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Anesthetic Efficacy of Articaine for Inferior Alveolar Nerve Blocks in Patients with Irreversible Pulpitis

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Abstract

The purpose of this prospective, randomized, double-blind study was to compare the anesthetic efficacy of 4% articaine with 1:100,000 epinephrine to 2% lidocaine with 1:100,000 epinephrine for inferior alveolar nerve blocks in patients experiencing irreversible pulpitis in mandibular posterior teeth. Seventy-two emergency patients diagnosed with irreversible pulpitis of a mandibular posterior tooth randomly received, in a double-blind manner, 2.2 ml of 4% articaine with 1:100,000 epinephrine or 2.2 ml of 2% lidocaine with 1:100,000 epinephrine using a conventional inferior alveolar nerve block. Endodontic access was begun 15 min after solution deposition, and all patients were required to have profound lip numbness. Success was defined as none or mild pain (Visual Analogue Scale recordings) on endodontic access or initial instrumentation. The success rate for the inferior alveolar nerve block using articaine was 24% and for the lidocaine solution success was 23%. There was no significant difference ($p = 0.89$)

between the articaine and lidocaine solutions. Neither solution resulted in an acceptable rate of anesthetic success in patients with irreversible pulpitis.

The inferior alveolar nerve (IAN) block is the most frequently used mandibular injection technique for achieving local anesthesia for endodontic treatment. However, the inferior alveolar nerve block does not always result in successful pulpal anesthesia. Clinical studies in endodontics (1-4) have found failure with the IAN block occurring between 44% and 81% of the time. Therefore, it would be advantageous to improve the success rate of the IAN block in endodontics.

Articaine has a reputation of providing an improved local anesthetic effect. Articaine was approved for use in the United States in April 2000 (5). The formulation is known as Septocaine (Septodont, Inc., New Castle, DE) and is available as a 4% solution with 1:100,000 epinephrine. Articaine is classified as an amide and contains a thiophene ring instead of a benzene ring like other amide local anesthetics (5). A second molecular difference between articaine and other amide local anesthetics is the extra ester linkage incorporated into the articaine molecule (5), which results in hydrolysis of articaine by plasma esterases. Isen (6) states that 90% to 95% of articaine is metabolized in the blood, whereas only 5% to 10% is broken down in the liver. The plasma half-life has been reported to be as low as 20 min (7, 8).

Articaine is a safe, local anesthetic. A number of studies (5, 9-16) have evaluated articaine and have concluded that it is safe when used in appropriate doses. Both lidocaine and articaine have the same maximum milligram dose of 500 mg (recommended dose, 6.6-7 mg/kg) for the adult patient (17). Because articaine is marketed as a 4% solution, the manufacturer's maximum recommended dose for a healthy 70-kg adult is 7 cartridges of an articaine solution compared with 13 cartridges of a 2% lidocaine solution (17).

The available literature indicates that articaine is equally effective when statistically compared to other local anesthetics (14, 16, 18-23). For example, Malamed et al. (18) studied the efficacy of articaine in three, identical, randomized, double-blind, multicenter, clinical trails. Subjects ranged from ages 4 to 80 yr and were given 4% articaine with 1:100,000 epinephrine or 2% lidocaine with 1:100,000 epinephrine during both simple and complex dental procedures. A total of 1325 subjects participated in the study. Articaine's onset time and duration were considered comparable to lidocaine. Malamed and co-authors found no statistical difference between the two anesthetic solutions tested. Therefore, considering the results of many studies (14, 16, 18-23), articaine has not been found to be statistically superior to other local anesthetics.

Articaine, like prilocaine, has the potential to cause methemoglobinemia and neuropathies (5). Although the incidence of methemoglobinemia is rare, dentists should be aware of this complication in patients who are at an increased risk of developing this condition (24). Haas and Lennon (25) and Miller and Lennon (26) investigated the incidence of local anesthetic-induced neuropathies. The incidence of neuropathies (which involved the lip and or tongue) associated with articaine and prilocaine was approximately five times that found with lidocaine or mepivacaine (26). Malamed et al. (5) found, in a total of 1325 patients, that the incidence of paresthesia was 1% (eight cases) for the articaine group and 1% (five cases) for the lidocaine group. In all cases, the paresthesias resolved. In the Haas and Lennon retrospective study (25),

the incidence of paresthesia was only 14 cases of 11 million injections or approximately 1 in 785,000 injections. Therefore, although the paresthesia incidence is higher for articaine and prilocaine, it is still a clinically rare event.

No study has investigated the efficacy of articaine in patients with irreversible pulpitis. Therefore, the purpose of this prospective, randomized, double-blind study was to compare the anesthetic efficacy of 4% articaine with 1:100,000 epinephrine with 2% lidocaine with 1:100,000 epinephrine for inferior alveolar nerve blocks in patients, with mandibular posterior teeth, experiencing irreversible pulpitis.

MATERIALS AND METHODS TOP

Seventy-two adult patients participated in this study. All were emergency patients of the College of Dentistry and were in good health as determined by a health history and oral questioning. The Human Subjects Review Committee approved the study, and written informed consent was obtained from each patient.

To qualify for the study, each patient had a vital mandibular posterior tooth (molar or premolar), was actively experiencing pain, and had a prolonged response to cold testing with Endo-Ice (1,1,1,2 tetrafluoroethane; Hygenic Corp., Akron, OH). Patients with no response to cold testing, periradicular pathosis (other than a widened periodontal ligament), or no vital coronal pulp tissue on access were excluded from the study. Therefore, each patient had a tooth that fulfilled the criteria for a clinical diagnosis of irreversible pulpitis.

Each patient rated his or her initial pain on a Heft-Parker Visual Analogue Scale (VAS) (Fig. 1) (27). The VAS was divided into four categories. No pain corresponded to 0 mm. Mild pain was defined as > 0 mm and ≤ 54 mm. Mild pain included the descriptors of faint, weak, and mild pain. Moderate pain was defined as > 54 mm and < 114 mm. Severe pain was defined as ≥114 mm. Severe pain included the descriptors of strong, intense, and maximum possible.

Fig 1. Heft-Parker VAS used for assessment of pain. The millimeter demarcations were not shown on the patients' VAS.

The 72 patients randomly received 2.2 ml of 4% articaine with 1:100,000 epinephrine (Septocaine, Septodont Inc., New Castle, DE) or 2.2 ml 2% lidocaine with 1:100,000 epinephrine (Xylocaine, AstraZeneca LP, Dentsply, York, PA) using a conventional inferior alveolar nerve block. Each patient was randomly assigned a five-digit random number to determine which anesthetic solution was administered. The senior author (E.C.) administered all injections.

Under sterile conditions, the articaine and lidocaine solutions were prepared each day of the appointment by drawing 2.2 ml of the appropriate anesthetic solution into 3-ml Luer-Lok disposable syringes equipped with aspirating ring assemblies (Becton Dickinson & Co., Franklin Lakes, NJ). The anesthetic solutions were obtained from commercial 1.8-ml cartridges. The appropriate five-digit random number was placed on a label, which was affixed to the outside of

the Luer-Lok syringe. Only the random number was used on the data collection sheets to further blind the experiment.

Topical anesthetic gel (20% benzocaine, Patterson Dental Supply, Inc., St. Paul, MN) was passively placed at the IAN injection site for 60 s using a cotton-tip applicator. A standard inferior alveolar nerve block (28) was administered with a 27-gauge, 1½-inch needle (Monoject; Tyco Healthcare Group LP, Mansfield, MA) using each anesthetic solution. After initial needle penetration, 0.4 ml of either anesthetic solution was deposited during 15 s as the needle was advanced toward the target site. After gentle contact with bone, the needle was withdrawn 1 mm, aspiration was performed, and the remaining 1.8 ml of anesthetic solution was deposited over a 1-min time period.

At 15-min postinjection, the patient was questioned regarding lip numbness. If profound lip numbness was not recorded, the block was considered missed and the patient was eliminated from the study.

At 15-min postinjection, the teeth were isolated with a rubber dam and access performed. Patients were instructed to definitively rate any pain felt during the endodontic procedure. If the patient felt pain, the treatment was immediately stopped and the patient rated their discomfort using the Heft-Parker VAS. The extent of access achieved when the patient felt pain was recorded as within dentin, entering the pulp chamber, or initial file placement. The success of the IAN blocks was defined as the ability to access and instrument the tooth without pain (VAS score of zero) or mild pain (VAS rating $\leq$ 54 mm).

Comparisons between the articaine and lidocaine solutions for gender and anesthetic success were analyzed using the Chi-square test, whereas differences in age and initial pain scores were analyzed using the Mann-Whitney-Wilcoxon test. Fisher's exact test was used to determine differences in tooth type and incidence of missed blocks. Comparisons were considered significant if $p < 0.05$.

RESULTS TOP

The age, gender, and initial pain of the patients are presented in Table 1. There were no significant differences ($p > 0.85$) between the two groups. The distribution of the teeth is outlined in Table 2. There were no significant differences ($p = 1$) between the two groups. A total of 7 patients, two using the articaine solution and five using the lidocaine solution, did not have profound lip numbness at 15 min and were not included in the data analysis of the 72 patients. The number of these missed blocks was not statistically different between the articaine and lidocaine solutions ($p = 0.43$). One hundred percent of the subjects used for data analysis had subjective lip anesthesia with either the articaine and lidocaine solutions.

Table 1. Initial values for the articaine and lidocaine groups

Table 2. Distribution of teeth for the articaine and lidocaine groups

Anesthetic success is presented in Table 3. The success rate for the IAN block using the articaine solution was 24% (9 of 37) and for the lidocaine solution success was 23% (8 of 35). There was no significant difference ($p = 0.88$) between the two solutions. Four patients had no pain (VAS score of zero) on access in the articaine group, and six had no pain in the lidocaine group. Five patients had mild pain (VAS score $\leq$ 54 mm) on access in the articaine group, and two had mild pain in the lidocaine group. Discomfort ratings for patients experiencing greater than mild pain (anesthetic failure) on access with the articaine and lidocaine solutions are summarized in Table 4.

Table 3. Percentages and number of patients who achieved anesthetic success with the inferior alveolar nerve block using the articaine and lidocaine solutions

Table 4. Discomfort ratings for patients experiencing greater than mild pain (anesthetic failure) upon access with the articaine and lidocaine solutions

DISCUSSION

The patients' age, gender, posterior tooth type, and initial pain were not significantly different between the two anesthetic solutions (Tables 1 and 2). Therefore, the effect of age, gender, posterior tooth type, and initial pain would be minimized between the two anesthetic solutions. The mean initial pain ratings of 96 mm for the patients in the articaine and lidocaine groups would correlate to moderate pain (Fig. 1). This pain is representative of patients with an irreversible pulpitis (1, 2, 4, 29-32) who present for emergency treatment.

The 4% articaine with 1:100,000 epinephrine did not statistically improve anesthetic success of the IAN block compared with 2% lidocaine with 1:100,000 epinephrine. No other study has objectively compared articaine with lidocaine in patients with irreversible pulpitis, therefore, no comparison to other studies is possible. However, the literature contains numerous studies demonstrating an equal anesthetic effect for articaine and lidocaine (14, 16, 18-23). The results of the present study would further confirm that articaine is not superior to lidocaine in anesthetic efficacy.

In previous studies of endodontic patients with irreversible pulpitis, success rates for the IAN block have ranged from 19% to 56% (1-4). All of the patients in these studies had lip numbness with the IAN block. Although lip numbness has typically been used as an indicator of a clinically successful block, clinicians must realize this does not guarantee successful pulpal anesthesia. Our results are similar to the 19% and 25% success rates recorded by Nusstein et al. (1) and Reisman et al. (2) but lower than the 50% to 56% success rate recorded by Cohen et al. (3) and Kennedy et al. (4). Differences in measurement of onset time, initial criteria for pulpal anesthesia using the electric pulp tester or cold stimuli, and patient populations may account for the varied success rates in the previous studies.

Discomfort ratings for patients experiencing greater than mild pain (anesthetic failure) on access demonstrated that more than half the patients (51-57%) experienced moderate-to-severe pain in dentin (Table 4). Obviously, the clinician would have difficulty entering the pulp to give an intrapulpal injection. Therefore, practitioners should consider supplemental techniques, such as

intraosseous (1, 2, 33, 34) or periodontal ligament injections (3), to achieve pulpal anesthesia when an IAN block fails to provide pulpal anesthesia for a particular tooth.

In conclusion, for mandibular posterior teeth with irreversible pulpitis, neither 4% articaine with 1:100,000 epinephrine or 2% lidocaine with 1:100,000 epinephrine, administered in a conventional IAN block, resulted in an acceptable rate of anesthetic success. There was no significant difference in anesthetic success between the articaine and lidocaine solutions.

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