Comparative Evaluation of Anesthetic Efficacy of 2% Lidocaine, 4% Articaine, and 0.5% Bupivacaine on Inferior Alveolar Nerve Block in Patients with Symptomatic Irreversible Pulpitis: A Prospective, Randomized, Double-blind Clinical Trial

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Aims: To compare the anesthetic efficacy of 1.8 mL of 2% lidocaine with 1:200,000 epinephrine, 4% articaine with 1:100,000 epinephrine, and 0.5% bupivacaine with 1:200,000 epinephrine on producing inferior alveolar nerve block (IANB) in patients with symptomatic irreversible pulpitis. **Methods:** A total of 91 adult patients who were actively experiencing mandibular molar pain were involved in this study. The patients were randomly divided into three groups on the basis of the anesthetic solution used. The first group received IANB with 1.8 mL of 2% lidocaine with 1:200,000 epinephrine, the second group received IANB with 4% articaine with 1:100,000 epinephrine, and the third group received IANB with 0.5% bupivacaine with 1:200,000 epinephrine. After 15 minutes of IANB, conventional endodontic access preparation was started. The pain during the treatment was noted on a Heft-Parker visual analog scale (HP VAS). The primary outcome measure was anesthetic success, and anesthesia was considered successful if the patient reported no pain or weak/mild pain (HP VAS score < 55 mm) during endodontic treatment (pulp access and canal preparation procedures). The data were analyzed with one-way analysis of variance and chi-square test. **Results:** The anesthetic success rates of 2% lidocaine, 4% articaine, and 0.5% bupivacaine were 23%, 33%, and 17%, respectively. The differences were statistically insignificant ($P > .05$). **Conclusion:** The 2% lidocaine solution used for IANB had similar success rates when compared with 4% articaine and 0.5% bupivacaine. *J Oral Facial Pain Headache 2017;31:124–128. doi: 10.11607/ofph.1642*

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Endodontic patients with acute pain often present with failed anesthesia, especially in attempts to produce inferior alveolar nerve block (IANB).[1,2] Although the patients may present with lip numbness, the clinician may encounter problems in achieving successful pulpal anesthesia.[1] This phenomenon can be explained by three major factors: first, the threshold of the nociceptors is reduced by inflammatory mediators; second, these inflammatory mediators activate local anesthetic-resistant channels such as tetrodotoxin (TTX) and transient receptor potential type 1 (TRPV1) channels in the nociceptive afferents; and third, the patients in pain are apprehensive and have a lower pain threshold.[1]

Lidocaine is a frequently used local anesthetic agent in dentistry.[3] It has a short onset of action and, combined with epinephrine, can provide pulpal anesthesia of 60 to 90 minutes.[1] Another commonly used anesthetic agent is 4% articaine combined with epinephrine. Articaine is an amide-type anesthetic agent and its liposolubility is increased by the presence of a thiophene ring[4,5]; however, in the majority of studies, 4% articaine was not superior to 2% lidocaine when given to produce IANB.[2,6,7] Bupivacaine is an amide-type local anesthetic agent with a long duration of action. It has a slow onset of action but provides duration of pulpal tissue anesthesia 2 to 3 times longer than lidocaine.[8]

Very few studies have evaluated the anesthetic efficacy of bupivacaine in achieving pulpal anesthesia in inflamed pulps. Sampaio et al[8] compared the anesthetic efficacy of 0.5% bupivacaine with that of 2% lidocaine in patients with irreversible pulpitis and reported a success rate of 80% for bupivacaine and 62.9% for lidocaine, while Gross et al[9] reported lower success rates for bupivacaine than lidocaine when used in maxillary infiltrations in asymptomatic patients. However, there is no study simultaneously comparing the anesthetic efficacy of lidocaine, articaine, and bupivacaine in patients with symptomatic irreversible pulpitis.

Therefore, the aim of the present study was to compare anesthetic efficacy of 1.8 mL of 2% lidocaine with 1:200,000 epinephrine, 4% articaine with 1:100,000 epinephrine, and 0.5% bupivacine with 1:200,000 epinephrine on producing IANB in patients with symptomatic irreversible pulpitis.

Materials and Methods

A total of 97 patients were initially included in this prospective, double-blind clinical study. The primary outcome was defined as success, which was indicated by no or mild pain (Heft-Parker visual analog scale [HP VAS] score < 55 mm) during endodontic procedures (pulp access and canal preparation to the apical one-third of the tooth).[2,10] To calculate the sample size, α level type I error was kept at 0.05 and β level type at 0.20. It was estimated that enrollment of 81 subjects would be needed to detect a 25% difference with 80% power. Assuming a 10% dropout rate, 30 patients per group were recruited. Institutional ethical clearance was provided (17/9/36/JMI/IEC/2015) and a written informed consent was obtained from each enrolled patient.

The criteria for inclusion were active pain in a mandibular molar (> 54 mm on the HP VAS[10]), the presence of an extended response to pulp sensitivity tests, no appearance of periapical radiolucency, and presence of vital pulp tissue on endodontic access preparation. The exclusion criteria included contraindications to any content of the local anesthetic solution. Pregnant or breastfeeding patients were also excluded, as were patients requiring endodontic intervention in more than one mandibular tooth. The patients were instructed how to mark the 170-mm HP VAS scale, where 0 described no pain and 170 described extreme/worst imaginable pain. The millimeter marks on the HP VAS were removed.[2]

The patients were allocated to three treatment groups (lidocaine, articaine, and bupivacaine). The allocation was randomized using an online random generator (randomization.com) using a permuted block stratified randomization protocol. A trained dental assistant loaded the local anesthetic solutions in masked disposable syringes and coded them (three digit alpha-numeric) for treatment sequence. For articaine injections, the solution was taken from a standard 4% articaine cartridge. Only the alpha-numeric code was recorded on the data sheets. To ensure blinding, neither the operator nor the assistant had knowledge of the solution tested. All injections were administered by one person (V.A.). A total of 32 patients received injections of 1.8 mL of 2% lidocaine with 1:200,000 epinephrine, 31 patients received 1.8 mL of 4% articaine with 1:100,000 epinephrine, and 34 patients received 1.8 mL of 0.5% bupivacaine with 1:200,000 epinephrine. A sterile gauze was used to dry the injection site, and topical anesthesia was applied by using 20% benzocaine with a sterile cotton-tip applicator. The solution was deposited over 120 seconds after aspiration.

After 15 minutes of IANB, the lip numbness was evaluated. In case of absence of profound lip numbness, the patient was no longer involved in the study. The excluded patients received supplemental anesthesia including intraligamentary and intrapulpal anesthesia, and their data were not included in the present study. For patients presenting with profound lip numbness, rubber dam was applied and endodontic treatment was initiated. If the patient experienced any pain during the treatment, the patients marked their pain on the HP VAS. The anesthetic injection was defined as successful if the patient reported no pain or weak/mild pain (HP VAS score < 55 mm) during endodontic treatment.

The patients' ages, genders, and preoperative pain statuses are presented in Table 1. The data were analyzed using one-way analysis of variance (ANOVA) at 5% significance level. The success rates were statistically evaluated by chi-square tests.

Results

A final total of 91 adult volunteer patients, 57 men and 34 women, were included in this study. The average age of the patients was 34 years, ranging from 27 to 47 years. Out of the original 97 patients included in the study, 1 patient each from the lidocaine and the articaine groups and 4 patients from the bupivacaine group did not present lip numbness at 15 minutes and were excluded from the study. The age, gender, preoperative pain status, and distribution of teeth of all the patients are presented in Table 1. There were no statistical differences between any of these variables ($P > .05$).

The percentages of successful anesthesia are presented in Table 2. IANB produced by lidocaine,

Table 1 Comparison of Age, Sex, and Distribution of Teeth

	2% lidocaine with 1:200,000 epinephrine	4% articaine with 1:100,000 epinephrine	0.5% bupivacaine with 1:200,000 epinephrine
Age (y), mean ± SD[a]	37 ± 8.3, range 31–47	34 ± 6.5, range 27–41	38 ± 4.25.5, range 29–45
Gender[a]			
Male	22	16	19
Female	9	14	11
Distribution of teeth[a]			
First molar	19	20	22
Second molar	12	10	8
Number of patients with preoperative mild pain[b]	0	0	0
Number of patients with preoperative moderate pain[b]	27	25	27
Number of patients with preoperative severe pain[b]	4	5	3
Preoperative HP VAS score, mean ± SD	87 ± 28	101 ± 36	92 ± 32

[a]There was no statistically significant difference between the groups ($P > .05$).
[b]On the HP VAS, mild pain corresponded to < 55 mm, moderate pain to 55 and 115 mm, and severe pain to > 115 mm.

Table 2 Comparison of Percentages of Successful Anesthesia

	2% lidocaine with 1:200,000 epinephrine	4% articaine with 1:100,000 epinephrine	0.5% bupivacaine with 1:200,000 epinephrine
Successful anesthesia	7/31 patients (23%)	10/30 patients (33%)	5/30 patients (17%)

There were no significant differences between the groups ($\chi^2 = 2.34$, df = 2, $P = .31$).

articaine, and bupivacaine injections was associated with success rates of 23%, 33%, and 17%, respectively. There were no significant differences between the anesthetic success rates of the different anesthetics ($\chi^2 = 2.34$, df = 2, $P = .31$). None of the anesthetics gave a 100% success rate.

Discussion

IANB is achieved by depositing anesthetic solution in the pterygomandibular space and provides local anesthesia for the mandibular molar teeth. Local anesthesia via IANB may provide successful anesthesia in 70% of uninflamed pulps, but the success rate drastically decreases to 30% in patients with irreversible pulpitis.[1,2,6–8,11–15] These reduced success rates can be attributed to the inflammation-induced changes in the nociceptors. Additionally, the presence of preoperative pain can make the patient apprehensive and increase the pain response, and psychological distress can also lead to increased pain sensitivity, causing neuropsychological alterations that shape the patient's behavior.[12] Another contributing factor is central sensitization caused by a long-lasting discharge of nociceptive afferents.[12]

Local anesthetic agents act by reversibly inhibiting the influx of sodium ions, thus blocking neuronal depolarization.[1] Contemporary local anesthetic agents contain an intermediate amide chain and are thus classified as amide-type local anesthetic agents.[11] Commonly used amide-type agents are lidocaine, articaine, mepivacaine, and bupivacaine,[11] which differ in terms of their potency, speed of onset, and duration of action.[1] A higher anesthetic potency may be associated with agents with higher lipid solubility,[11] which increases the diffusion of the local anesthetic agent through the nerve sheath. Articaine and bupivacaine have higher lipid solubility than lidocaine. In addition, bupivacaine has a higher affinity for the proteins in the sodium channels. This increases the duration of neural blockade, and so bupivacaine is classified as a long-acting amide-type anesthetic agent.[11]

The present study evaluated the efficacy of three different amide-type local anesthetic agents—lidocaine, articaine, and bupivacaine—in providing pulpal anesthesia in patients with painful irreversible pulpitis. Injections with 2% lidocaine gave a 23% success rate. In a retrospective study, Fowler and Reader[16] reported a 28% success rate with a 1.8-mL volume of 2% lidocaine to produce IANB. Some authors have reported higher success rates with 2% lidocaine in a volume of 3.6 mL of anesthetic solution.[6,8,17] Sampaio et al[8] and Tortamano et el[6] have reported success rates of 62.9% and 45%, respectively, by using 3.6 mL of 2% lidocaine with 1:100,000 epinephrine. However, the results of the retrospective analysis by Fowler and Reader[16] differed, and these authors stated that success rates were not improved by increasing the volume from 1.8 mL to 3.6 mL. The epinephrine concentration in the local anesthetic solution in the present study differed from those used

in the studies mentioned above, but a recent report has suggested that increasing the amount of epinephrine from 1:200,000 to 1:80,000 has no effect on the anesthetic efficacy of 2% lidocaine.[18]

Articaine is considered as a better local anesthetic agent than lidocaine, especially when given as infiltration in mandibular molars.[19–22] Jung et al[19] reported that the anesthetic efficacy of the buccal infiltration of 4% articaine is similar to the standard IANB in healthy subjects. Matthews et al[20] used buccal supplemental infiltration of 4% articaine after standard IANB in patients with inflamed pulps and achieved a success rate of 58%. It has been demonstrated that articaine can depress the compound action potentials of A-fibers in the isolated rat sural nerve more effectively than either 2% or 4% lidocaine, or 3% mepivacaine[23]; however, when used as the primary injection for IANB, articaine is not superior to lidocaine.[2,6] Claffey et al[2] reported similar success rates with the use of 2.2 mL of 4% articaine and 2% lidocaine for IANB in patients experiencing irreversible pulpitis. Tortamano et al[6] compared 3.6 mL of 4% articaine to 2% lidocaine and reported success rates of 65% and 45%, respectively, with statistically insignificant differences. In the present study, 1.8 mL of 4% articaine with 1:100,000 epinephrine produced a success rate of 33%. There was no statistically significant difference between lidocaine and articaine. Since it has been well documented that 4% articaine is not superior than 2% lidocaine to achieve IANB, and since it has been reported that articaine has a higher incidence of nerve paresthesia,[24] its use should be limited to supplementary anesthesia.

Bupivacaine is a long-acting amide-type local anesthetic agent[8,9,11,25–27] that provides a longer duration of pulpal anesthesia when administered to produce nerve block. Fernandez et al[25] reported that bupivacaine solution has a lower incidence of anesthetic success but significantly longer duration compared with lidocaine, except for the first molar. However, when given in maxillary infiltrations, bupivacaine does not provide a clinically significant longer duration of pulpal anesthesia compared to lidocaine. Gross et al[9] compared the anesthetic efficacy of 1.8 mL of 0.5% bupivacaine with 1.8 mL of 2% lidocaine in maxillary lateral incisors and first molars. The authors found that bupivacaine had a lower success rate than lidocaine (64% vs 82%) with a pulpal anesthesia of less than 1 hour. These studies were done in patients with asymptomatic teeth.

As stated before, the anesthetic success of local anesthetic agents decreases in patients with symptomatic irreversible pulpitis. Few studies have compared bupivacaine with lidocaine or articaine in patients with irreversible pulpitis. Sampaio et al[8] compared 3.6 mL of 0.5% bupivacaine containing 1:200,000 epinephrine with 2% lidocaine containing 1:100,000 epinephrine in patients with symptomatic mandibular molars, and reported 80% and 62.9% success rates for bupivacaine and lidocaine, respectively, with no difference between the two solutions. In the present study, 1.8 mL of 0.5% bupivacaine with 1:200,000 epinephrine gave a 17% success rate, much lower than the success rate reported by Sampaio et al.[8] The difference in the results can be attributed to the volume of local anesthetic agent used.

Conclusions

There were no significant differences in the anesthetic efficacy of 2% lidocaine, 4% articaine, and 0.5% bupivacaine administered to produce IANB in patients with symptomatic irreversible pulpitis.

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