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# A Comparison of the Periodontal Ligament Injection Using 2% Lidocaine with 1:100,000 Epinephrine and Saline in Human Mandibular Premolars

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The purpose of this study is to evaluate, with the electric pulp tester, the anesthetic efficacy of the periodontal ligament injection using 2% lidocaine with 1:100,000 epinephrine and saline in human mandibular premolars. The periodontal ligament injection using 2% lidocaine with 1:100,000 epinephrine was found to be an effective technique for anesthetizing mandibular first premolars. However, the duration of profound pulpal anesthesia was approximately 10 minutes. The periodontal ligament injection using sterile saline was not an effective technique for anesthesia. Teeth mesial and distal to the injected tooth may also become anesthetized with this injection technique. The initial needle penetration and injection of the anesthetic solution in clinically healthy teeth were only mildly discomforting. No increase in tooth mobility was observed 45 minutes after the periodontal ligament injection. No clinically observable pulpal or periodontal damage was seen at 3 weeks after the injection.

Local anesthesia is the primary method used in dentistry to control patients' pain. However, profound pulpal anesthesia is not always achieved.[1,2] Kaufman et al,[3] in a survey of 93 general dentists, found that 90% reported some anesthetic failure during restorative visits over the 5 days preceding the survey. Forty-four percent of dentists reporting initial anesthetic failure noted disrupted or lengthened visits and 11% were not able to complete the procedure they had begun. Malamed[4] states that despite advances in anesthetics and anatomical studies, adequate pain control is a difficult clinical problem.

Recently the periodontal ligament injection technique has been advocated as a primary and a supplemental anesthesia technique.[1,4–10] Overall success rates reported in clinical studies have ranged from 81% to 86% when used as a primary technique,[4,5,9] and from 83% to 92% when used for supplemental anesthesia.[1,10] Many of these authors have stated that strong back-pressure was necessary for success of the periodontal ligament injection. This has led to speculation that a portion of the anesthesia obtained may be related to a pressure phenomenon. Birchfield and Rosenburg[11] found that successful intrapulpal anesthesia was obtained with either an anesthetic solution or saline, provided strong back-pressure was produced during the injection. The exact role of pressure alone in the success of the periodontal ligament injection is unknown.

The purpose of this study is to evaluate, with the electric pulp tester, the anesthetic efficacy of the periodontal ligament injection using 2% lidocaine with 1:100,000 epinephrine and sterile saline in human mandibular premolars.

## MATERIALS AND METHODS

Nineteen patients, 15 males and 4 females, served as subjects for this study. The subjects were judged to be in good health as determined by a written clinical medical history and oral questioning. They were currently taking no medications and had never had an allergic or toxic reaction to any of the local anesthetic solutions. The

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study was approved by the Human Subjects Committee of The Ohio State University and written consent was obtained from each subject.

The experimental solutions tested were 2% lidocaine with 1:100,000 epinephrine (Astra Pharmaceuticals Products, Inc.) and sterile saline. The saline cartridges were prepared in the following manner: Anesthetic cartridges and plungers were washed for 5 minutes with soap and water using a nylon brush. All cartridges and plungers were then rinsed with tap water for 5 hours and autoclaved for 50 minutes. Using sterile technique, each cartridge was filled with 1.8 mL of sterile saline and the plungers were replaced.

Mandibular first premolars were chosen as the experimental teeth. Upon clinical examination, all teeth were free of caries, deep restorations, and had no exposed dentin. Mobility was tested with horizontal pressure using two mirror handles positioned on the buccal and lingual surfaces of each tooth. No tooth exhibited mobility more than 0.5 mm in any direction. Periodontal probing was done on the mesial and distal aspects of each tooth. Subjects with periodontal pockets more than 3 mm were eliminated from the study. The gingival tissue met Glickman's criteria[12] for gingival health.

Electric pulp testing was performed by trained assistants using a pulp tester (Analytic Technology Corp.) with toothpaste (Sensodyne, Block Drug Inc.) used as an electrolyte between the pulp tester probe and the tooth. The rate of current increase was kept constant for all testing procedures and was set at 25 seconds to increase from no output (0) to the maximum output of 80. The pulp tester was checked with an oscilloscope to insure proper operation. The teeth were isolated with cotton rolls, dried with air, and the probe tip placed on the buccal surface midway between the gingival margin and the occlusal edge. Two baseline readings were recorded for each experimental tooth as well as the adjacent mesial and distal teeth prior to the periodontal ligament injections. Each subject was instructed to respond when a sensation was first felt within the tooth. If the subjects felt a sensation in their gingiva, the tooth was reisolated and the pulp testing repeated.

A double-blind method was employed with a randomly selected right or left mandibular premolar receiving the anesthetic solution and the contralateral premolar receiving the saline solution. Twenty cartridges of the anesthetic solution and 20 cartridges of the saline solution were separately masked with opaque autoclave tape. Ten cartridges of the anesthetic solution and 10 cartridges of the saline solution were designated right. Another 10 cartridges of each solution was designated left. Twenty autoclave bags were marked with a random number and one cartridge of anesthetic solution and one cartridge of saline solution were placed in each bag. One of the cartridges had the designation right and the other cartridge had the designation left. The cartridge designated right was removed from the autoclave bag by a trained assistant and loaded into the syringe. The right mandibular premolar received the solution marked right and the contralateral premolar received the solution marked left. At no time did the assistant or dentist know which solution was being injected.

Periodontal ligament injections were given with Ligmaject syringes (Healthco Inc.) and 30 gauge short needles (Monoject). With the subject in a reclining position, the needle was inserted through the mesial gingival sulcus to a point of maximum penetration. The bevel of the needle was directed away from the tooth surface at approximately a 30 degree angle to the long axis of the tooth. The handle of the syringe was squeezed firmly until back-pressure was achieved; this pressure was then sustained for approximately 20 seconds. If no back-pressure was achieved, the needle was repositioned and the injection repeated. The injection was then repeated on the distal surface. A second Ligmaject syringe, loaded with the other solution, was used to inject the mesial and distal of the contralateral premolar.

Prior to giving the injections, each subject was instructed to separately rate the pain of the initial needle penetration and the injection of solution for all injections. The rating scale was: 1—none or mild (pain that was recognizable, but not discomforting); 2—moderate (pain that was discomforting, but bearable); 3—severe (pain that caused considerable discomfort and was difficult to bear). Each subject used their fingers to indicate the rating after needle insertion and again after the solution was injected.

Immediately after the completion of each injection, an automatic timer was started. The depth of anesthesia was monitored throughout the experimental procedure by pulp testing the teeth. Complete anesthesia was defined as the absence of patient response at the maximum output of the pulp tester (an 80 reading on the 0–80 scale). A trained assistant tested the experimental teeth at postinjection times of 2, 4, 10, 20, 30, and 45 minutes. Thirty seconds after pulp testing the experimental tooth, the mesial tooth (immediately adjacent to the experimental tooth) was tested at the same basic time intervals. Sixty seconds after pulp testing the experimental tooth, the distal tooth was tested at the same basic time intervals. The same testing procedures were repeated on the contralateral premolar and adjacent teeth. At 45 minutes after injection, all teeth were tested for mobility as previously described.

All subjects were recalled after 21 days. The teeth were pulp tested, the periodontium probed for pocket depths, and the teeth examined for mobility.

Between group pulp test readings, needle insertion and

**Table 1.** Anesthetic Efficacy and Duration

| Tooth | Time | Saline[a] | 2% Lidocaine with 1:100,000 Epinephrine | p Value |
|---|---|---|---|---|
| Premolar | 2 | 0/19 ( 0.0%) | 15/19 (78.9%) | 0.001 |
| | 4 | 2/19 (10.5%) | 15/19 (78.9%) | 0.001 |
| | 10 | 0/19 ( 0.0%) | 8/19 (42.1%) | 0.01 |
| | 20 | 0/19 ( 0.0%) | 3/19 (15.8%) | 0.25 |
| | 30 | 0/19 ( 0.0%) | 3/19 (15.8%) | 0.25 |
| | 45 | 0/19 ( 0.0%) | 2/19 (10.5%) | 0.50 |
| Mesial | 2.5 | 0/19 ( 0.0%) | 3/19 (15.8%) | 0.25 |
| | 4.5 | 0/19 ( 0.0%) | 0/19 ( 0.0%) | — |
| | 10.5 | 0/19 ( 0.0%) | 0/19 ( 0.0%) | — |
| | 20.5 | 0/19 ( 0.0%) | 0/19 ( 0.0%) | — |
| | 30.5 | 0/19 ( 0.0%) | 0/19 ( 0.0%) | — |
| | 45.5 | 0/19 ( 0.0%) | 0/19 ( 0.0%) | — |
| Distal | 3 | 1/19 ( 5.3%) | 12/19 (63.2%) | 0.002 |
| | 5 | 1/19 ( 5.3%) | 11/19 (57.9%) | 0.004 |
| | 11 | 1/19 ( 5.3%) | 6/19 (31.6%) | 0.125 |
| | 21 | 0/19 ( 0.0%) | 3/19 (15.8%) | 0.50 |
| | 31 | 0/19 ( 0.0%) | 2/19 (10.5%) | 0.50 |
| | 46 | 0/19 ( 0.0%) | 2/19 (10.5%) | 0.50 |

[a] Number of teeth anesthetized/Total number of teeth.

injection of solution pain scores were analyzed using the Wilcoxon matched pairs, signed-ranks test. All other comparisons were done using the McNemar test unless the expected frequency was less than five, in which case the binomial test was used.

## RESULTS

The 2% lidocaine with 1:100,000 epinephrine anesthetized more premolars at all time intervals when compared to saline (Table 1). The differences were statistically significant through 10 minutes. The highest percentage of teeth anesthetized by 2% lidocaine with epinephrine was 79% (15/19) at 2 and 4 minutes. The duration of profound pulpal anesthesia (no patient response at an 80 reading) was approximately 10 minutes for 2% lidocaine with 1:100,000 epinephrine (Table 1). Saline produced a 10.5% (2 of 19) success rate at 4 minutes (Table 1). No other experimental premolar teeth were anesthetized with saline.

The number of adjacent mesial teeth anesthetized by 2% lidocaine with epinephrine, when compared to saline, was not statistically significant at any time interval (Table 1). At 2.5 minutes after injection, 2% lidocaine with epinephrine anesthetized 15.8% (3/19) of the mesial teeth. None of the mesial teeth in the saline group were anesthetized at any time interval (Table 1).

Two percent lidocaine with epinephrine anesthetized more distal teeth at all time intervals when compared with saline (Table 1). The differences were significant at 3 and 5 minutes. The highest percentage of distal teeth anesthetized by 2% lidocaine with epinephrine was 63% (12 of 19) at 3 minutes. Saline produced a 5.3% (1/19) success rate for the distal teeth at 3–11 minutes.

There was no significant difference between the baseline pulp test readings of the two groups of premolars. The median pulp test readings for the experimental, the mesial, and distal teeth prior to and after the injections are summarized in Table 2. For 2% lidocaine with epinephrine, median pulp test readings of the experimental teeth remained elevated above baseline readings through 45 minutes (Table 2, Figure 1).

Eighteen of 19 subjects rated pain as none or mild upon needle insertion for 2% lidocaine with epinephrine (Table 3). Fifteen of 19 rated pain as none or mild for needle insertion with saline. The differences were not statistically significant (Table 3). For injection of 2%

**Table 2.** Median Pulp Readings

| | Premolar | | Mesial | | Distal | |
|---|---|---|---|---|---|---|
| Time | 2% Lidocaine with Epinephrine | Saline | 2% Lidocaine with Epinephrine | Saline | 2% Lidocaine with Epinephrine | Saline |
| Baseline: | | | | | | |
| 0 | 40[a] | 38 | 40 | 37 | 39 | 44 |
| Postinjection: | | | | | | |
| 2 | 80 | 41 | 50 | 42 | 80 | 45 |
| 4 | 80 | 46 | 49 | 38 | 80 | 56 |
| 10 | 71 | 40 | 45 | 40 | 60 | 42 |
| 20 | 50 | 40 | 43 | 42 | 50 | 44 |
| 30 | 56 | 41 | 42 | 41 | 56 | 44 |
| 45 | 47 | 40 | 42 | 40 | 47 | 46 |

[a] Median readings of 19 subjects.

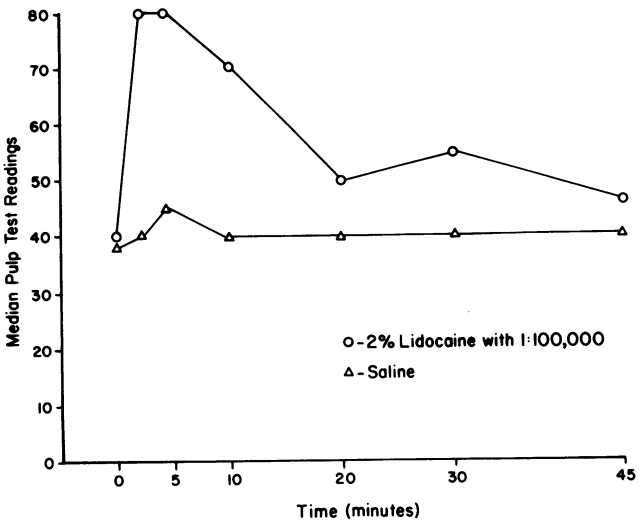


**Figure 1.** Graph of the mandibular first premolars median pulp test readings versus time.

lidocaine with epinephrine, 15/19 rated the pain as none or mild. The injection of saline resulted in 14 moderate and 2 severe pain responses. The differences were statistically significant (Table 3). No teeth demonstrated an increase in mobility when tested at 45 minutes after injection.

At recall examination, mobility, the periodontium, and vitality tests were all within normal limits. There were no significant differences between the preinjection baseline pulp test readings and the recall readings.

## DISCUSSION

The results of this study demonstrated that 2% lidocaine with 1:100,000 epinephrine produced significantly higher rates of successful pulpal anesthesia than saline. The highest success rate of pulpal anesthesia for 2% lidocaine with epinephrine was 79%. This compares favorably to clinical studies where success rates, when used as a primary injection technique, have ranged from 81% to 86%.[4,6,9] Further objective research should be done to determine if the success rate is different in various maxillary and mandibular teeth. Two teeth were anesthetized with sterile saline. Of the adjacent teeth receiving sterile saline, only one distal tooth and no mesial teeth were anesthetized at any time. Therefore, some degree of anesthesia may be infrequently obtained using saline via periodontal ligament injection. This finding is clinically insignificant because of its unpredictable occurrence, low success rate, and brief duration. The exact mechanism of anesthesia produced by saline is difficult to explain. Pashley et al[13] found that injections of saline in periodontal ligament sites showed fairly high pressures, low compliance and a slow rate of fall in tissue pressure. These high pressures may cause a compression of nerves periapically and result in anesthesia. Although back-pressure during the injection is necessary for success of this technique,[1,10] pressure alone is not the primary mechanism by which anesthesia is achieved. Saline was not effective because the chemical action of the local anesthetic was absent.

Various authors,[14–16] in animal studies, have reported that carbon particles or dyes were distributed in the periapex, medullary bone, pulp, and, frequently, in the same tissues of adjacent teeth after the periodontal ligament injection. Because the 30 gauge needle (average width, 0.28 mm) only wedges at the crestal bone opening of the periodontal ligament (average width, 0.18 mm), this injection technique is probably an intraosseous injection with diffusion of the anesthetic solution through the cribiform plate under pressure.

Several authors[4,5] have stated that the duration of anesthesia, after the periodontal ligament injection, lasted 30–60 minutes. This study found that the duration of profound pulpal anesthesia (80/80 reading) was approximately 10 minutes with 2% lidocaine with 1:100,000

**Table 3.** Discomfort Ratings of Needle Insertion and Injection of Solution

| *Solution* | *Discomfort Ratings* | | | | |
|---|---|---|---|---|---|
| | *None–mild* | *Moderate* | *Severe* | *Median* | *p Value*[a] |
| 2% Lidocaine with 1:100,000 epinephrine | | | | | |
| Needle insertion[b] | 18 | 1 | 0 | 1 | 0.15 |
| Injection of solution[b] | 15 | 4 | 0 | 1 | 0.01 |
| Saline | | | | | |
| Needle insertion | 15 | 4 | 0 | 1 | — |
| Injection of Solution | 3 | 14 | 2 | 2 | — |

[a] Comparison of 2% lidocaine with 1:100,000 epinephrine to saline.
[b] Average of mesial and distal ratings for insertion or injection.

epinephrine. Many of the clinical studies have relied on the dentist's evaluation of the patient's pain felt during operative or surgical procedures. These clinical evaluations are more variable when compared to the objective measurement of analgesia provided by the electric pulp tester. Dreven et al[17] have shown that an 80/80 reading in normal and asymptomatic teeth resulted in complete clinical analgesia. Therefore, although successful anesthesia is almost assured if the patient does not respond to the maximum output of the pulp tester, a reading of less than 80 but greater than baseline may or may not correlate with success. This would depend on the procedure (shallow cavity preparation, extraction, crown preparation, or pulp extirpation) the dentist is performing and the duration of these procedures. The finding that median pulp test readings for 2% lidocaine with epinephrine were high initially and remained elevated through 45 minutes (Figure 1), may indicate that procedures of short duration (extractions) and shallow cavity preparations could be accomplished clinically. This would also explain the higher success rates reported in clinical studies. Because 2% lidocaine with epinephrine provided a duration of approximately 10 minutes in mandibular premolars, it may be better clinically to use block injections if profound anesthesia is required for longer than 10 minutes.

Anesthesia of adjacent teeth, both mesial and distal to the injected tooth, was obtained for 2% lidocaine with epinephrine. This concurs with the histologic study of Smith and Walton.[14] They showed perfusion of the pulp and surrounding bone of the injected and adjacent teeth with injected dye solutions in dogs. These results are not in agreement with Simon et al[18] and Littner et al.[19] They reported that single tooth anesthesia could be obtained with the periodontal ligament injection and this technique could be used as an aid in endodontic diagnosis. Littner et al[19] injected the buccal surfaces of teeth to avoid anesthesia of adjacent teeth. Whether this limits the diffusion of the anesthetic solution has yet to be determined. Because the periodontal ligament injection is an intraosseous injection and the solution is deposited around adjacent teeth, it is questionable if it should be used as an aid in endodontic diagnosis.

When compared with the saline solution, 2% lidocaine with epinephrine anesthetized more mesial and distal teeth for a longer duration. More distal teeth than mesial teeth were anesthetized by 2% lidocaine with epinephrine. Kaufman et al[6] found that teeth with longer roots were more difficult to anesthetize, specifically canine teeth. This may possibly explain our findings, because the anesthetic solution would have to diffuse a longer distance for the mesial teeth (canines). Birn[20] observed that perforations in the wall of the cribiform plate increased in the mandible from the incisors toward the molar. This could allow for diffusion of the anesthetic solution distally more readily than mesially. More research is needed to determine the exact diffusion pattern of the anesthetic solution related to adjacent teeth.

Needle insertion was rated as none to mild pain (median, 1; Table 3) and indicated that patients did not generally find this initial needle insertion to be very painful. Pain of injection for the 2% lidocaine with epinephrine was rated none to mild pain (median, 1; Table 3) and indicated that patients did not generally find injection of the anesthetic solution very painful. Injection pain was rated moderately painful (median, 2; Table 3) for injections of saline. Because saline produced no anesthesia, the injections produced considerably more discomfort when compared to the 2% lidocaine with epinephrine. Further research should be done to determine if needle insertion and solution injection pain is different in maxillary and mandibular teeth and in different pathologic conditions of the pulp.

No teeth showed an increase in mobility 45 minutes after receiving the periodontal ligament injection. In a letter to the editor, Nelson[21] reported on avulsion of a tooth following periodontal ligament injections. All clinical and animal studies to date have reported no instances of avulsion or loosening of teeth with this technique. Since this technique is really an intraosseous injection and does not irreversibly damage the periodontium, there is no reason why avulsion should occur clinically.

The recall examinations showed that all pulps and the periodontium were within normal limits after 21 days. This corroborates previous clinical[5,6,9,10] and animal studies[14,15,22–25] that damage was minimal and this injection technique was safe to the pulp and periodontium of clinically normal, healthy teeth. However, more research is needed to determine the effects on periodontally involved teeth and teeth with compromised pulps.

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