

# Anesthetic efficacy of the palatal–anterior superior alveolar injection

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**T**raditionally, dentists have anesthetized maxillary anterior teeth by administering an infiltration injection near the apex of the target tooth. In the past five years, a site-specific injection for anesthetizing anterior

maxillary teeth has been introduced: the palatal–anterior superior alveolar, or P-ASA, injection.<sup>1,2</sup> Friedman and Hochman<sup>1</sup> reported that bilateral pulpal anesthesia of the maxillary incisors and usually the canines will be achieved with a P-ASA injection of 0.9 to 1.4 milliliters of anesthetic solution for approximately 60 minutes. Additionally, they stated that soft-tissue anesthesia of the anterior one-third of the palate and facial gingivae are achieved without numbness to the lips and face or interference with the muscles of facial expression. Nasopalatine injections are intended to anesthetize the soft tissues of the anterior palate.<sup>3</sup> In P-ASA injections, the needle penetrates more deeply and more volume of anesthetic solution is injected than in nasopalatine injections. The P-ASA injection involves a palatal injection into the incisive canal, and it

derives its name from the injection's ability to supposedly anesthetize both the right and left ASA nerves.

The right and left ASA nerves branch from their respective infraorbital nerves for approximately 6 to 10 millimeters before they exit from the infraorbital

**Background.** A single palatal–anterior superior alveolar, or P-ASA, injection has been reported to provide pulpal anesthesia of the four maxillary incisors and usually the canines. The authors conducted a prospective, randomized, double-blind study to compare the anesthetic efficacy of 2 percent lidocaine with 1:100,000 epinephrine and 3 percent mepivacaine using a computer-assisted injection system to administer the P-ASA injection.

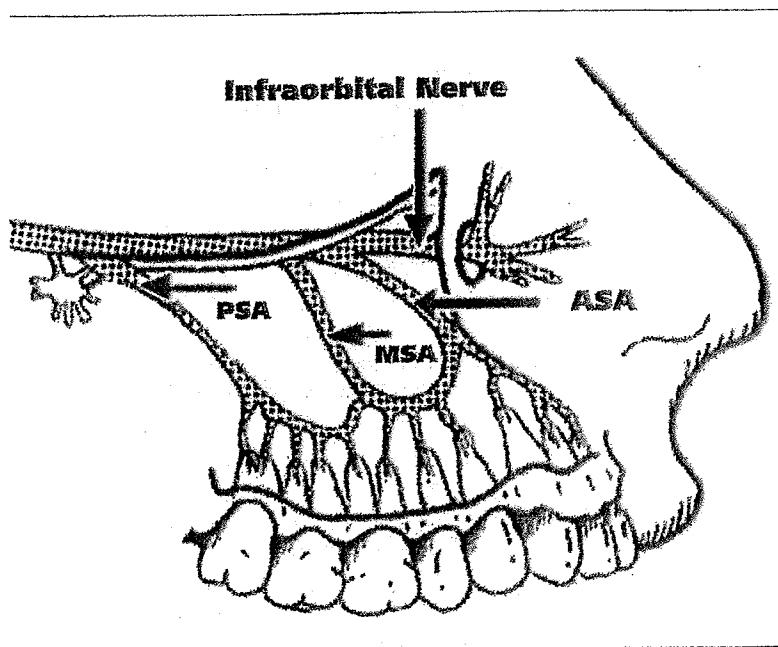
**Materials and Methods.** In a double-blind manner, the authors used a crossover design to administer randomly P-ASA injections of 1.4 milliliters of the lidocaine solution and 1.4 mL of the mepivacaine solution using the computer-assisted injection system at two appointments to 40 subjects. They used a pulp tester to test for anesthesia of the central incisors, lateral incisors and canines in four-minute cycles for 72 minutes. Anesthesia was considered successful when two consecutive maximum readings (80 readings) with the pulp tester were obtained.

**Results.** For the lidocaine solution, successful pulpal anesthesia ranged from 32 to 58 percent for the six anterior teeth. For the mepivacaine solution, successful pulpal anesthesia ranged from 22 to 38 percent. Except for the left canine, the lidocaine solution was significantly more likely to result in pulpal anesthesia than the use of the mepivacaine solution. The duration of pulpal anesthesia, for both solutions, declined steadily over 72 minutes.

**Conclusions and Clinical Implications.** Using the computer-assisted injection system for the P-ASA injection, we concluded that the rather modest-to-low success rates of the lidocaine and mepivacaine solutions would not ensure predictable pulpal anesthesia of the four maxillary incisors and the canines.

foramina<sup>3</sup> (Figure 1). The ASA 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

The rather modest-to-low success rates of the lidocaine and mepivacaine solutions would not ensure predictable pulpal anesthesia of the four maxillary incisors and the canines.



**Figure 1.** Distribution of the maxillary division of the trigeminal nerve showing the infraorbital nerve and anterior superior alveolar, or ASA, nerve, as well as the posterior superior alveolar, or PSA, and middle superior alveolar, or MSA, nerves.

membranes adjacent to these teeth.<sup>3</sup>

Palatal injections administered into the incisive papilla with a traditional syringe usually are painful.<sup>3</sup> A computer-assisted injection system (Wand Plus, Milestone Scientific, Livingston, N.J.) was developed recently with claims that it would provide a "virtually painless" injection.<sup>14</sup> The majority of the literature on this system has dealt with the pain of an injection administered with the computer-assisted injection system compared with that of standard injections administered using a syringe.<sup>5-16</sup> In general, the results have been favorable<sup>5,6,10-16</sup> with two studies showing no difference<sup>7,8</sup> and one study showing higher pain ratings<sup>9</sup> with the computer-assisted injection system.

Friedman and Hochman<sup>1</sup> reported that the P-ASA injection administration technique is comfortable for the patient. Gibson and colleagues<sup>10</sup> and Allen and colleagues<sup>16</sup> studied the P-ASA injection, anterior middle superior alveolar injection, buccal infiltration and traditional palatal injection in children. They found that use of the computer-assisted injection system resulted in significantly fewer children exhibiting disruptive behavior and that it produced less pain when compared with a conventional syringe injection.

Studies by McLean and colleagues<sup>17</sup> and Cohen

and colleagues<sup>18</sup> have shown that 3 percent mepivacaine alone is as effective as 2 percent lidocaine with 1:100,000 epinephrine in an inferior alveolar nerve block. Therefore, 3 percent mepivacaine should be as effective as 2 percent lidocaine with 1:100,000 epinephrine in the P-ASA technique, which has been called a nerve block.<sup>1,2</sup> Additionally, when medical conditions or drug therapies suggest caution in the use of epinephrine-containing solutions, it would be advantageous to use 3 percent mepivacaine for the P-ASA injection.

No study has objectively measured the efficacy or duration of pulpal anesthesia obtained with the P-ASA injection. Therefore, the purpose of this prospective, randomized, double-blind study was to compare the anesthetic efficacy of 2 percent lidocaine with 1:100,000 epinephrine and 3 percent mepivacaine using the computer-assisted injection system to administer the P-ASA injection.

#### MATERIALS AND METHODS

Forty adult subjects (20 men and 20 women) aged 19 to 47 years, with an average age of 27 years, participated in this study. All subjects were in good health, and we determined via a written health history and oral questioning that they were not taking any medication that would alter their pain perception. The Ohio State University Human Subjects Review Committee approved the study, and we obtained written informed consent from each subject.

In a crossover design, the 40 subjects randomly received two P-ASA injections at two appointments that were spaced at least one week apart. The P-ASA injections the subjects received used 1.4 mL of 2 percent lidocaine (28 milligrams) with 1:100,000 epinephrine (14 micrograms) (Xylocaine, Dentsply Pharmaceutical, York, Pa.) at one appointment and 1.4 mL of 3 percent mepivacaine (42 mg) (Polocaine, Dentsply Pharmaceutical) at the other appointment using the computer-assisted injection system. The senior author (Y.B.) administered all of the injections in this study. She also administered the P-ASA injection using the computer-assisted injection system to emergency and routine endodontic patients during the three months before the beginning of the study. In this period, she administered more than 80 P-ASA injections.

The computer-assisted injection system is a microprocessor-driven device that delivers a controlled infusion of anesthetic solution.<sup>4</sup> The device

accepts standard 1.8-mL dental anesthetic glass cartridges. 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 a precisely regulated rate. Sterile tubing connects the cartridge receptor to a penlike, hand-held plastic wand that is attached to a Luer-Lok needle (Becton-Dickinson, Franklin Lakes, N.J.), which together form a disposable syringe assembly. A small portion of solution from a standard cartridge is lost during the purge cycle (solution is expressed from the needle when the tubing is filled), and some of the solution remains in the cartridge and tubing; thus, only 1.4 mL of anesthetic solution from 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 handpiece, microtubing and anesthetic cartridge are designed for one use only.

The teeth we tested in the study were the right and left maxillary central incisors, lateral incisors and canines. We used the mandibular right canine as the unanesthetized control to ensure that the pulp tester was operating properly and that the subject was responding appropriately during the experiment. We conducted clinical examinations of the subjects, which indicated that all of the test teeth were free of caries, large restorations and periodontal disease, and that none of them had a history of trauma or sensitivity.

Trained personnel, who were blinded to the anesthetic solutions being administered, performed all preinjection and postinjection tests. At the beginning of each appointment and before any injections were given, they tested the experimental teeth and control canine three times using a Kerr pulp tester (Analytic Technology, Redmond, Wash.) to record baseline vitality. After isolating the teeth with cotton rolls and drying them with gauze, the trained personnel applied toothpaste to the probe tip and placed it midway between the gingival margin and the incisal edge of the tooth to be tested. They set the current rate on the pulp tester at 25 seconds to increase from no output (0) to the maximum output (80). They then recorded the number at initial sensation.

Before the experiment, we randomly assigned the two anesthetic solutions six-digit numbers from a random number table. We assigned the random numbers to a subject to designate which anesthetic solution was to be administered at each appointment. We blinded the anesthetic solutions by completely masking the cartridges with permanent black marker; we checked the expiration dates on the cartridges before masking them. Two blinded cartridges of the same anesthetic solution were placed in letter-sized envelopes that were labeled with the six-digit code, so the code would not have to be broken in the event of a broken or dropped cartridge. Only the random numbers were recorded on the data collection sheets to further blind the experiment.

One blinded cartridge was removed from the envelope, placed into the plastic barrel of the computer-assisted injection system's handpiece assembly, which was placed into the cartridge holder socket with a one-quarter turn in a counterclockwise direction. The cap was removed from the needle and the foot pedal was depressed once to activate the purge cycle, remove air from the plastic tubing and fill the

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line with anesthetic solution.

The senior author administered the P-ASA injection with the computer-assisted injection system according to the recommendations of Friedman and Hockman.<sup>1,2</sup> She informed the subjects that the injection would take almost five minutes and that they would hear chimes during the injection. The subjects were placed in a supine position with their heads tilted up and back. The initial P-ASA injection site was located at a groove just lateral to the incisive papilla. The injection was administered with a 30-gauge, 1-inch Luer-Lok needle.

In the needle-insertion phase of the injection, the beveled surface of the needle was placed against the subjects' palatal tissue without puncturing the tissue, and a plain cotton tip applicator was pressed firmly on the needle tip for the prepuncture phase of the needle-insertion phase.<sup>1,2</sup> The computer-assisted injection system was activated at a slow rate (by partially depressing the foot pedal) for eight seconds to supposedly force the anesthetic solution into the tissue.<sup>4</sup> When the senior author removed her foot from the foot pedal, she activated the computer-assisted injection

tion system's cruise control function (continuous flow of anesthetic solution at a slow rate). One chime from the machine corresponded to one second, which allowed for audible monitoring of the elapsed time. Approximately one 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 to 2 mm, followed by a pause of four chimes. Then the needle was advanced another 1 to 2 mm, followed by a pause of four chimes, and the cotton tip applicator was removed so that the senior author could observe the papilla for blanching. Approximately 0.08 mL of anesthetic solution was delivered during the needle-insertion phase.

In the needle-placement phase of the injection, the needle was reoriented to an angle parallel to the facial aspect of the maxilla so that it would gain entrance into the incisive canal. The needle was rotated 45 degrees axially and was advanced slowly (as described in the needle-insertion phase) into the canal. The needle was placed to a depth of 6 to 10 mm within 65 to 90 seconds from the initiation of needle placement. In approximately 25 percent of the injections, the needle had to be redirected to gain entrance into the canal. In these cases, the flow of anesthetic solution was stopped briefly by depressing the foot pedal, and the needle's direction was changed until entrance into the canal was accomplished. Approximately 0.32 to 0.45 mL of anesthetic solution was delivered during the needle placement phase.

The five-second aspiration cycle was activated by tapping the foot pedal. No positive aspirations (blood in the microtubing) occurred in the 80 injections administered in this study.

In the solution-deposition phase of the injection, the computer-assisted handpiece was held in position at the depth described previously, and the unit was kept on cruise control at the slow setting to deposit the remaining anesthetic solution. By visually monitoring the green lights on the unit and auditorily monitoring the corresponding chimes, the senior author was able to determine 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 senior author had direct vision of the injection site and confirmed that none of the anesthetic solution was expressed out of the injection site. She waited for six seconds before slowly removing the needle from the injection site to allow the anesthetic solution to dissipate within the tissue and to reduce the amount of solution dripping from the site before needle withdrawal.

Trained personnel monitored the depth of anesthesia with the pulp tester. At one minute after the P-ASA injection, they obtained pulp test readings for the right canine and the right lateral incisor; at two minutes, they tested the right central incisor and left canine; at three minutes, they tested the left lateral incisor and left central incisor; and at four minutes, they tested the mandibular control canine. The testing continued in four-minute cycles for a period of 72 minutes.

We used no response from the subject to the maximum output (80 reading) of the pulp tester as the criterion for pulpal anesthesia. We considered anesthesia to be successful when two consecutive 80 readings were obtained.

We analyzed the data statistically. We made a comparison of anesthetic success between the two anesthetic solutions for each experimental tooth using a logistic regression model with age, sex, period and anesthetic solution as the predictor variables. We considered comparisons to be significant at  $P < .05$ .

## RESULTS

Anesthetic success is presented in Table 1. For injections of the 2 percent lidocaine with 1:100,000 epinephrine solution, successful pulpal anesthesia ranged from 32 to 58 percent for the six anterior teeth. For injections of the 3 percent mepivacaine solution, successful pulpal anesthesia ranged from 22 to 38 percent. We used a logistical regression analysis to compare the effect the anesthetic solutions had on each tooth's odds of achieving pulpal anesthesia (Table 2). For all teeth except the left canine, the use of 2 percent lidocaine with 1:100,000 epinephrine was significantly more likely to result in pulpal anesthesia than was the use of 3 percent mepivacaine.

We did not perform a statistical analysis of onset and duration of anesthesia between the two

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anesthetic solutions because of the low number of successes with the 3 percent mepivacaine solution, which resulted in insufficient numbers for matched-pairs analysis. Therefore, we use the figures for the individual teeth to explain the onset and duration of the anesthetic solutions.

For the left and right central incisors (Figures 2 and 3), onset (the

**TABLE 1**

PERCENTAGE OF ANESTHETIC SUCCESS OF THE PALATAL-ANTERIOR SUPERIOR ALVEOLAR INJECTION USING A COMPUTER-ASSISTED INJECTION SYSTEM.		
TOOTH	PERCENTAGE OF ANESTHETIC SUCCESS (NO. ANESTHETIZED OF TOTAL SUBJECTS)	
	2% Lidocaine With 1:100,000 Epinephrine	3% Mepivacaine
Right Canine	35 (14)	30 (12)
Right Lateral Incisor	48 (19)	38 (15)
Right Central Incisor	58 (23)	35 (14)
Left Central Incisor	55 (22)	30 (12)
Left Lateral Incisor	58 (23)	30 (12)
Left Canine	32 (13)	22 (9)

**TABLE 2**

LOGISTIC REGRESSION ANALYSIS TO DETERMINE THE EFFECT THE ANESTHETIC SOLUTIONS HAD ON EACH TOOTH'S ODDS OF ACHIEVING PULPAL ANESTHESIA.				
TOOTH	ODDS RATIO*	LOWER CONFIDENCE BOUNDARY (95%)	UPPER CONFIDENCE BOUNDARY (95%)	P VALUE
Right Canine	4.14	1.68	10.2	.002
Right Lateral Incisor	5.44	2.50	11.8	< .0001
Right Central Incisor	5.71	2.39	13.7	.0001
Left Central Incisor	5.85	2.66	12.9	< .0001
Left Lateral Incisor	7.51	3.64	15.5	< .0001
Left Canine	2.41	0.92	6.28	.0724

\* Adjusted odds ratios for pulpal anesthesia after injection of 2 percent lidocaine with 1:100,000 epinephrine compared with that after injection of 3 percent mepivacaine. The odds ratios were adjusted for age, sex and period.

highest percentage of 80 readings) of anesthesia was within the first four to eight minutes for both anesthetic solutions. However, the highest percentage of teeth anesthetized was 55 to 58 percent for the lidocaine solution and 30 to 35 percent for the 3 percent mepivacaine solution. For both solutions, the duration of pulpal anesthesia decreased steadily over the 72-minute test period.

The results for the left and right lateral incisors mimicked the results of the central incisors (Figures 4 and 5). Onset of anesthesia also took place within the first four to eight minutes. The highest percentage of teeth anesthetized was 48 to 58 percent for the lidocaine solution and 30 to 38 percent for the 3 percent mepivacaine solution. As in the central incisors,

the duration of pulpal anesthesia decreased steadily over the 72-minute test period.

A lower percentage of the left and right canines (Figures 6 and 7, page 1275) were anesthetized compared with the central and lateral incisors. Onset of anesthesia took place within the first four to eight minutes. The highest percentage of teeth anesthetized was 32 to 35 percent for the lidocaine solution and 22 to 30 percent for the 3 percent mepivacaine solution. As in the other anterior teeth, the duration of pulpal anesthesia decreased steadily over the 72-minute test period.

**DISCUSSION**

We based our use of the 80 reading (maximum output of the pulp tester) as a criterion for pulpal

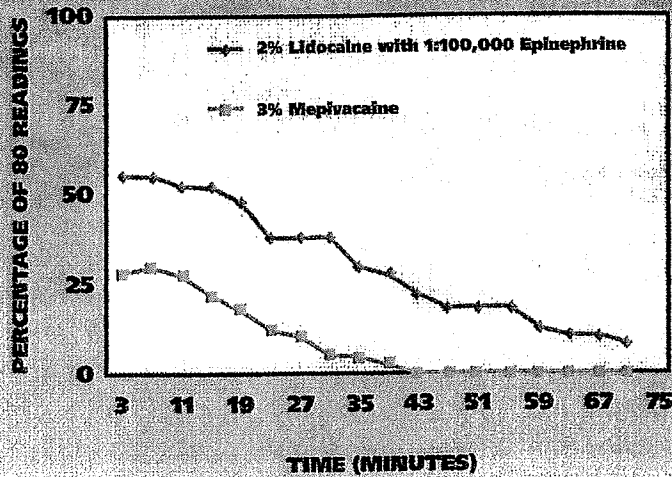


Figure 2. Incidence of left central incisor pulpal anesthesia as determined by lack of response to electrical pulp testing at the maximum setting (percentage of 80 readings) at each postinjection interval for the two anesthetic solutions.

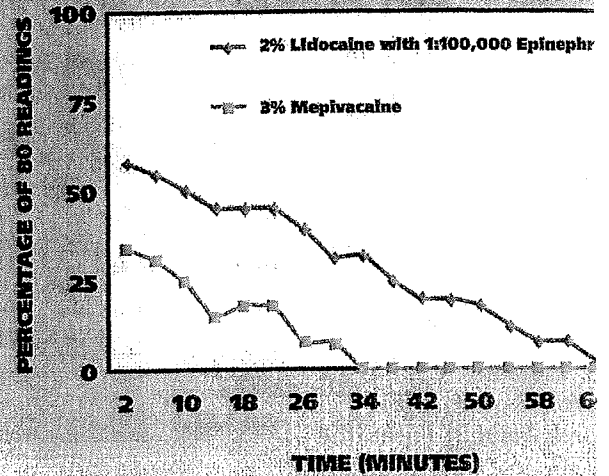


Figure 3. Incidence of right central incisor pulpal anesthesia as determined by lack of response to electrical pulp testing at the maximum setting (percentage of 80 readings) at each postinjection interval for the two anesthetic solutions.

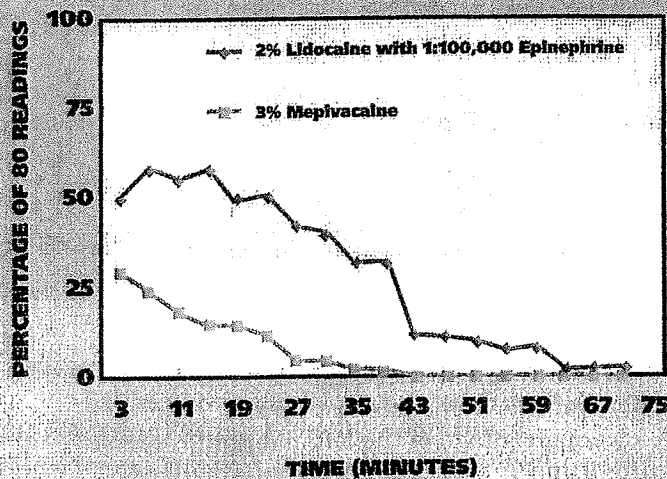


Figure 4. Incidence of left lateral incisor pulpal anesthesia as determined by lack of response to electrical pulp testing at the maximum setting (percentage of 80 readings) at each postinjection interval for the two anesthetic solutions.

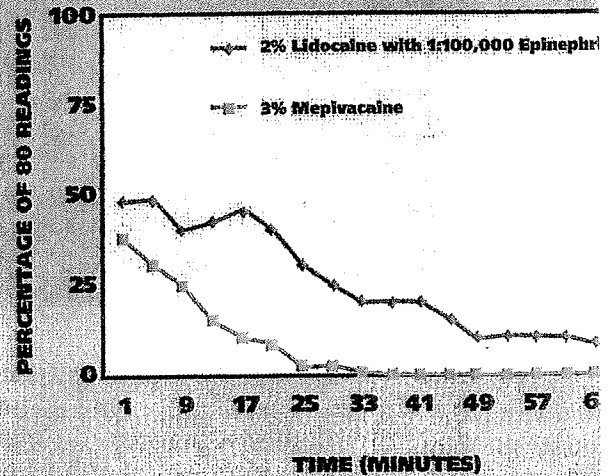


Figure 5. Incidence of right lateral incisor pulpal anesthesia as determined by lack of response to electrical pulp testing at the maximum setting (percentage of 80 readings) at each postinjection interval for the two anesthetic solutions.

anesthesia on the studies of Dreven and colleagues<sup>19</sup> and Certosimo and Archer.<sup>20</sup> These two studies showed that an 80 reading ensures pulpal anesthesia in vital asymptomatic teeth. Additionally, Certosimo and Archer<sup>20</sup> demonstrated that pulp testing readings of less than 80 resulted in

pain during restorative procedures.

Clinically, the results of our study indicate that 3 percent mepivacaine generally would be less effective than 2 percent lidocaine with 1:100,000 epinephrine in the P-ASA technique (Tables 1 and 2, Figures 2-7). However, the lidocaine solution

resulted in successful pulpal anesthesia 32 to 58 percent of the time and would not clinically ensure predictable pulpal anesthesia from the right canine to the left canine. The use of the P-ASA injection for clinical anesthesia of the six anterior teeth theoretically would be advantageous because only one injection would anesthetize all the anterior teeth bilaterally for 60 minutes; thus, it would be ideal for restorative and cosmetic dentistry.<sup>1,2</sup> Unfortunately, we could not confirm some authors' clinical impressions that the P-ASA injection would be so successful.<sup>1,2</sup> Because we studied a young adult population, the results of this study may not apply to children or the elderly.

Onset of anesthesia generally occurred within the first four to eight minutes (Figures 2-7). However, with fewer than 60 percent of the teeth achieving pulpal anesthesia after receiving 2 percent lidocaine with 1:100,000 epinephrine and fewer than 40 percent achieving pulpal anesthesia after receiving 3 percent mepivacaine, onset of anesthesia may be of little clinical importance. The duration of anesthesia in our study was not 60 minutes for the P-ASA injection as was documented by Friedman and Hochman.<sup>1</sup> For example, when the right central incisors were anesthetized using 2 percent lidocaine with 1:100,000 epinephrine, approximately 35 percent of the subjects were numb at 30 minutes, 20 percent were numb at 45 minutes, and 8 percent were numb at 60 minutes (Figure 2 and 3). Therefore, we could not confirm the clinical impression<sup>1</sup> that duration of pulpal anesthesia with the P-ASA injection was 60 minutes.

While the P-ASA injection has been called a nerve block, it did not behave like a nerve block. Malamed<sup>8</sup> defines a nerve block as when a local anesthetic solution is deposited close to a main nerve trunk. Therefore, the anesthetic solution would have to be deposited close to where the ASA nerves branch from the infraorbital nerves, which is 6 to 10 mm before the nerves exit from the infraorbital foramina. The result should be a high rate of pulpal anesthesia for all the anterior teeth without a pronounced decline of pulpal anesthesia over a 60-minute period. Additionally, as shown by McLean and colleagues<sup>17</sup> and Cohen and colleagues,<sup>18</sup> the success rate should be comparable for 2 percent lidocaine with 1:100,000 epinephrine and 3 percent mepivacaine if the P-ASA truly was a nerve block.

We concluded that the P-ASA injection, as administered in this study, did not effectively

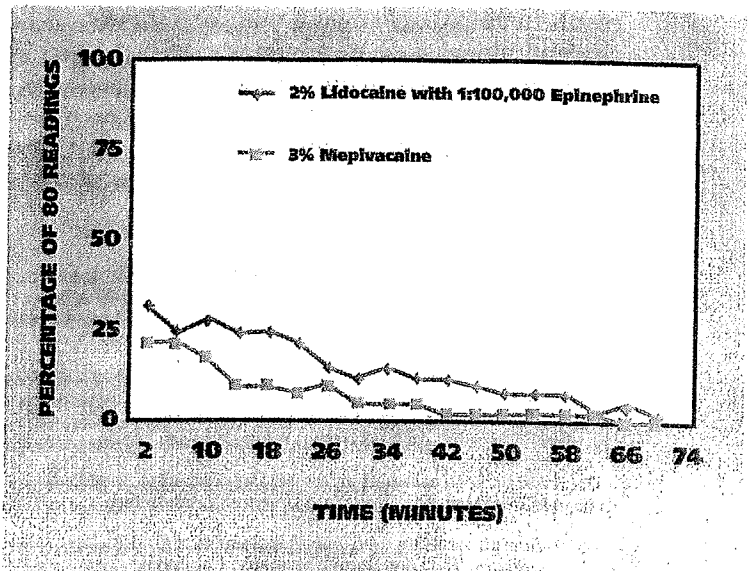


Figure 6. Incidence of left canine pulpal anesthesia as determined by lack of response to electrical pulp testing at the maximum setting (percentage of 80 readings) at each postinjection interval for the two anesthetic solutions.

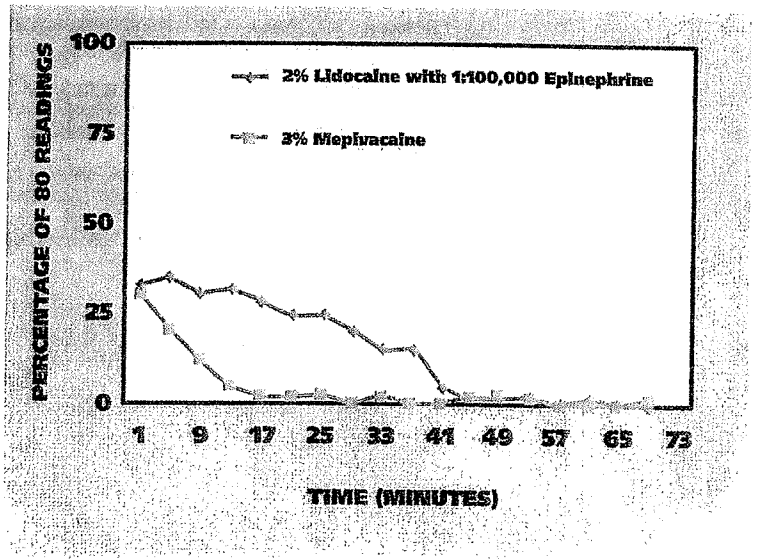


Figure 7. Incidence of right canine pulpal anesthesia as determined by lack of response to electrical pulp testing at the maximum setting (percentage of 80 readings) at each postinjection interval for the two anesthetic solutions.

block the ASA nerves nor was the anesthetic solution in close enough proximity to the apexes of all six anterior teeth to provide reliable pulpal anesthesia.

**CONCLUSIONS**

We found that 2 percent lidocaine with 1:100,000 epinephrine was significantly more likely to

result in pulpal anesthesia than was the use of 3 percent mepivacaine administered with a P-ASA injection using the computer-assisted injection system. However, the rather modest-to-low success rates of both solutions would not ensure predictable pulpal anesthesia of the four maxillary incisors and the canines. ■

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