 6 to 10 mm before they exit from the infraorbital foramina<sup>3</sup> (Fig 1). The anterior superior alveolar nerves provide pulpal innervation to the central and lateral incisors and canines as well as sensory innervation to the periodontal tissues, labial bone, and mucous membranes adjacent to these teeth.<sup>3</sup>

Routinely, palatal injections into the incisive papilla administered with a traditional syringe are painful.<sup>3</sup> The Wand Plus<sup>®</sup> local anesthesia system has been developed to supposedly enable a virtually painless injection.<sup>1,4</sup> The majority of the literature on the Wand<sup>®</sup> has dealt with the pain of injection with the Wand<sup>®</sup> compared to standard injections using a syringe.<sup>5-16</sup> In general, the results have been favor-

able<sup>5,6,10-16</sup> with the Wand<sup>®</sup>, with 2 studies showing no difference<sup>7,8</sup> and 1 study showing higher pain ratings<sup>9</sup> with the Wand<sup>®</sup>. Friedman and Hochman<sup>1</sup> state that the P-ASA technique is comfortable for the patient. Only two studies<sup>10,16</sup> have evaluated the P-ASA injection using 2% lidocaine with 1:100,000 epinephrine. Gibson et al<sup>10</sup> and Allen et al<sup>16</sup> studied the P-ASA, anterior middle superior alveolar (AMSA), buccal infiltration, and traditional palatal injection in children. In both studies,<sup>10,16</sup> pain behavior was measured using established pain behavior categories (body movements, crying, movements requiring restraints, movements requiring a temporary halt to treatment). Pain was measured in the Gibson et al<sup>10</sup> study by using a 10-point visual analog scale (VAS). They found that the Wand<sup>®</sup> allowed significantly fewer children to exhibit disruptive behavior and produced less pain when compared to a conventional syringe injection.

Anesthetic solutions without vasoconstrictors have been reported to cause less pain than solutions with vasoconstrictors, possibly because of the higher pH of the plain anesthetic solutions.<sup>17-19</sup> Kramp et al<sup>17</sup> found 4% prilocaine plain was associated with significantly less pain perception as compared to 2% lidocaine with 1:100,000 epinephrine and 2% mepivacaine with 1:20,000 levonordefrin. Wahl et al<sup>18</sup> found 4% prilocaine plain produced less pain on injection than 0.5% bupivacaine with 1:200,000 epinephrine. Oikarinen et al,<sup>19</sup> using varying mepivacaine solutions, found that low-pH solutions caused more frequent pain on injection than a high-pH solution. They also found that the addition of a vasoconstrictor caused more frequent pain

than a plain solution. However, Wahl et al<sup>20</sup> found no significant difference in perceived pain on injection of 2% lidocaine with 1:100,000 epinephrine versus 4% prilocaine. Replogle et al,<sup>21</sup> studying the pain of a primary intraosseous injection in mandibular molars, found no significant difference between 2% lidocaine with 1:100,000 epinephrine and 3% mepivacaine. An additional factor in injection pain, other than pH, is the site of the injection. Meechan and Day<sup>22</sup> found that palatal injection pain did not differ between epinephrine-containing lidocaine and plain lidocaine. Wahl et al<sup>18</sup> found that palatal injections caused significantly more pain than other intraoral injections. The authors<sup>18,22</sup> speculated that palatal injection pain might be mainly the result of pressure, rather than the pH of the anesthetic solution, due to the noncompliant nature of the tissue.

Regarding postinjection pain, Oikarinen et al<sup>19</sup> found 4% prilocaine caused less pain than 2% lidocaine with epinephrine. Replogle et al,<sup>21</sup> studying primary intraosseous anesthesia in mandibular molars, found no significant differences in postinjection pain between 2% lidocaine with 1:100,000 epinephrine and 3% mepivacaine.

When medical conditions or drug therapies contraindicate the use of epinephrine-containing solutions, it would be advantageous to use 3% mepivacaine for the P-ASA injection. Therefore, we wanted to evaluate the aspects of injection pain, postinjection pain, and sequelae between 2% lidocaine with 1:100,000 epinephrine and 3% mepivacaine.

Hochman and Friedman<sup>1</sup> state that topical anesthetic can be used, if desired, with the P-ASA injection. Basically, no scientific information is available on the use of topical anesthetic with this technique. Therefore, this study was used to determine if the use of topical anesthetic decreased the pain of needle insertion with the P-ASA.

The purpose of this prospective, randomized, double-blind study was to compare the pain of injection and postinjection pain of 2% lidocaine with 1:100,000 epinephrine and 3% mepivacaine using the computer-assisted Wand Plus<sup>®</sup> injection system to administer the P-ASA injection. Additionally, the study was done to see if the use of topical anesthetic decreased the pain of needle insertion with the P-ASA.

## MATERIALS AND METHODS

Forty adult subjects participated in this study. All subjects were in good health and were not taking any medication that would alter pain perception as determined by a written health history and oral questioning. Inclusion criteria were: between the ages of 18 and 65 years; in good health (ASA classification I or II); and

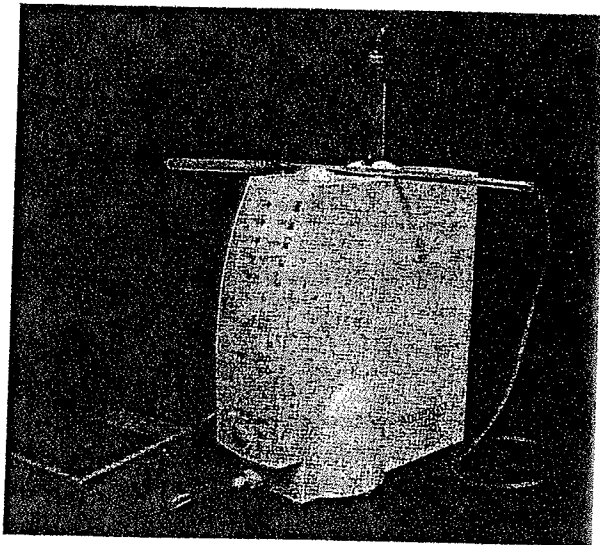


Fig 2. The Wand Plus<sup>®</sup> computer-assisted local anesthetic delivery unit. The Wand Plus<sup>®</sup> handpiece assembly and microtubing are also seen.

informed consent granted. Exclusion criteria were: allergy to lidocaine, mepivacaine, or sulfites; history of significant medical problem (ASA classification III or greater); have taken CNS depressants (including alcohol or any analgesic medications) within the last 48 hours; pregnancy; or inability to give informed consent. The Ohio State University Human Subjects Review Committee approved the study, and written informed consent was obtained from each subject. After completion of the medical history and consent form the subjects completed the Corah Dental Anxiety Scale questionnaire.<sup>23-25</sup>

Forty subjects randomly received 2 palatal-anterior superior alveolar (P-ASA) injections at 2 separate appointments spaced at least 1 week apart, in a crossover design. If postoperative sequelae occurred, the second appointment was delayed until complete healing was observed. The 40 subjects received P-ASA injections of 1.4 mL of 2% lidocaine (28 mg) with 1:100,000 epinephrine (14  $\mu$ g) (Xylocaine; Astra-Zeneca LP, Wilmington, Del) at one appointment and 1.4 mL of 3% mepivacaine (42 mg) (Polocaine; Astra-Zeneca) at the other appointment using the Wand Plus<sup>®</sup> local anesthesia system (Milestone Scientific, Deerfield, Ill). Eighty injections were administered in the study, 40 using 2% lidocaine with 1:100,000 epinephrine and 40 using 3% mepivacaine. One investigator gave all injections.

The Wand Plus<sup>®</sup> local anesthesia system<sup>4</sup> (Fig 2) is a microprocessor-driven device that delivers a controlled infusion of anesthetic solution. The Wand Plus<sup>®</sup> accepts standard 1.8-mL dental anesthetic glass car-

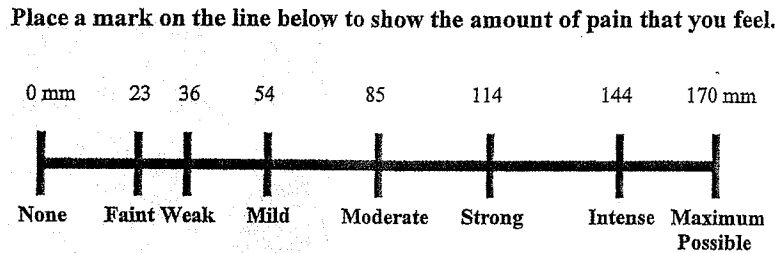


Fig 3. Heft-Parker VAS used for assessment of pain. The millimeter demarcations were not shown on the patients' VAS.

tridges. The microprocessor monitors and varies the infusion pressure while maintaining a constant flow rate. An electronically driven plunger contacts the rubber plunger in the cartridge and expels the anesthetic solution at the precisely regulated rate. Sterile tubing connects the cartridge receptor to a pen-like, hand-held plastic wand that is attached to a Luer-Lok needle, together forming a disposable syringe assembly. A small portion of solution from a standard cartridge is lost during the purge cycle and some of the solution remains in the cartridge and tubing, thus only 1.4 mL of a standard cartridge is delivered. Flow rate, initiation and cessation of flow, and aspiration are controlled with a foot pedal. To prevent cross-contamination, the hand-piece, microtubing and anesthetic cartridge are designed for single use only.

Before the experiment, the 2 anesthetic solutions were randomly assigned 6-digit numbers from a random number table. The random numbers were assigned to a subject to designate which anesthetic solution was to be administered at each appointment and if topical anesthetic or placebo gel was to be used. The anesthetic solutions administered were blinded by completely masking the cartridges with permanent black marker. The expiration dates on the cartridges were checked before they were masked. Two blinded cartridges of the same anesthetic solution were placed in letter-sized envelopes labeled with the 6-digit code. Two blinded cartridges were placed in the envelope so the code would not have to be broken in the event of a broken or dropped cartridge. The envelope was also marked to indicate whether topical anesthetic or a placebo was to be used at each appointment. Only the random numbers were recorded on the data collection and post-injection survey sheets to further blind the experiment.

One blinded cartridge was removed from the envelope, placed into the plastic barrel of the Wand Plus® handpiece assembly, and placed into the Wand Plus® cartridge holder socket with a quarter turn in a counterclockwise direction. The cap was removed from the needle and the foot pedal depressed once to activate the

purge cycle to remove air from the plastic tubing and fill the line with anesthetic solution.

Before the injection, each subject was informed of the pain ratings for needle insertion, needle placement, and deposition of solution and shown the visual analog scale. A Heft-Parker VAS<sup>26</sup> was used in this study (Fig 3). Immediately after the P-ASA injection, each subject rated the pain for each injection phase on the VAS. The VAS was a 170-mm line with various descriptive terms. The subjects placed a mark on the scale where it best described their pain level. To interpret the data, the VAS was divided into the following 4 categories. No pain corresponded to 0 mm on the scale. Mild pain was defined as greater than 0 mm and less than or equal to 54 mm. Mild pain included the descriptors of faint, weak, and mild pain. Moderate pain was defined as greater than 54 mm and less than 114 mm. Severe pain was defined as equal to or greater than 114 mm. Severe pain included the descriptors of strong, intense, and maximum possible.

Either benzocaine (Patterson Brand, St. Paul, Minn) topical anesthetic gel or a petroleum gel (K Mart, Troy, Mich) placebo was used at the injection site by random distribution. The 40 subjects randomly received either topical anesthetic gel or the placebo gel at the first appointment, and the anesthetic gel or placebo gel not assigned at the first appointment was used at the second appointment. Eighty injections were administered in the study, 40 using topical anesthetic and 40 using placebo gel. Two cotton tip applicators were used at each appointment. To make it difficult for each subject to know if they received the topical anesthetic, 0.2 mL of benzocaine on a cotton tip applicator, was placed on the lateral surface of each subjects' tongue. The applicator was then placed in the mandibular right molar vestibule for 1 minute and removed immediately prior to the injection. The experimental cotton tip applicator, with either 0.2 mL of benzocaine or petroleum jelly (placebo), was then held on the incisive papilla for 1 minute. A tuberculin syringe was used to dispense the 0.2 mL of benzocaine.

The soft tissue of the papilla and surrounding tissue was visually inspected to ensure that this area was healthy before the start of the study. The P-ASA injection was administered with the Wand Plus® according to the recommendations of Friedman and Hochman.<sup>1,2</sup> The subject was informed that the injection would take almost 5 minutes and that they would hear chimes during the injection. The subject was placed in a supine position with the head tilted up and back. The initial P-ASA injection site was located at a groove just lateral to the incisive papilla. The injection was performed with a 30-gauge, 1-inch Luer-Lok needle (Becton Dickinson and Co, Franklin Lakes, NJ). For the needle insertion phase of the injection, the needle bevel was placed against the palatal tissue, without puncturing the tissue, and a plain cotton tip applicator was firmly pressed on the needle tip for the pre-puncture phase of needle insertion.<sup>1,2</sup> The Wand Plus® was activated at a slow rate (by partially depressing the foot pedal) for 8 seconds to supposedly force the anesthetic solution into the tissue.<sup>4</sup> By removing the foot from the foot pedal, the Wand Plus® unit was activated on cruise control (continuous flow of anesthetic solution at the slow rate). One chime from the Wand Plus® machine corresponded to 1 second, allowing audible monitoring of the elapsed time. Approximately 1 drop of anesthetic solution was delivered every other second on the slow setting. The handpiece, with attached needle, was rotated in an axial manner (45 degrees clockwise and 45 degrees counterclockwise) for needle insertion. The needle was slowly advanced 1-2 mm, followed by a brief pause of 4 chimes. The needle was advanced another 1-2 mm, followed by a pause of 4 chimes, and the cotton tip applicator was then removed to observe the papilla for blanching. Approximately 0.08 mL of anesthetic solution was delivered during the needle insertion phase.

For the needle placement phase of the injection, the needle was then reoriented to an angle parallel to the facial aspect of the maxilla to gain entrance into the incisive canal. The needle was axially rotated 45 degrees and was slowly advanced (as described for the needle insertion phase) into the canal. The needle was placed to depth within 65 to 90 seconds from the initiation of needle placement. The needle was inserted to a depth of at least 6 mm and no more than 10 mm. In approximately 25% of the injections the needle had to be redirected to gain entrance into the canal. In these cases, the flow of anesthetic solution was briefly stopped by depressing the foot pedal and the needle's direction changed until entrance of the canal was accomplished. Approximately 0.32 to 0.45 mL of anesthetic solution was delivered during the needle placement phase.

The 5-second aspiration cycle was activated by tapping the foot pedal. No positive aspirations (blood in the microtubing) occurred in the 80 injections in this study. For the solution deposition phase of the injection, the Wand Plus® handpiece was held in position at the depth described above and the Wand Plus® continued on cruise control, at the slow setting, to deposit the remaining anesthetic solution. Visually monitoring the green lights on the Wand Plus® unit and audibly monitoring the corresponding chimes determined when the deposition of solution was complete. Approximately 0.9 to 1.0 mL of anesthetic solution was delivered during the solution deposition phase. The operator had direct vision of the injection site and confirmed that none of the anesthetic solution was expressed out of the injection site. The operator waited 6 seconds before slowly removing the needle from the injection site. This supposedly allowed the anesthetic solution to dissipate within the tissue and reduced the amount of solution dripping from the site before needle withdrawal.

No operative or restorative dental procedures were performed. Additionally, no probing or needle sticks of the soft tissues were performed. The 6 anterior teeth (right canine to left canine) were pulp tested in 4-minute cycles for 72 minutes. The results have been reported elsewhere.<sup>27</sup> Pulp testing the teeth would not result in postinjection pain or sequelae.<sup>28</sup>

All subjects completed postinjection surveys after each P-ASA injection administered. The subjects rated pain in the injection area, using the previous VAS, upon discontinuation of anesthesia on the day of the injection and upon waking in the morning for 3 days following the appointment. Patients were also instructed to describe and record any problems other than pain that they experienced.

Data were analyzed nonparametrically. Differences in needle insertion pain for topical anesthetic use versus placebo use were analyzed using the Wilcoxon matched pairs and signed rank tests. Between anesthetic solution differences in pain ratings for needle insertion, needle placement, solution deposition, and postinjection survey ratings were analyzed using Wilcoxon matched pairs and signed rank tests. Postinjection sequelae were compared using the McNemar test. Comparisons were considered significant at  $P < .05$ . With 40 subjects and a nondirectional alpha risk of 0.05, the power of the Mann-Whitney-Wilcoxon test to detect a difference of  $\pm 10$  mm on the VAS was greater than 99%; and the power of the McNemar test to detect a difference of  $\pm 30\%$  in the occurrence of postinjection sequelae was 80%.

**Table I.** Percentages and pain ratings of the P-ASA injections

Solution	None	Mild	Moderate	Severe	Mean*
Needle Insertion**					
Lidocaine with Epi	8% (3/40)	62% (25/40)	28% (11/40)	2% (1/40)	52 ± 32
Mepivacaine	2% (1/40)	55% (22/40)	35% (14/40)	8% (3/40)	57 ± 41
Needle Placement**					
Lidocaine with Epi	5% (2/40)	40% (16/40)	52% (21/40)	2% (1/40)	66 ± 38
Mepivacaine	8% (3/40)	35% (14/40)	48% (19/40)	10% (4/40)	73 ± 39
Solution Deposition**					
Lidocaine with Epi	25% (10/40)	68% (27/40)	8% (3/40)	0% (0/40)	22 ± 26
Mepivacaine	22% (9/40)	65% (26/40)	12% (5/40)	0% (0/40)	24 ± 28

\*Mean values on the VAS, ± SD.

\*\*There were no significant differences ( $P > .05$ ) between the solutions.

## RESULTS

Twenty men and 20 women ranging in age from 19 to 47 years (average age was 27 years) participated in this study. The mean dental anxiety score was  $5.8 \pm 1.5$  SD from a possible score of 4 to 20. A score of 4 corresponded to the least anxious and 20 indicated the most anxious.

Forty subjects received topical anesthetics and the same 40 received a placebo at a separate appointment. The mean VAS pain rating for needle insertion using topical anesthetic and a placebo was  $55 \pm 35$  mm and  $54 \pm 38$  mm, respectively. There was no significant difference ( $P > .05$ ) between the topical and placebo groups.

Anesthetic injection pain ratings are summarized in Table I. For needle insertion, 28% to 35% of the subjects reported moderate pain and 2% to 8% reported severe pain. For needle placement into the incisive canal, 48% to 52% of the subjects reported moderate pain and 2% to 10% reported severe pain. For anesthetic solution deposition, 8% to 12% of the subjects reported moderate pain. There were no significant differences ( $P > .05$ ) in needle insertion, needle placement, and solution deposition pain ratings between the lidocaine and mepivacaine solutions.

Postinjection pain is summarized in Table II. When anesthesia wore off on the day of the appointment, 12% to 18% of the subjects reported moderate pain and 2% reported severe pain. Pain ratings decreased over the next 3 days. There were no significant differences ( $P > .05$ ) between the lidocaine and mepivacaine solutions.

Table III lists the percentage of subjects who experienced post-injection sequelae. Twenty percent to 28% of the subjects reported incisive papilla swelling or soreness. Twelve percent to 18% of the subjects reported temporary numbness/paresthesia of the incisive papilla. Two percent to 5% of the subjects reported pulpal sensitivity or ulcerations. There was no significant difference ( $P > .05$ ) between the lidocaine and mepivacaine solutions.

## DISCUSSION

Clinically, the low mean anxiety score, using the Corah Dental Anxiety Scale questionnaire, of 5.8 indicates minimal anxiety. If more anxious patients had participated in this study, pain ratings could have been higher. However, many factors such as anxiety, fear, trust, perceived control over painful stimulus, interpretation of the painful stimulation, and personality influence pain.<sup>29</sup> Additionally, because of studying a young adult population, the results of this study may not apply to children or the elderly.

The use of topical anesthetic has been advocated as an aid in reducing the pain of needle insertion. The current study demonstrated no significant difference in needle insertion pain between the topical and placebo injections. While Rosivack et al<sup>30</sup> demonstrated the effectiveness of topical anesthetic, Gill and Orr<sup>31</sup> and Kincheloe et al<sup>32</sup> showed no significant pain reduction with the use of topical anesthetic. Meechan and Day<sup>22</sup> found that the palatal mucosa was more resistant to the effect of topical anesthetics than other intraoral sites. Therefore, the palatal injection site for the P-ASA injection may have more to do with the pain of needle insertion into non-compliant tissue than the use of topical anesthetic. Martin et al<sup>29</sup> found patients who believed they would receive topical anesthetic anticipated significantly less pain than patients who thought they would receive a placebo. Therefore, the most important aspect of using topical anesthetic may not be its clinical effectiveness, but rather the psychological effect on the patient who feels the practitioner is doing everything possible to prevent pain.<sup>29</sup> If the clinician would decide to use the P-ASA injection, we would advocate the use of topical anesthetic to convey a sense of concern for the patient's comfort.

For needle insertion with the P-ASA technique, 28% of the subjects reported moderate pain and 2% reported severe pain with the lidocaine solution and 35% reported moderate pain and 8% severe pain with the mepivacaine solution (Table I). There are no published

**Table II.** Percentages and pain ratings for postinjection survey

Solution	None	Mild	Moderate	Severe	Mean*
Day 0***					
Lidocaine with Epi	18% (7/40)	62% (25/40)	18% (7/40)	2% (1/40)	25 ± 33
Mepivacaine	22% (9/40)	62% (25/40)	12% (5/40)	2% (1/40)	25 ± 30
Day 1**					
Lidocaine with Epi	25% (10/40)	68% (27/40)	8% (3/40)	0% (0/40)	12 ± 25
Mepivacaine	33% (13/40)	58% (23/40)	8% (3/40)	2% (1/40)	13 ± 26
Day 2**					
Lidocaine with Epi	48% (19/40)	50% (20/40)	2% (1/40)	0% (0/40)	1 ± 20
Mepivacaine	40% (16/40)	60% (24/40)	0% (0/40)	0% (0/40)	2 ± 18
Day 3**					
Lidocaine with Epi	60% (24/40)	40% (16/40)	0% (0/40)	0% (0/40)	0 ± 15
Mepivacaine	45% (18/40)	55% (22/40)	0% (0/40)	0% (0/40)	1 ± 16

\*Mean values on the VAS, ± SD.

†Day of injection when anesthesia wore off

\*\*There were no significant differences ( $P > .05$ ) between the solutions.**Table III.** Percentages and number of subjects reporting postinjection sequelae.

Problem	2% Lidocaine with 1:100,000 epinephrine		3% Mepivacaine	P-value*
Incisive papilla swelling or soreness	20% (8/40)	28% (11/40)		0.549
Temporary anesthesia/ paresthesia of incisive papilla	12% (5/40)	18% (7/40)		0.727
Thermal pulpal sensitivity	2% (1/40)	2% (1/40)		1.000
Ulcerations	5% (2/40)	0% (0/40)		0.157

\*There were no significant differences ( $P > .05$ ) between the solutions.

reports to compare the pain of needle insertion with the P-ASA, because previous authors<sup>10,16</sup> did not divide injections into needle insertion, needle placement and solution deposition. Friedman and Hochman<sup>1</sup> speculated that the prepuncture technique, the careful axial needle rotation, and the controlled slow anesthetic deposition rate would reduce the sensation of needle insertion. Unfortunately, even with these techniques and a slow deposition rate, needle insertion was not painless. The results of the current study would caution practitioners not to advise patients that needle insertion will be painless, because 30% to 43% of the subjects rated needle insertion as moderately to severely painful.

For both anesthetic solutions, needle placement with the P-ASA technique resulted in a higher incidence of pain than did needle insertion. For needle placement with the lidocaine solution, 52% of the subjects reported moderate pain and 2% reported severe pain (Table I). For the mepivacaine solution, 48% of the subjects reported moderate pain and 10% reported se-

vere pain. Although previous studies<sup>10,16</sup> did not divide the P-ASA injection into needle placement and solution deposition, they did report overall findings on the P-ASA injection. Gibson et al<sup>10</sup> studying the P-ASA, AMSA, buccal infiltration, and traditional palatal injection in children aged 5-13 years, found that the Wand® produced significantly fewer children who exhibited disruptive behavior during the initial 15 seconds of the injection as compared to a conventional syringe injection. Additionally, more of the children receiving the conventional palatal injection rated the experience as extremely more painful than those children who received the Wand® palatal injections. Allen et al<sup>16</sup> administered P-ASA, AMSA, buccal, and palatal infiltrations in children aged 2 to 5 years and found that the Wand® significantly reduced disruptive behaviors as compared to a conventional syringe injection. Again, the results of the current study would caution practitioners not to advise patients that needle placement will be painless, because 54% to 58% of the subjects rated needle placement as moderately to severely painful. Needle placement was usually the most uncomfortable phase of the P-ASA injection (Table I).

The current study followed the manufacturer's directions for the P-ASA injection. For needle insertion and placement, the computer controlled the rate of deposition of small amounts of the anesthetic solutions as the needle was advanced. The needle was placed to a depth of at least 6 mm and no more than 10 mm over 65 to 90 seconds. It has been speculated that the Wand® creates a continuous positive solution pressure that delivers anesthetic solution that precedes the needle path.<sup>4</sup> The information in the Wand Plus® manual states, "This anesthetic pathway is believed to assist in virtually eliminating discomfort as the needle penetrates through the tissue."<sup>4</sup> Unfortunately, owing to the moderate to

severe pain ratings recorded in this study, these speculations do not apply to the P-ASA injection with the Wand Plus®. Because the deposition rate is controlled by the Wand Plus®, it is not possible to decrease the rate of anesthetic solution deposition during needle placement. One way to potentially decrease the pain of needle placement would be to advance the needle at a slower rate. However, slowing the rate of needle placement would increase the amount of solution deposited during this phase and reduce the amount deposited at the target site (solution deposition phase). Whether the decreased amount of anesthetic solution would effect clinical anesthesia would have to be studied.

For both anesthetic solutions, solution deposition with the P-ASA technique resulted in a lower incidence of pain than did needle insertion or placement. For solution deposition with the lidocaine solution, 8% of the subjects reported moderate pain and none reported severe pain (Table I). For the mepivacaine solution, 12% of the subjects reported moderate pain and none reported severe pain. Again, because the deposition rate is controlled with the Wand Plus®, it is not possible to decrease the rate of solution deposition. The P-ASA injection with the Wand Plus®, on the slow setting, took approximately 4 minutes and 45 seconds. Slowing the rate of deposition further, according to the manufacturer, would result in an injection time of perhaps 6 to 8 minutes. The increase in injection time may not be clinically practical. Additionally, studies would have to determine if a slower rate of deposition would result in less pain with the P-ASA injection. While deposition resulted in less pain than the other phases, the results of the current study would caution practitioners not to advise patients that solution deposition will be painless, because 8 to 12% of the subjects rated solution deposition as moderately painful.

While the pH of solutions may have an effect on injection pain,<sup>17-19</sup> a more important consideration in the pain of the P-ASA injection is the nature of the noncompliant palatal tissue<sup>18,22</sup> and placement of the needle and deposition of the anesthetic solution into very sensitive tissue.

Postinjection pain ratings, at the time anesthesia wore off, were similar for the lidocaine and mepivacaine solutions (Table II). The incidence of moderate pain was 12% to 18%, with 2 reports of severe pain (Table II). The incidence of moderate/severe pain decreased over the next day and by day 2 only 1 subject reported moderate pain. By day 3, no subjects reported moderate/severe pain (Table III). There are no published reports to compare the postinjection pain of the P-ASA injection with the current study. In general, the P-ASA injection does result in some postinjection pain.

Subjects reported some sequelae and complications

on the postinjection questionnaire (Table III). When postinjection sequelae were recorded, follow-up of the subject was provided until the problem resolved. Twelve percent to 18% of the subjects reported temporary numbness/paresthesia of the incisive papilla. Most of these resolved by the third day but a few needed a week to 10 days for resolution. The numbness/paresthesia was likely caused by direct damage from the needle or deposition of anesthetic solution. Generally, the numbness/paresthesia was described by the subjects as only an annoyance. Patients who receive the P-ASA injection should be reassured that temporary numbness/paresthesia might occur and should resolve within 10 days. Twenty percent to 28% of the subjects reported minor swelling or soreness of the incisive papilla. Almost all had resolved by the third day and were only a minor irritation with no effect on eating or speech. Patients should be informed that some minor swelling or soreness of the papilla might occur after the P-ASA injection. Two percent of the subjects reported cold or hot pulpal sensitivity that began about the third day and continued for 2-4 days. It is not clear exactly what caused the sensitivity but it may be related to neural alteration. Patients who experience this sensitivity need to be reassured that it is transient and should resolve within a few days. Two subjects reported ulcerations just lateral to the incisive papilla. The ulcerations developed 3 to 4 days postinjection, were painful, and resolved within a week to 10 days. The most likely cause of the ulcerations were recurrent herpes simplex virus infections.<sup>33</sup> Patients who are prone to ulcerations after dental treatment should be cautioned that the P-ASA injection might precipitate an eruption, like any injection in keratinized oral tissue.<sup>33</sup> Most patients are aware of their condition and accept it as an unpleasant complication to dental treatment.

The pain and postinjection pain and sequelae may be related to the volume of solution injected. However, the volume of anesthetic solution used in this study is not considered excessive in the description of the technique by Freidman and Hochman;<sup>1,4</sup> they advocated using 0.9 to 1.4 mL for efficacy of the P-ASA injection. Future studies could compare reduced volumes of solution to determine if there would be less injection pain and fewer postinjection sequelae.

It is unknown if the P-ASA injection with a conventional syringe, or the more conventional use of an incisive injection supplemented with an infiltration of the region, would provide less pain and postinjection pain. Future studies may want to evaluate these techniques.

The finding of no significant differences between 2% lidocaine with 1:100,000 epinephrine and 3% mepivacaine in terms of pain of injection, postinjection pain,

and postinjection sequelae would indicate the 2 anesthetic agents are similar for the variables measured. Therefore, if medical conditions or drug therapies contraindicate the use of epinephrine-containing solutions, 3% mepivacaine could be used in the P-ASA technique and would cause similar pain and sequelae as 2% lidocaine with epinephrine.

In conclusion, the P-ASA injection of 1.4 mL of 2% lidocaine with 1:100,000 epinephrine or 3% mepivacaine, administered with the Wand Plus®, has the potential to be a painful injection. The use of topical anesthetic did not significantly reduce pain of needle insertion when compared to a placebo. The incidence of post-injection pain, temporary numbness/paresthesia and incisive papilla swelling or soreness would indicate that some pain and problems occur with the P-ASA technique, regardless of whether 2% lidocaine with 1:100,000 epinephrine or 3% mepivacaine is used.

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## Reprint requests:

Dr. John Nusstein  
Advanced Endodontics  
College of Dentistry  
Ohio State University  
305 W 12th Avenue  
Box 182357  
Columbus, OH 43218-2357  
nusstein.1@osu.edu

