ANESTHETIC EFFICACY OF ARTICAINE AND LIDOCAINE IN ENDODONTIC TREATMENT OF MANDIBULAR MOLARS WITH SYMPTOMATIC IRREVERSIBLE PULPITIS

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Achieving adequate anesthesia in mandibular molars with symptomatic irreversible pulpitis remains challenging. This study compared the anesthetic efficacy of two common clinical regimens, 4% articaine via buccal infiltration and 2% lidocaine via inferior alveolar nerve block. A controlled clinical study was conducted on 60 mandibular molars with symptomatic and electric pulp test (EPT) responses were recorded. Pre-injection pain was comparable between groups (p = 0.528). Post-injection pain was significantly lower in the articaine group (30.8 ± 16.4 vs 38.4 ± 24.8, p = 0.040). The need for supplemental anesthesia was lower in the articaine group than in the lidocaine group (23.3% vs 46.7%, p = 0.046). Pain during instrumentation was also lower with articaine (p = 0.044), whereas no difference reported during access or obturation. The time to achieve a negative EPT response was shorter with articaine (8.6 ± 2.3 vs 10.1 ± 3.4 minutes, p = 0.048). The overall success rate was significantly higher in the articaine group (76.7% vs 53.3%, p = 0.048). To conclude, the articaine buccal infiltration regimen demonstrated superior anesthetic efficacy compared with the lidocaine via inferior alveolar nerve block regimen, particularly in reducing post-injection pain, shortening onset time, and decreasing the need for supplemental anesthesia.

Keywords: Articaine, lidocaine, endodontic anesthesia, symptomatic irreversible pulpitis, mandibular molars.

I. INTRODUCTION

Symptomatic irreversible pulpitis is a common endodontic condition characterized by severe, persistent pain, which may progress to pulp necrosis and periapical infectious complications if not treated promptly.[1] In endodontic practice, achieving effective anesthesia in mandibular molars remains a clinical challenge due to the interplay of anatomical and pathophysiological factors. The thick buccal cortical plate limits the diffusion of local anesthetics, while the complex root canal system, including isthmuses and accessory canals, makes complete pulpal anesthesia difficult to achieve.[2,3] In addition, according to the central core theory, local anesthetics have limited ability to penetrate nerve fibers located deep within the inferior alveolar nerve bundle.[4]

The inferior alveolar nerve block (IANB), a commonly used technique, has a reported failure rate ranging from 10% to 39% in patients with symptomatic irreversible pulpitis, resulting in persistent pain during access cavity preparation or canal instrumentation.[5] Lidocaine is considered the gold standard in dental anesthesia due to its consistent efficacy

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and high safety profile, however, its diffusion through dense mandibular bone is limited. Articaine, with its thiophene ring structure, exhibits superior tissue diffusibility and is suggested to enhance pain control. Although some studies have reported advantages of articaine, the findings remain inconsistent in the endodontic management of mandibular molars with symptomatic irreversible pulpitis.[6,7]

In clinical practice, despite their frequent use, direct comparisons between their specific clinical regimens, namely 4% articaine via buccal infiltration and 2% lidocaine via inferior alveolar nerve block, remain a subject of ongoing debate. Each protocol represents a distinct clinical approach tailored for mandibular anesthesia. Therefore, evaluating the overall anesthetic efficacy of these two commonly employed clinical regimens in the management of symptomatic irreversible pulpitis is warranted to provide evidence-based guidance for practitioners..

II. MATERIALS AND METHODS

1. Study population

Patients presenting for examination and indicated for endodontic treatment of symptomatic irreversible pulpitis in mandibular molars at Ho Chi Minh City Odonto-Stomatology Hospital from June 2025 to February 2026 were included.

Inclusion Criteria

Patients aged ≥ 18 years old, classified as American Society of Anesthesiologists physical status I or II. Patients diagnosed with symptomatic irreversible pulpitis in the first or second mandibular molars, with pain intensity > 54 mm on the 170-mm Heft-Parker visual analog scale (HP-VAS), and indicated for endodontic treatment. The diagnosis was established based on the presence of spontaneous pain or prolonged pain to stimuli, a lingering response to cold testing, vital pulp upon access cavity preparation, and no radiographic evidence of periapical bone loss except for periodontal ligament widening. Teeth had to be restorable, with at least 1.5-2 mm of sound tooth structure above the gingival margin and sufficient coronal structure to ensure retention of the final restoration.

Exclusion criteria

Pregnant or breastfeeding patients, history of allergy to any component of the local anesthetic, presence of acute infection at the injection site, use of analgesics, antibiotics, anti-inflammatory drugs, sedatives, or antidepressants within 48 hours prior to treatment that could affect pain perception, patients with uncontrolled systemic conditions such as hypertension, cardiovascular disease, hepatic or renal impairment. Teeth were excluded if they had previous endodontic treatment, a history of pulp necrosis or periapical pathology, vertical root fracture, or root malformation. Cases in which pulp necrosis was identified upon access opening, characterized by gray or black, dry, friable pulp tissue with no bleeding, were also excluded from the study.

2. Study methods

Study design

A controlled clinical interventional study.

Sample size and sampling method

A total of 60 mandibular molars from 42 patients meeting the inclusion criteria were enrolled. Patients were consecutively recruited using a convenience sampling method, with the tooth defined as the primary unit of analysis (n = 60, 30 per group). Among the participants, 24 patients contributed a single tooth, while 18 patients contributed two teeth. To minimize inter-individual variability and enhance group comparability, those with two eligible teeth received both anesthetic protocols (articaine and lidocaine) in a cross-over manner. Group comparability was a predefined objective, a targeted enrollment strategy was implemented to balance prognostic factors, including age, gender, and tooth type, ensuring a proportionate distribution of baseline characteristics. To ensure data independence and safety, only one tooth was treated per session. For patients requiring two treatments, a minimum 24-hour washout period was mandated, ensuring complete metabolic clearance and resolution of any local effects.

Study contents

The independent variable was the anesthetic protocol, representing standard clinical practice:

+ Group 1 (articaine): 4% articaine with 1:100.000 epinephrine.

+ Group 2 (lidocaine): 2% lidocaine with 1:100.000 epinephrine.

The independent variable was the type of local anesthetic used in endodontic treatment, including two groups: articaine and lidocaine.

Outcome variables included pain intensity, anesthetic efficacy, and parameters related to anesthetic response:

+ Pain intensity was assessed using the 170-mm HP-VAS. This scale is categorized as follows: 0 mm indicates no pain, 1-54 mm indicates mild pain, 55-114 mm indicates moderate pain, and > 114 mm indicates severe pain.[8] Assessments were recorded at the following time points: before injection, after injection, during access cavity preparation, and during root canal instrumentation. Values were recorded as continuous quantitative variables.

+ Anesthetic efficacy was defined as success or failure. Success was defined as the ability to perform endodontic procedures with none or mild pain (HP-VAS ≤ 54 mm). Failure was defined as any pain score > 54 mm (moderate to severe pain) requiring supplemental anesthesia.

+ The need for supplemental anesthesia was recorded as a binary variable (yes/no). Other outcome variables included pain during injection, results of the electric pulp test (EPT) at 15 minutes (negative or positive), and the time to achieve a negative EPT response (minutes).

Clinical procedure and safety monitoring

Patients diagnosed with symptomatic irreversible pulpitis in the first or second mandibular molars, meeting the inclusion and exclusion criteria, and presenting with moderate to severe pain on the 170-mm HP-VAS were enrolled. Upon enrollment, all patients underwent a comprehensive clinical examination, medical history recording, and digital periapical radiography to confirm the diagnosis and exclude periapical pathology. Prior to the procedure, oral prophylaxis was performed for all eligible cases. Patients were then randomly assigned to their respective intervention groups. In cases where a patient required treatment for two tooth, each tooth was allocated independently, with a minimum 24-hour washout period mandated between appointments to ensure complete metabolic clearance of the anesthetic agents and resolution of any local effects. To ensure pharmaceutical standardization, all anesthetic agents were obtained from the same manufacturer (Septodont, Saint-Maur-des-Fossés, France). A fixed volume of one 1.7-mL cartridge was used for the initial injection, delivering a conservative dose of 0.017 mg of epinephrine. In the articaine group, Septanest (4% articaine hydrochloride with 1:100.000 epinephrine) was administered via buccal infiltration. In the lidocaine group, Lignospan Standard

(2% lidocaine hydrochloride with 1:100.000 epinephrine) was administered via inferior alveolar nerve block. Both techniques utilized a 27G needle. Throughout the clinical session, patients were closely monitored via baseline vital signs and continuous visual observation to detect any potential adverse cardiovascular or systemic effects. After a 15-minute onset period, anesthetic effectiveness was evaluated using cold testing and electric pulp testing. Adequate pulpal anesthesia was defined as no response to EPT at the maximum output (80 mA). In cases of inadequate anesthesia (HP-VAS > 54 mm during the procedure), supplemental anesthesia was administered using the same anesthetic solution as the initial injection. If anesthesia remained insufficient to allow for comfortable treatment, a periodontal ligament (intraligamentary) injection was performed as a rescue technique. All patients were instructed to report any symptoms of prolonged anesthesia or paresthesia following the appointment to ensure a comprehensive safety profile.

Statistical analysis

Data were entered and analyzed using SPSS version 27.0. The unit of analysis was the tooth. Quantitative variables were tested for normal distribution and presented as mean ± standard deviation. Comparisons between the two groups were performed using the independent samples t-test for normally distributed data. Qualitative variables were presented as frequencies and percentages, and comparisons were conducted using the Chi-square test or Fisher's exact test as appropriate. A p-value < 0.05 was considered statistically significant.

3. Ethics in research

The study was reviewed and approved by the Institutional Review Board of Can Tho University of Medicine and Pharmacy under approval code 25.540.HV/PCT-HĐĐĐ. All study procedures were conducted in accordance with established ethical principles and standards for biomedical research.

III. RESULTS

During the study period, a total of 42 patients with 60 mandibular molars diagnosed with symptomatic irreversible pulpitis and meeting the inclusion criteria were included in the analysis. The mean age of the study population was 34.8 ± 10.9 years old, ranging from 18 to 58 years old, with the 20-45 years old age group accounting for the highest proportion. Females slightly outnumbered males, comprising 54.8% and 45.2%, respectively. Among the 60 teeth included, first mandibular molars accounted for 58.3%, while second mandibular molars represented 41.7%. Regarding etiology, dental caries was the predominant cause (76.7%), followed by cervical abrasion (11.7%) and trauma (6.6%), with other causes accounting for a small proportion.

Table 1. Comparison of baseline characteristics between the two study groups

Characteristics		Articaine group (n = 30)	Lidocaine group (n = 30)	p-value
Age (year), mean ± SD		33.9 ± 11.2	35.7 ± 10.6	0.525*
Gender, n (%)	Male	13 (43.3%)	15 (50.0%)	0.605**
	Female	17 (56.7%)	15 (50.0%)	

Characteristics		Articaine group (n = 30)	Lidocaine group (n = 30)	p-value
Tooth type, n (%)	First molar	18 (60.0%)	17 (56.7%)	0.598**
	Second molar	12 (40.0%)	13 (43.3%)	
Baseline HP-VAS (mm), Mean ± SD		130.43 ± 14.2	131.2 ± 13.9	0.528*

**Independent Samples t-test, **Chi-square test*

Statistical analysis of baseline characteristics showed that there were no significant differences between the articaine and lidocaine groups regarding age, gender, or tooth type ($p > 0.05$). Similarly, baseline pain intensity, as measured by HP-VAS, was comparable between the two groups ($p > 0.05$).

Table 2. Pain assessment during the anesthesia phase

Characteristics	Articaine group (n = 30)	Lidocaine group (n = 30)	p-value
Severity of pain before injection	130.43 ± 14.2	131.2 ± 13.9	0.528*
Severity of pain after injection	30.8 ± 16.4	38.4 ± 24.8	**0.040***
Supplemental anesthesia, n (%)	7 (23.3)	14 (46.7)	**0.046****
Severity of pain after supplemental injection	22.4 ± 14.1	28.7 ± 17.6	0.080*

**Independent Samples t-test, **Chi-square test*

Pain levels before injection were comparable between the two groups (130.43 ± 14.2 vs 131.2 ± 13.9, $p = 0.528$). After injection, the articaine group demonstrated significantly lower pain scores compared to the lidocaine group (30.8 ± 16.4 vs 38.4 ± 24.8, $p = 0.040$). The need for supplemental anesthesia was significantly lower in the articaine group (23.3% vs 46.7%, $p = 0.046$). No significant difference was observed in pain after supplemental injection between the two groups ($p = 0.080$).

Table 3. Pain assessment during endodontic treatment

Characteristics	Articaine group (n = 30)	Lidocaine group (n = 30)	p-value
During access cavity preparation	41.6 ± 28.3	48.9 ± 31.7	0.320*
During root canal instrumentation	24.5 ± 19.6	36.7 ± 27.4	**0.044***
During obturation	8.7 ± 12.4	11.3 ± 15.6	0.480*

**Independent Samples t-test*

No statistically significant differences were observed between the two groups during the access cavity preparation and obturation stages (p > 0.05). However, during root canal instrumentation, the articaine group exhibited significantly lower pain levels compared to the lidocaine group (24.5 ± 19.6 vs 36.7 ± 27.4, p = 0.044).

Table 4. Assessment of anesthetic effectiveness using electric pulp testing and onset time

Characteristics	Articaine group (n = 30)	Lidocaine group (n = 30)	p-value
Negative EPT after 15 minutes, n (%)	29 (96.7)	26 (86.7)	0.160*
Time to negative EPT (minutes)	8.6 ± 2.3	10.1 ± 3.4	**0.048****

**Fisher's Exact test, **Independent Samples t-test*

The proportion of negative EPT responses at 15 minutes was higher in the articaine group than in the lidocaine group (96.7% vs 86.7%), however, the difference was not statistically significant (p = 0.160). The time to achieve a negative EPT response was significantly shorter in the articaine group compared to the lidocaine group (8.6 ± 2.3 minutes vs 10.1 ± 3.4 minutes, p = 0.048).

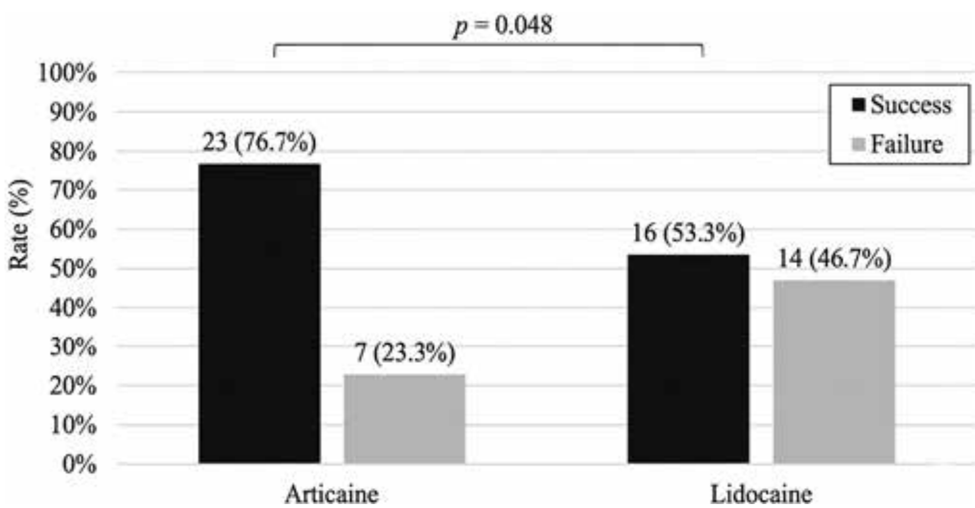

Figure 1. Comparison of anesthetic success rates between articaine and lidocaine

Chi-square test

The anesthetic success rate in the articaine group was 76.7%, which was significantly higher than 53.3% in the lidocaine group (p = 0.048).

No systemic adverse events, such as local anesthetic systemic toxicity or significant cardiovascular complications were observed. Regarding neurological safety, no cases of prolonged anesthesia or paresthesia were reported by patients in the 4% articaine group or the 2% lidocaine group. All patients recovered normal sensation within the expected pharmacological duration of the respective anesthetic agents.

IV. DISCUSSION

In this study, two distinct clinical regimens including 4% articaine via buccal infiltration and 2% lidocaine via inferior alveolar nerve block for the endodontic treatment of mandibular molars with symptomatic irreversible pulpitis. The results showed that articaine buccal infiltration regimen provided significantly lower pain levels after injection and during root canal instrumentation. The anesthetic success rate was higher in the articaine group than in the lidocaine group (76.7% vs 53.3%), with a significantly lower need for supplemental anesthesia. In addition, the time to achieve objective pulpal anesthesia, as assessed by electric pulp testing, was shorter in the articaine group.

Our findings are consistent with previous literature. A clinical trial by Ashraf et al. on mandibular molars with irreversible pulpitis demonstrated that, when buccal infiltration was used as a supplemental technique following a failed IANB, articaine significantly increased the anesthetic success rate compared to lidocaine (71.0% vs 29.0%, $p < 0.001$), highlighting its effectiveness as a supplemental anesthetic after initial failure with lidocaine.[9] Recent systematic reviews and meta-analyses further support these observations. Miglani et al. reported that 4% articaine was more effective than 2% lidocaine in patients with symptomatic irreversible pulpitis, particularly when using infiltration techniques.[10] Pooled evidence also indicates that articaine has an overall advantage in anesthetic success rates across both nerve block and infiltration techniques, with approximately a 2.09-fold higher likelihood of success in mandibular interventions.[11]

The observed difference in efficacy may be explained by the pharmacological properties of articaine, particularly its superior diffusion through osseous tissue due to the presence of a thiophene ring. This structural feature enhances its ability to penetrate the dense cortical bone of the mandible more effectively and rapidly, resulting in a faster onset of action and higher anesthetic success rates in various clinical situations. This advantage has also been reported in other reviews on dental anesthesia.[12] However, some recent studies suggest that, in certain cases, the success rate of IANB alone does not differ significantly between articaine and lidocaine, particularly when no supplemental anesthesia is employed.[13] In practice, achieving profound pulpal anesthesia in the mandible is further influenced by the anatomical and physiological characteristics of the inferior alveolar nerve. According to the central core theory, local anesthetic solutions have limited ability to diffuse into nerve fibers located deep within the nerve bundle. This challenge is exacerbated in teeth with symptomatic irreversible pulpitis, where the decreased tissue pH reduces the proportion of the non-ionized base form of the anesthetic capable of penetrating the nerve sheath. Additionally, inflammation alters the resting membrane potential, lowers the excitation threshold, and promotes the upregulation of anesthetic-resistant sodium channels, contributing to the high failure rates of conventional anesthetic techniques.[4] Electric pulp testing is used to assess the onset and presence of pulpal anesthesia, but it does not reliably predict clinical anesthetic success during endodontic procedures. A negative EPT response does not necessarily indicate complete pulpal anesthesia during endodontic procedures, as it primarily reflects A-delta fiber blockade rather than C-fiber-mediated pain, which is more relevant in symptomatic irreversible pulpitis.

In the present study, both 4% articaine and 2% lidocaine demonstrated excellent safety profiles, with no significant systemic or local complications observed in either group. However, potential adverse effects are documented in the literature. For 4% articaine, the rare risk of paresthesia is predominantly associated with nerve blocks rather than the buccal infiltration technique employed here.[14] Additionally, its rapid plasma metabolism minimizes systemic toxicity. Conversely, while 2% lidocaine via IANB is a safe and established standard, it inherently carries higher risks of intravascular injection and technique-related trismus due to deeper tissue penetration.[15] The absence of adverse effects for both anesthetics in our study indicates that utilizing a conservative dose and precise injection techniques ensures clinical efficacy while effectively mitigating the procedural risks associated with both agents.

Overall, evidence from the present study and previous literature indicates that the 4% articaine buccal infiltration regimen offers a significant advantage in pain control and anesthetic success rates compared to the conventional 2% lidocaine via inferior alveolar nerve block protocol. These findings highlight the importance of selecting appropriate anesthetic techniques tailored to specific clinical scenarios. Nevertheless, these findings should be interpreted with caution due to several limitations. While the use of a cross-over design and targeted enrollment strategy significantly enhanced group comparability and internal validity, we acknowledge that a one-patient-one-tooth design would be the ideal method to ensure absolute data independence. Although the 24-hour washout period was strictly mandated to prevent carry-over effects, the inclusion of multiple teeth from the same individuals may still introduce a potential clustering effect. Furthermore, the relatively small sample size (n = 60) reduces statistical power and increases the risk of random error. The single-center nature of the study also limits generalizability, as the results may be influenced by the specific patient population and clinical expertise at the study site. Future studies with larger, multi-center cohorts and stricter protocols are recommended to further validate these findings.

V. CONCLUSION

Within the limitations of this study, the 4% articaine buccal infiltration regimen demonstrated favorable anesthetic efficacy compared to the conventional 2% lidocaine inferior alveolar nerve block (IANB) protocol for mandibular molars with symptomatic irreversible pulpitis. This was evidenced by lower pain levels during injection and instrumentation, a higher success rate, and a reduced requirement for supplemental anesthesia in our sample. Furthermore, both regimens exhibited safe clinical profiles with no adverse effects. These findings suggest that the articaine-based infiltration protocol may serve as a viable and effective alternative for managing pain in these challenging cases.

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