Pulpal Anesthesia of Adjacent Teeth Following Infiltration of 2% Lidocaine With 1:100,000 Epinephrine in the Maxillary Lateral Incisor and First Molar

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The purpose of this study was to determine anesthetic success in adjacent teeth following a primary infiltration of the maxillary lateral incisor and first molar using 1.8 mL of 2% lidocaine with 1:100,000 epinephrine. Three hundred eight asymptomatic subjects received an infiltration of a cartridge of 2% lidocaine with 1:100,000 epinephrine over the maxillary lateral incisor (163 subjects) or first molar (145 subjects). Pulpal anesthesia of the injected tooth and adjacent mesial and distal teeth was monitored with the electric pulp tester in 2-minute cycles for a total of 60 minutes. No response from the subject at the maximum output (80 reading) of the pulp tester was used as the criterion for pulpal anesthesia. Comparisons of the odds of pulpal anesthesia (defined as an 80/80 response to electric pulp testing over 60 minutes) between the experimentally injected tooth and adjacent teeth were analyzed using mixed-models, repeated-measures logistic regression. When compared with the lateral incisor infiltration, the adjacent mesial tooth (central incisor) and distal tooth (canine) achieved statistically lower anesthetic success. When compared with the first molar, the mesial tooth (second premolar) did not differ statistically. However, significant differences were shown between the first molar and the second molar, with the distal tooth (second molar) achieving a statistically higher rate of pulpal anesthesia, which was related to a better duration of anesthesia. For asymptomatic patients, local anesthesia of the adjacent mesial (central incisor) and distal (canine) teeth to the infiltrated lateral incisor had lower pulpal anesthetic success. Because standard infiltration anesthesia of the lateral incisor is of short duration, repeating the infiltration at 30 minutes will result in a high incidence of pulpal anesthesia for 60 minutes. Local anesthesia of the adjacent distal tooth to the first molar (second molar) had a statistically higher rate of total pulpal anesthesia than the infiltrated first molar due to the longer duration of pulpal anesthesia. However, if pulpal anesthesia is required for 60 minutes in the first and second molars, the clinician may need to add an additional infiltration to ensure anesthesia.

Key Words: Maxillary anesthesia; Pulpal anesthesia; Anesthesia of adjacent teeth; Pulp testing.

Infiltration anesthesia is a common method to anesthetize maxillary teeth. Previous studies^{1–13} have evaluated the success of maxillary infiltrations using the electric pulp tester. Using a volume of 1.8 mL or less and various anesthetic formulations, pulpal anesthetic suc-

cess (obtaining maximum output with an electric pulp tester) has ranged from 64% to 100%.

However, the exact effect of an infiltration on adjacent teeth has not been adequately studied. The clinician may perform procedures on adjacent teeth that require pulpal anesthesia, and it may be helpful to evaluate if pulpal anesthesia would also be obtained on these teeth. The purpose of this study was to determine the anesthetic success of adjacent teeth following a primary infiltration of the maxillary lateral incisor and first molar using 1.8 mL of 2% lidocaine with 1:100,000 epinephrine.

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MATERIALS AND METHODS

Three hundred eight maxillary infiltrations were studied. The patients were in good health as determined by a written health history and oral questioning. Exclusion criteria were as follows: younger than 18 years of age, allergies to local anesthetics or sulfites, pregnancy, history of significant medical conditions (American Society of Anesthesiologist class II or higher), taking any medications (over-the-counter pain-relieving medications, narcotics, sedatives, antianxiety or antidepressant medications) that may affect pain assessment, active sites of pathosis in the area of injection, and inability to give informed consent. The patients' data were part of 5 master theses conducted at The Ohio State University. The Ohio State University Human Subjects Committee approved each study, and informed consent was obtained from each patient. Patients were volunteers who were recruited for the research.

One hundred sixty-three subjects received an infiltration of the maxillary lateral incisor, and 145 subjects received an infiltration of the maxillary first molar. A cartridge of 2% lidocaine with 1:100,000 epinephrine (Xylocaine, AstraZeneca LP, Dentsply, York, Penn) was administered for each infiltration. All lidocaine cartridges were checked to ensure that the anesthetic solution had not expired. Cartridges marked 1.7 mL and 1.8 mL will deliver the same amount of anesthetic solution using a standard aspirating syringe of approximately 1.76 mL.¹⁴

For the lateral incisor infiltration, 80 infiltrations were administered on the left side and 83 on the right side. For the first molar infiltration, 70 infiltrations were administered on the left side and 75 on the right side. There were 5 operators performing the infiltrations. All were second-year endodontic residents. Each subject was in a supine position for all infiltrations.

A visual and clinical examination was conducted to ensure that all teeth were free of caries, large restorations, crowns, and periodontal disease and that none had a history of trauma or sensitivity. Before the injections, at both appointments, the experimental tooth and adjacent teeth as well as the contralateral control tooth were tested 3 times with the electric pulp tester (Kerr, Analytic Technology Corp, Redmond, Wash) to obtain baseline information. For the anterior teeth, the contralateral mandibular canine was used as the control, and for the posterior teeth, the contralateral maxillary canine was used as a control. The testing of the control tooth was used to ensure that the pulp tester was operating properly and that the subject was responding appropriately. The teeth were isolated with cotton rolls and dried with an air syringe. Toothpaste was applied to the probe tip that was placed in the middle third of the

facial or buccal surface of the tooth being tested. The current rate was set at 25 seconds to increase from no output (0) to the maximum output (80). Trained research personnel performed all preinjection and postinjection tests.

A standard maxillary infiltration injection was administered with an aspirating syringe and a 27-gauge 1-inch needle (Sherwood Medical Co, St Louis, Mo). The target site was centered over the root apex of the maxillary lateral incisor or between the mesiobuccal and distobuccal root apices of the maxillary first molar. The needle was gently placed into the alveolar mucosa with the bevel toward bone and advanced until the needle was estimated to be at or just superior to the apex of the lateral incisor or the buccal apices of the first molar. The anesthetic solution was deposited over a period of 1 minute.

The depth of anesthesia was monitored with the electric pulp tester. At 1 minute after the infiltration, pulp test readings were obtained for the experimental tooth (first molar or lateral incisor) and the distal tooth (canine or second molar). At minute 2, the mesial tooth (central incisor or second premolar) and control tooth were tested. The testing continued in 2-minute cycles for a total of 60 minutes. At every third cycle, the control tooth, either the contralateral mandibular canine or contralateral maxillary canine, was tested by an inactivated electric pulp tester to test the reliability of the subject. That is, if the subject responded positively to an inactivated pulp tester, they were not reliable and could not be used in the study. No subjects were excluded for this reason in the final data set.

No response from the subject at the maximum output (80 reading) of the pulp tester was used as the criterion for pulpal anesthesia. The data were analyzed statistically. Odds of achieving pulpal anesthesia between the experimentally injected tooth and adjacent teeth were analyzed using a mixed-models, repeated-measures logistic regression. The odds ratio is the ratio of the odds of an event occurring in one group to the odds of it occurring in another group. The 95% confidence interval is used to estimate the precision of the odds ratio. Comparisons were considered significant at $p < .05$.

RESULTS

For the lateral incisor infiltration, 112 men and 51 women ranging in age from 18 to 43 years, with an average age of 25 years, participated in this study. For the first molar infiltration, 83 men and 62 women ranging in age from 18 to 42 years, with an average age of 25 years, participated. While we recorded the gender

Figure 1. The incidence of pulpal anesthesia as determined by the lack of response to electric pulp testing at the maximum setting (percentage of 80 readings) at each postinjection time interval, for the infiltrated lateral incisor and adjacent central incisor and canine.

of the patient, we did not divide the patients by female and male for success and did not perform statistical analysis. A further study could investigate gender differences, with statistical analysis, for anesthetic success of adjacent teeth. We did not record height or weight.

Pulpal anesthesia for the anterior and posterior teeth is presented in Figures 1 and 2. Significant differences were shown between the central and lateral incisor and canine and lateral incisor $p < .0001$ (Table). In addition, significant differences were shown between the first molar and the second molar ($p < .0001$; Table). There was no significant difference ($p > .066$) between the first molar and second premolar.

DISCUSSION

Regarding the lateral incisor (injected tooth), Figure 1 depicts the time course for pulpal anesthesia as determined by the percentage of patients who did not respond to an 80 EPT reading across time for 60 minutes. The highest incidence of pulpal anesthesia (80/80 readings) was almost 90% at 9 through 13 minutes. Therefore, the infiltration of 1.8 mL of 2% lidocaine with 1:100,000 epinephrine may not be 100% successful because of the individual variations in response to the drug administered, operator differences, and variations of anatomy as well as tooth position. The duration of pulpal anesthesia was good until around 20 to 25 minutes, when a decline in pulpal anesthesia occurred (Figure 1). Approximately 75% of the subjects had pulpal anesthesia at 30 minutes. However, at 45 minutes, less than 50% of the subjects had pulpal

Figure 2. The incidence of pulpal anesthesia as determined by the lack of response to electric pulp testing at the maximum setting (percentage of 80 readings) at each postinjection time interval, for the infiltrated first molar and adjacent second premolar and second molar.

anesthesia, and at 60 minutes, only 28% had pulpal anesthesia (Figure 1). Therefore, the most significant problem with lateral incisor infiltration is the declining duration of pulpal anesthesia if pulpal anesthesia is required for 60 minutes.

Various authors have addressed this declining duration of pulpal anesthesia. Gross et al¹⁵ determined the anesthetic efficacy of 1.8 mL 0.5% bupivacaine with 1:200,000 epinephrine and 1.8 mL of 2% lidocaine with 1:100,000 epinephrine in maxillary lateral incisors. They found bupivacaine exhibited a significantly lower anesthetic success rate (no patient response to 2 consecutive 80 readings with the EPT) of 78% when compared with a 97% success rate with lidocaine. Duration was not better with the bupivacaine formulation. Therefore, while bupivacaine provides long-acting anesthesia for the inferior alveolar nerve block,^{16,17} it does not provide better or prolonged pulpal anesthesia in maxillary lateral incisor infiltration.

Mikesell et al¹⁸ increased the volume of anesthesia to 3.6 mL of 2% lidocaine with 1:100,000 epinephrine for lateral incisors. They reported that the incidence of anesthesia of short duration (ie, the patient had no response to 2 consecutive 80 readings but lost the 80 reading and never regained it within a 60-minute period) was significantly decreased for the lateral incisor when compared with 1.8 mL of 2% lidocaine with 1:100,000 epinephrine. With the 3.6 mL volume, approximately 97% of the subjects had pulpal anesthesia at 30 minutes, 78% at 45 minutes, and 50% at 60 minutes. However, 44% of the subjects still demonstrated anesthesia of short duration. Therefore, the duration of pulpal anesthesia was still problematic in the lateral incisor,

Regression Analysis for Pulpal Anesthesia of Anterior and Posterior Teeth

<i>Comparison</i>	<i>Odds Ratio</i>	<i>DF*</i>	<i>95% Confidence Limits</i>	<i>p</i>
Anterior teeth				
Central vs lateral	0.377	14449	0.344–0.413	<.0001
Canine vs lateral	0.662	14449	0.604–0.726	<.0001
Posterior teeth				
Second premolar vs first molar	0.907	11412	0.819–1.01	.0660
Second molar vs first molar	2.05	11412	1.83–2.30	<.0001

* DF indicates degrees of freedom.

even though 3.6 mL of 2% lidocaine with 1:100,000 epinephrine was administered.

Mason et al¹⁹ increased the concentration of epinephrine by using 1.8 mL of 2% lidocaine with 1:50,000 epinephrine. They found a significant increase in the duration of pulpal anesthesia when compared with 1.8 mL of 2% lidocaine with 1:100,000 epinephrine in maxillary lateral incisors. Approximately 97% of the subjects had pulpal anesthesia at 45 minutes and almost 80% at 60 minutes. Therefore, the 1:50,000 epinephrine concentration in 1.8 mL of 2% lidocaine provided a longer duration than 3.6 mL of 2% lidocaine with 1:100,000 epinephrine.¹⁸ However, the duration of pulpal anesthesia was not 60 minutes.

Scott and coauthors²⁰ studied a repeated infiltration of a cartridge of 2% lidocaine with 1:100,000 epinephrine given 30 minutes after an initial infiltration of a cartridge of 2% lidocaine with 1:100,000 epinephrine. They found that the repeated infiltration significantly improved pulpal anesthesia from 37 minutes through 90 minutes in the maxillary lateral incisor. With the repeated infiltration, approximately 90% of the subjects had pulpal anesthesia at 45 minutes and 87% at 60 minutes. At 75 minutes, approximately 85% of the subjects had pulpal anesthesia and at 90 minutes, 70% were anesthetized. The repeated infiltration was not painful. Therefore, knowing that standard infiltration anesthesia is of short duration and that repeating the infiltration at 30 minutes will result in a high incidence of pulpal anesthesia for 60 minutes should be very helpful for the clinician.

The mesial tooth (central incisor) had a lower incidence of pulpal anesthesia (80/80) approximating 64% (Figure 1) and was statistically lower when compared with the lateral incisor (Table). Pulpal anesthesia followed a similar curve to the lateral incisor, showing a decline in pulpal anesthesia over the 60 minutes (Figure 1). Since pulpal anesthesia was less with the central incisor, profound anesthesia would not be obtained clinically. Therefore, it would be best to anesthetize this tooth separately if performing a procedure requiring pulpal anesthesia on the mesial tooth.

The distal tooth (canine) had a success rate (80/80) of approximately 75% (Figure 1). Pulpal anesthesia of the canine was statistically lower when compared with the lateral incisor (Table). Pulpal anesthesia again followed a similar curve to the lateral incisor, showing a decline in pulpal anesthesia over the 60 minutes (Figure 1). As in the central incisor, pulpal anesthesia is less with the adjacent canine, and it would be best to anesthetize this tooth separately if performing a procedure on this distal tooth.

Regarding both adjacent teeth, apparently not enough of the infiltrated anesthetic solution over the lateral incisor diffused in sufficient concentrations to the central incisor and canine (Figure 1) to be as effective as the primary infiltration. Because the distal canine tooth is longer than the lateral incisor, perhaps less anesthetic solution reached the apex and surrounding bone. Future studies could address increasing the volume, epinephrine concentration, or using additional anesthetic solutions over the adjacent teeth in addition to anesthetizing the primary target tooth.

Regarding the first molar (injected tooth), the success (80/80 reading) was approximately 88%, which was similar to the lateral incisor (Figures 1 and 2). Therefore, the infiltration of 1.8 mL of 2% lidocaine with 1:100,000 epinephrine may not always be 100% successful. There was a declining duration of pulpal anesthesia after 33 minutes (Figure 2). The decline occurred more slowly than in the lateral incisor (Figures 1 and 2). However, if pulpal anesthesia is required for 60 minutes, the clinician may need to add an additional infiltration to ensure anesthesia.

Various authors have addressed this declining duration of pulpal anesthesia. Gross et al¹⁵ determined the anesthetic efficacy of 1.8 mL 0.5% bupivacaine with 1:200,000 epinephrine and 1.8 mL of 2% lidocaine with 1:100,000 epinephrine in maxillary first molars. They found there was no significant difference between the 2 anesthetic formulations. However, neither solution provided pulpal anesthesia for an hour. Therefore, while bupivacaine provides long-acting anesthesia for the inferior alveolar nerve block,^{16,17} it will not provide prolonged pulpal anesthesia in maxillary first molar infiltration.

Mikesell et al,¹⁸ using 3.6 mL of 2% lidocaine with 1:100,000 epinephrine, reported the incidence of anesthesia of short duration (ie, the patient had no response to 2 consecutive 80 readings but lost the 80 reading and never regained it within a 60-minute period) was reduced to 9% when compared with 50% for the 1.8-mL volume. Therefore, anesthesia achieved with a volume of 3.6 mL provided a longer duration than that achieved with a volume of 1.8 mL and offered better pulpal anesthesia after 49 minutes in the first molar. It is important to realize that even though pulpal anesthesia duration was prolonged with a volume of 3.6 mL, if an hour of pulpal anesthesia is required for the first molar, 3.6 mL of 2% lidocaine with 1:100,000 epinephrine may not provide the necessary duration of pulpal anesthesia.

Mason and coauthors¹⁹ found that increasing the epinephrine concentration to 1:50,000 epinephrine in 2% lidocaine was not significantly different than using a 1:100,000 epinephrine formulation in the maxillary first molar. Pulpal anesthesia started to decline for 2% lidocaine with 1:100,000 or 1:50,000 epinephrine after about 49 to 53 minutes. It is important to realize that if an hour of pulpal anesthesia is required for the first molar, 1.8 mL of 2% lidocaine with either 1:100,000 or 1:50,000 epinephrine may not provide the necessary duration of pulpal anesthesia.

By pulp testing the first molar with cold (Endo-Ice, Hygenic Corp, Akron, Ohio) or an electric pulp tester, the clinician can determine if pulpal anesthesia is declining and administer more anesthesia.^{14,21,22}

The mesial tooth (second premolar) had similar success (approximately 82%) as the first molar (odds ratio 0.907, $p = .066$; Figure 2). Pulpal anesthesia followed a similar curve to the first molar with declining pulpal anesthesia over the 60 minutes (Figure 2). Apparently, enough of the anesthetic solution diffused to the second premolar to be fairly similar to the first molar. While pulpal anesthesia was similar to the first molar, it has to be recognized that pulpal anesthesia will decline over the 60 minutes.

The distal tooth (second molar) had a success rate of approximately 87% (Figure 2). The overall pulpal anesthesia of the second molar was statistically higher when compared with the first molar (odds ratio = 2.05, $p < .0001$; Table). Pulpal anesthesia showed a slower decline of pulpal anesthesia after 31 minutes than the first molar (Figure 2). All patients were in a supine position during anesthetic deposition. Whether this played a role in the slower decline of anesthesia in the second molar would need further investigation. Perhaps the character of the bone in the posterior molar region compared with the anterior region is different. Misch^{23(p244)} stated, “The softest bone is most often found in the posterior maxilla (40%), especially in the

molar region.” Perhaps a better diffusion of the anesthetic solution occurs in the molar region than in the anterior maxilla. Therefore, an infiltration of the first molar will provide pulpal anesthesia of the second molar with a slow decline in pulpal anesthesia over the 60 minutes. If the clinician required pulpal anesthesia on the adjacent second molar, after an infiltration of the first molar, there is a good chance pulpal anesthesia would also be present in this tooth. However, while duration of pulpal anesthesia was improved over the first molar, the clinician may still have to add additional anesthesia after 45 minutes to ensure profound pulpal anesthesia.

The results of the cited documents^{15,18–20} are similar, even though they were performed in anterior and posterior teeth. However, there were differences. The duration of anesthesia was shorter in the anterior teeth than in the posterior teeth when a primary injection was considered. We outlined the results of the previous research to give readers background information. The purpose of this study was to determine the anesthetic success of adjacent teeth following a primary infiltration of the lateral incisor and first molar using 1.8 mL of 2% lidocaine with 1:100,000 epinephrine. Further studies would have to compare the results of the cited documents and their effects on the adjacent teeth. Comparing this information to the current study is not possible unless a study was performed on adjacent teeth using each of the cited research.

CONCLUSIONS

For asymptomatic patients, local anesthesia of the adjacent mesial (central incisor) and distal (canine) teeth to the infiltrated lateral incisor had lower pulpal anesthetic success. Because standard infiltration anesthesia of the lateral incisor is of short duration, repeating the infiltration at 30 minutes will result in a high incidence of pulpal anesthesia for 60 minutes.

Local anesthesia of the adjacent distal tooth to the first molar (second molar) had a statistically higher rate of total pulpal anesthesia than the infiltrated first molar because of the longer duration of pulpal anesthesia. However, if pulpal anesthesia is required for 60 minutes in the first and second molars, the clinician may need to add an additional infiltration to ensure anesthesia.

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