Journal of Dental Sciences 20 (2025) 1139–1147

Available online at www.sciencedirect.com

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journal homepage: www.e-jds.com

Original Article

Efficacy and safety of infiltration anesthesia with 4 % Articaine and block anesthesia with 2 % Lidocaine in the mandibular third molar extraction

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Received 21 November 2024; Final revision received 19 January 2025
Available online 30 January 2025

KEYWORDS
Articaine;
Block anesthesia;
Infiltration anesthesia;
Lidocaine;
Local anesthesia;
Third molar extraction

Abstract *Background/Purpose:* Articaine is a dental anesthetic that has been developed and widely used in recent years. This study aimed to compare the anesthetic efficacy and safety of infiltration anesthesia with 4 % Articaine (with 1:100,000 epinephrine) and block anesthesia with 2 % Lidocaine (with 1:100,000 epinephrine) in the mandibular third molar extraction.
Materials and methods: This prospective, randomized, split-mouth clinical trial was planned to involve 30 adults with the bilateral mandibular third molars. Participants were randomly assigned to receive 4 % Articaine (Articaine group) by infiltration anesthesia on one side and 2 % Lidocaine (Lidocaine group) by block anesthesia on the opposite side. Parameters such as the heart rate, blood pressure, oxygen saturation, anesthetic usage, operation duration, pain score, satisfaction, and adverse events were recorded and analyzed.
Results: Finally, 26 participants receiving the bilateral mandibular third molar extraction were included. There were no significant differences in the heart rate, blood pressure, oxygen saturation, and maximum fluctuations during the extraction procedure between the two groups, except the maximum heart rate fluctuation showing statistical significance. Additionally, the amount of anesthetic used was significantly lower in the Articaine group (1.5 ± 0.4 cartridges) than in the Lidocaine group (2.2 ± 0.5 cartridges) ($P < 0.001$). There were no significant differences in the operation duration, pain score, and satisfaction between the two groups, and no adverse events were reported in either group.

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https://doi.org/10.1016/j.jds.2025.01.018

Conclusion: Using 4 % Articaine for infiltration anesthesia offers comparable pain control to 2 % Lidocaine for block anesthesia in the mandibular third molar extraction surgery. Using 4 % Articaine can safely achieve similar pain control with lower doses and less invasive anesthesia techniques.

Introduction

Articaine is a dental anesthetic developed and widely used in dentistry for nearly 50 years. Due to its higher concentration and unique chemical structure, Articaine exhibits excellent tissue penetration and anesthesia efficacy.[1] Some dental clinical studies have found that Articaine shows better anesthetic efficacy compared to the most commonly used traditional anesthetic, Lidocaine, while maintaining similar safety.[2,3] Particularly, superior diffusion ability of Articaine is highlighted in infiltration anesthesia, even showing good performance in the mandibular posterior teeth area with thick and dense bone.[2] However, controversy has surrounded Articaine in the past due to clinical reports suggesting a higher risk of causing nerve damage and neurosensory disturbance.[4–7]

Wisdom tooth extraction surgery is one of the common outpatient procedures in dentistry. Traditionally, during wisdom tooth extraction, an Inferior Alveolar Nerve Block (IANB) is often employed for adequate pain control. This anesthesia technique relies on locating the position where the inferior alveolar nerve enters the mandible by identifying surface anatomical landmarks in the patient's oral cavity.[1] Achieving success with this technique depends on the clinician's experience and tactile sensitivity to the patient's anatomy, making it a technique-sensitive method. Moreover, the success of an IANB can be compromised by variations in individual anatomy, leading to inadequate anesthesia effectiveness. Consequently, the success rate of IANB is statistically reported to range from 31 % to 81 %.[1] Additionally, the IANB carries a relatively high risk of inadvertent intravascular injection, with a positive aspiration rate of around 10—15 %.[1] This poses a significant risk for systemic toxicity, such as arrhythmias or central nervous system depression. Therefore, ensuring that the needle tip is not in a blood vessel before injection is advised, especially for patients with severe cardiovascular conditions.

Furthermore, IANB might not be suitable in specific clinical scenarios, such as cases where the injection site is affected by a tumor (e.g. patients with oropharyngeal cancer), limited mouth opening that prevents traditional IANB, or severe hemophilia patients concerned of hematoma formation affecting the airway.[8] In such cases, clinicians may consider alternative anesthesia techniques for mandibular anesthesia (e.g. Gow-Gates or closed mouth technique), or explore using an anesthetic with better infiltration properties (such as Articaine) for local infiltration anesthesia as a substitute for the traditional IANB.

However, there is still insufficient evidence on whether Articaine infiltration anesthesia alone can be used for the mandibular third molar extraction. Currently, there is a lack of comparative studies in the literature regarding the safety and effectiveness differences between infiltration anesthesia by Articaine and block anesthesia by Lidocaine for this type of surgery. Therefore, this study aimed to compare the efficacy and safety of infiltration anesthesia using 4 % Articaine and block anesthesia using 2 % Lidocaine with 1:100,000 epinephrine in the mandibular third molar extraction surgery.

Materials and methods

Study design

The present study design was a single-blinded, prospective, randomized, split-mouth clinical trial. The Research Ethics Committee of National Taiwan University Hospital reviewed and approved this clinical trial (Ethics Approval Number: 202211014MINB), and it was registered on ClinicalTrials.gov (ClinicalTrials.gov Identifier: NCT05804630). Recruitment took place from March 2023 to June 2023, and all volunteers provided written informed consent prior to participating in the research procedures. The CONSORT (Consolidated Standards of Reporting Trials) flowchart for this study is presented in Fig. 1.

Participants

This clinical trial was planned to include 30 participants who met the inclusion criteria and had no exclusion criteria. Inclusion criteria consisted of adult patients aged between 20 and 60 years, with overall normal health or controlled mild chronic diseases (such as well-controlled hypertension, diabetes, hyperlipidemia, etc.) These patients underwent thorough evaluation of past medical history, allergy history, surgical history, clinical examination, and panoramic radiography to assess for the presence of bilateral mandibular third molars with similar difficulty for extraction (according to Pell and Gregory's classification & Winter's classification), clinically diagnosed as suitable for extraction under local anesthesia. Exclusion criteria were patients with known or suspected allergies to amide-type local anesthetics. The patients with systemic contraindications for tooth extraction, such as severe systemic diseases (e.g., severe heart disease, severe kidney disease, liver cirrhosis, uncontrolled diabetes), were excluded. The patients with systolic blood pressure (>150 mmHg or <90 mmHg) or diastolic blood pressure (>100 mmHg or <60 mmHg) were also excluded. Additionally, the patients

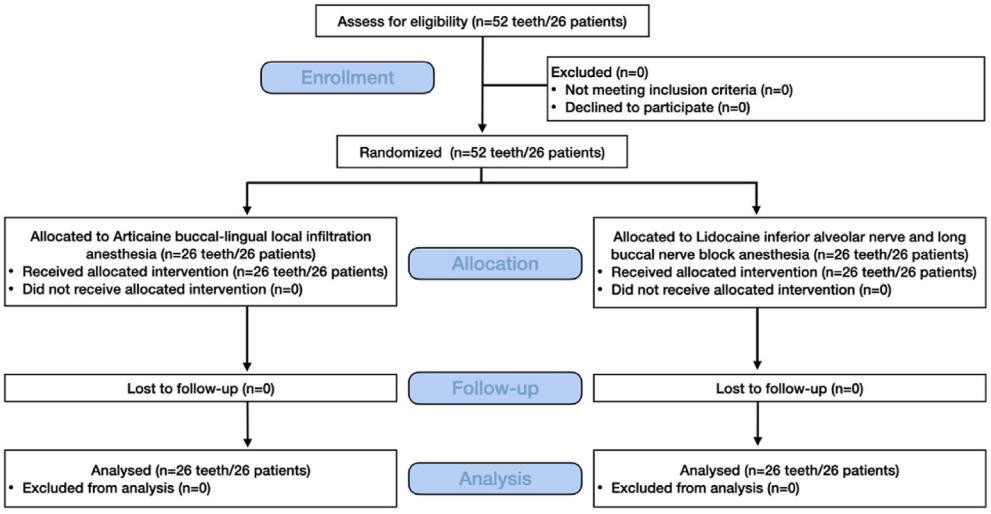

Figure 1 CONSORT (Consolidated Standards of Reporting Trials) flow diagram of the study design.

with local contraindications for tooth extraction, such as a history of local radiation therapy, acute local infectious symptoms, and cellulitis, were excluded. Pregnant or breastfeeding patients, those who have taken analgesics or sedatives within 24 h, and the patients who cannot tolerate tooth extraction under clinical local anesthesia due to anxiety or pain reasons were also excluded.

The research team explained the trial details to the patients who met the inclusion criteria and obtained their consent. These 30 participants were randomly assigned to receive either 4 % Articaine or 2 % Lidocaine for anesthesia on the left and right sides, respectively. Articaine was used with buccal-lingual infiltration anesthesia, while Lidocaine was used with inferior alveolar nerve, lingual nerve, and long buccal nerve block anesthesia. The anesthesia and tooth extraction procedures were performed by either a professor in oral and maxillofacial surgery (C.H.H.) or a resident in oral and maxillofacial surgery (H.N.C.).

Anesthesia protocol

Two types of local anesthetic agents were used in this study: 4 % Articaine with 1:100,000 epinephrine (Orabloc®, 40 mg/ml Articaine + 0.01 mg/ml epinephrine, 1.8ml/cartridge, PIERREL S.P.A, Capua, Italy) and 2 % Lidocaine with 1:100,000 epinephrine (Octocaine 100®, 20 mg/ml Lidocaine + 0.01 mg/ml epinephrine, 1.8ml/cartridge, Novocol, Cambridge, Canada).

The patients were positioned in a supine position for the surgery. Before the initiation of anesthesia, the patients were connected to a physiological monitoring device to measure their heart rate, blood pressure, and oxygen saturation. Subsequently, the extraoral and intraoral regions were disinfected using 0.12 % Chlorhexidine and draped. Following this, the localized anesthesia procedure was carried out. The administration of anesthesia drugs was performed using disposable dental long needles (27 Gauge, 0.4 × 35mm, J. Morita USA, Irvine, CA, USA). Each administration of anesthesia was slowly injected, with each dose lasting for a minimum of 1 min.

The standardized anesthesia protocol is shown in Fig. 2. If Articaine was used for the infiltration anesthesia in the first stage, a total of 0.9 mL (0.5 cartridges) was administered into the mucogingival fold of the buccal side of the tooth. The target area included the soft tissue on the buccal side and the region around the root of the third molar. Slow infiltration was then performed towards the lingual side, and an additional 0.9 mL (0.5 cartridges) of anesthesia was administered into the target area on the lingual side, which covered the mucosa adjacent to the wisdom tooth. Subsequently, using the pointed tip of a periosteal elevator, pressure was applied to the buccal and lingual sides of the gingiva to assess whether the patient felt pain, confirming the adequacy of anesthesia.

If the subject experienced pain 3 min after the first-stage anesthesia injection, an additional 0.3 mL (1/6

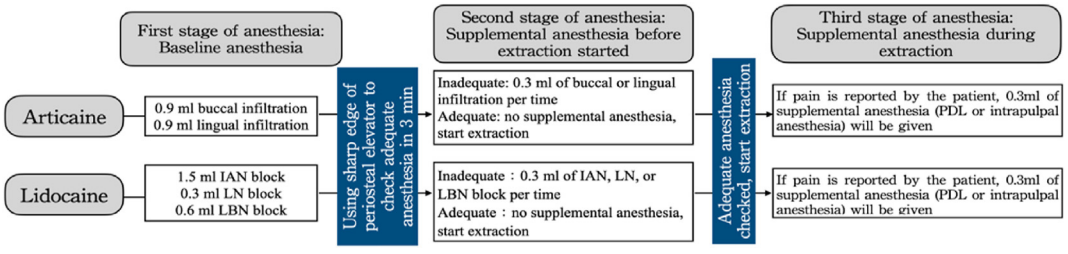

Figure 2 Standardized anesthesia protocol of this study. IAN: inferior alveolar nerve; LN: lingual nerve; LBN: long buccal nerve; PDL: periodontal ligament.

cartridge) of anesthesia was added to the area where the patient felt pain (either on the buccal or lingual side) as a supplementary second-stage anesthesia. Tooth extraction started once the same test confirmed the absence of pain. If the patient did not experience pain after the first-stage injection, a second-stage anesthesia was not administered, and tooth extraction proceeded. If the patient reported ongoing pain during the tooth extraction, supplemental anesthesia of 0.3 mL per instance was administered as a third-stage anesthesia based on the situation (such as injection into the periodontal ligament or intrapulpal injection after tooth separation and pulp exposure).

If Lidocaine was used for the block anesthesia in the first stage, the traditional Helsted approach[9] included using a total of 1.8 mL (1 cartridge) for the inferior alveolar nerve block and lingual nerve block and 0.6 mL (1/3 cartridge) for the long buccal nerve block. Similar to the Articaine procedure, pressure was applied to the buccal and lingual sides of the gingiva using the tip of a periosteal elevator to confirm anesthesia adequacy. The same protocol for supplementary anesthesia as described for Articaine was followed for Lidocaine.

Surgical protocol

One of the two surgeons who provided anesthesia performed the tooth extraction with a sterile technique. Decisions on flap reflection, bone removal, and tooth sectioning depended on factors such as depth of impaction, angle of impaction, and intraoperative findings. Extraction was performed using a high-speed drill by burr technique and buccal approach.

After surgery, the patients received detailed postoperative instructions. They were prescribed antibiotics and analgesics (Amoxicillin 250 mg every 8 h for five days, Naproxen 500 mg three times a day for five days). One week later, a follow-up appointment for suture removal was arranged. The interval between two surgeries on both sides was shorter than two months.

Parameter

Patients were connected to monitors before anesthesia to track heart rate, blood pressure, and blood oxygen saturation levels at different times: before anesthesia, immediately after anesthesia, 5 min after anesthesia, and after tooth removal. The amount of anesthetic used and operation duration were also recorded. After the extraction, participants filled out a questionnaire about pain score (Numerical Rating Scale, 0—10) and satisfaction, rated as 1(bad), 2(low), 3(acceptable), 4(good), and 5 (excellent). Any adverse effects, such as headache, dizziness, or vomiting, were recorded. Numbness or paresthesia in the lip, chin, and tongue appointment was also recorded during the follow-up visit.

Statistical analysis

This split-mouth study compared mandibular third molars of similar difficulty on the left side and right side within the same participant, and each side served as its own experimental and control group. Statistically, the Chi-square test was used to assess baseline characteristics of studies teeth, including impaction or not, depth of impaction, angle of impaction, and details of the surgical procedures (such as flap reflection or not, bone removal or not, tooth sectioning or not) for each experimental group. This ensured that the third molars were included and that the surgical procedures undertaken in the Articaine and Lidocaine groups were similar and comparable. Finally, non-parametric analysis (Wilcoxon signed-rank test) was applied to examine the safety and efficacy of the anesthetics. IBM SPSS software was used for analysis, with the statistical significance set at $P < 0.05$.

Results

Finally, we recruited 26 patients (52 mandibular third molars) for this study. The recruitment period was from March 2023 to June 2023, and the participants' ages ranged from 20 to 47 (average age of 25.6 $\pm$ 6.3). There were 14 male participants (average age of 25.6 $\pm$ 6.9) and 12 female participants (average age of 25.5 $\pm$ 5.6). Fourteen participants underwent surgery performed by CHH, while 12 underwent surgery performed by HNC.

Regarding the laterality of the studied teeth, both Articaine and Lidocaine were used in 13 left mandibular third molar extraction (50 %) and 13 right mandibular third molar extraction (50 %). Among 26 patients, 14 of them (53.8 %) underwent their first surgery using Articaine, and 12 of them (46.2 %) used Lidocaine for their first surgery. Chi-square tests indicated no significant differences between the two groups in terms of using in left side/right side or first/second surgery (*P*-values >0.05), implying similar baseline characteristics of studied teeth in two groups and little influence of these variables on the experimental results (as shown in Table 1).

This study selected bilateral wisdom teeth with similar difficulty levels upon patient inclusion (as shown in Table 1). In the Articaine group, 23 of the mandibular third molars were impacted (88.5 %), while 3 were non-impacted (11.5 %). Of the 23 impacted teeth in the Articaine group, 22 were bony impactions, and 1 was a soft tissue impaction. Similarly, the Lidocaine group also contained 23 impacted teeth and three non-impacted teeth, with 22 being bony impactions and one being a soft tissue impaction. In terms of angle and depth of impaction (Pell and Gregory's classification and Winter's classification), the Articaine group consisted of six mesial impactions (23.1 %), 13 horizontal impactions (50.0 %), and three vertical impactions (11.5 %). For the Lidocaine group, it included four mesial impactions (15.4 %), 13 horizontal impactions (50.0 %), and five vertical impactions (19.2 %). Regarding detailed surgical procedures such as flap reflection, bone removal, and tooth sectioning, the Articaine group included 23 flap reflection (88.5 %), 21 bone removal (80.7 %), and 18 tooth sectioning cases (69.2 %). The Lidocaine group had 23 flap reflection (88.5 %), 21 bone removal (80.7 %), and 16 tooth sectioning cases (61.5 %). Chi-square tests demonstrated no significant differences between the Articaine and Lidocaine groups in terms of angle and depth of impaction, flap reflection, bone removal, and tooth sectioning (*P*-values >0.05), suggesting that the characteristics of studied teeth and

Table 1 The baseline characteristics of study teeth in two groups.

	Articaine infiltration N = 26 (%)	Lidocaine block N = 26 (%)	*P*-Value
Used in			>0.99
Left side of mandible (tooth 38)	13 (50.0 %)	13 (50.0 %)	
Right side of mandible (tooth 48)	13 (50.0 %)	13 (50.0 %)	
Used in			>0.99
First surgery	14 (53.8 %)	12 (46.2 %)	
Second surgery	12 (46.2 %)	14 (53.8 %)	
Impacted tooth status			0.579
Impaction	23 (88.5 %)	23 (88.5 %)	
Non-impaction	3 (11.5 %)	3 (11.5 %)	
Pell and Gregory's classification			>0.99
Class I	11 (42.3 %)	10 (38.5 %)	
Class II	11 (42.3 %)	12 (46.2 %)	
Class III	1 (3.8 %)	1 (3.8 %)	
Non-impaction	3 (11.5 %)	3 (11.5 %)	
Pell and Gregory's classification			0.550
Position A	4 (15.4 %)	4 (15.4 %)	
Position B	19 (73.1 %)	17 (65.4 %)	
Position C	0 (0.0 %)	2 (7.7 %)	
Non-impaction	3 (11.5 %)	3 (11.5 %)	
Winter's classification			0.925
Mesial	6 (23.1 %)	4 (15.4 %)	
Horizontal	13 (50.0 %)	13 (50.0 %)	
Distal	0 (0.0 %)	0 (0.0 %)	
Vertical	3 (11.5 %)	5 (19.2 %)	
Soft tissue impaction	1 (3.8 %)	1 (3.8 %)	
Non-impaction	3 (11.5 %)	3 (11.5 %)	
Flap reflection			>0.99
Yes	23 (88.5 %)	23 (88.5 %)	
No	3 (11.5 %)	3 (11.5 %)	
Bone removal			>0.99
Yes	21 (80.7 %)	21 (80.7 %)	
No	5 (19.3 %)	5 (19.3 %)	
Tooth sectioning			>0.99
Yes	18 (69.2 %)	16 (61.5 %)	
No	8 (30.8 %)	10 (38.5 %)	

$P < 0.05$ means statistical significance.

detailed surgical procedures would minimally influence the outcome.

Heart rate, blood pressure, and oxygen saturation

Heart rates increased gradually in both groups from pre-injection to post-injection and then stabilized after tooth removal (Fig. 3). The maximum heart rate change was significantly higher in the Articaine group (16.5 ± 7.7 beats per minute) than in the Lidocaine group (12.8 ± 6.6 beats per minute) ($P = 0.022$). However, no patients experienced symptoms of tachycardia or bradycardia during or after surgery.

Systolic blood pressure showed a similar trend to heart rate, with gradual increases from pre-injection to post-injection and then a decline after tooth removal (Fig. 4). There was no significant difference in maximum systolic blood pressure change between the Articaine group (12.7 ± 7.1 mmHg) and the Lidocaine group (12.8 ± 4.2 mmHg) ($P = 0.686$).

Diastolic blood pressure changes showed divergent trends, with the Articaine group showing an increasing trend similar to systolic blood pressure and the Lidocaine group showing a decreasing trend (Fig. 5). However, no significant difference was found in maximum diastolic blood pressure change between the two groups (Table 2).

Oxygen saturation remained between 99 % and 100 % on average with minimal fluctuations (Fig. 6), and there was no significant difference between the groups in terms of maximum saturation fluctuation (Table 2).

Amount of anesthetic used.

Regarding the amount of anesthetic used, the Articaine group used an average of 1.5 ± 0.4 cartridges, whereas the Lidocaine group used 2.2 ± 0.5 cartridges ($P < 0.001$), indicating a statistically significant difference (Table 3). In the Articaine group, 73.1 % (19/26) of the patients required fewer than 1.5 cartridges for the tooth extraction, while in

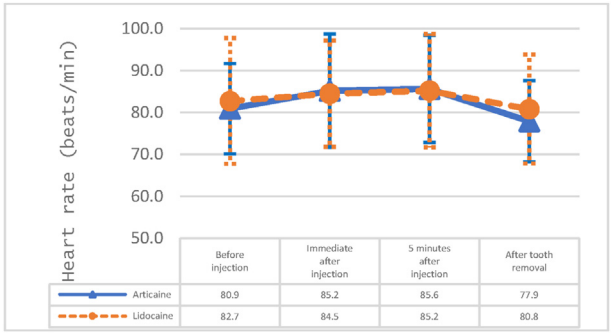

Figure 3 Heart rate variations of participants at four time points.

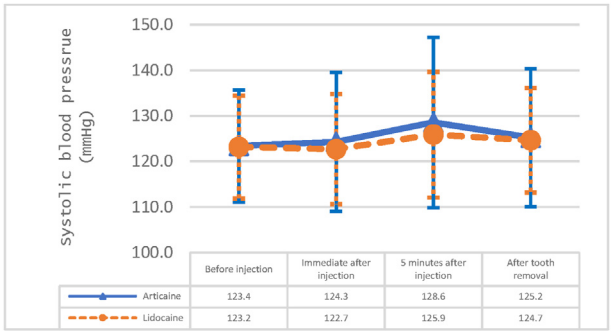

Figure 4 Systolic blood pressure variations of participants at four time points.

the Lidocaine group, only 3.8 % (1/26) used fewer than 1.5 cartridges for the extraction (Fig. 7).

Pain, satisfaction, and operation duration

Regarding pain control efficacy, the Articaine group had an average pain score of 2.4 ± 1.9, while the Lidocaine group had a score of 2.4 ± 1.4 ($P = 0.986$), indicating no statistically significant difference between the two groups. Similarly, satisfaction ratings were not significantly different, with the Articaine group at 3.8 ± 1.0 and the Lidocaine group at 3.8 ± 1.0 ($P = 0.985$). The operation duration was 16.7 ± 10.9 min for the Articaine group and 17.7 ± 10.2 min for the Lidocaine group ($P = 0.594$), with no significant difference (Table 3).

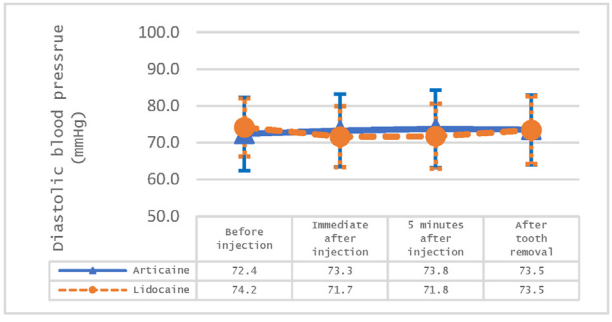

Figure 5 Diastolic blood pressure variations of participants at four time points.

Adverse events

No adverse events occurred in either group during the lower wisdom tooth surgery, such as headache, dizziness, vomiting, nausea, rapid heartbeat, shortness of breath, or abnormal sensations or numbness in the lower lip, chin, and tongue.

Discussion

In terms of cardiovascular stability, there were no significant differences in vital signs (including heart rate, systolic blood pressure, diastolic blood pressure, and blood oxygen saturation) between the two groups at four measurement time points (pre-injection, post-injection, 5 min after injection, and after tooth extraction), as well as in maximum value changes. Except for the maximum heart rate fluctuation during surgery, which was significantly higher in the Articaine group (16.5 ± 7.7 beats per minute) than in the Lidocaine group (12.8 ± 6.6 beats per minute) ($P = 0.022$), no patients experienced symptoms of tachycardia or bradycardia during or after the surgery. The differences were relatively small, and their clinical significance might be limited. Despite the Lidocaine group using inferior alveolar nerve block anesthesia, which has a higher chance of intravascular injection or potential cardiovascular impact due to its proximity to larger vessels (inferior alveolar vessels), this study did not observe significant differences in heart rate, blood pressure, and blood oxygen saturation values between the two groups. Similarly, the Articaine group did not show more stable heart rates, blood oxygen levels, or blood pressures due to buccal-lingual infiltration anesthesia.

Furthermore, no adverse events were observed, including symptoms like palpitations, headaches, chest pain, numbness of the lower lip, or abnormal tongue sensations. In this study, the buccal-lingual infiltration anesthesia used for lower wisdom teeth with Articaine was administered in a position near the lingual nerve. Yet, no cases of abnormal tongue sensation occurred. Past anatomical and imaging studies by Kiesselbach and Miloro have found anatomical variations in the relationship between the lingual nerve and the lower third molar among different patients. On average, the lingual nerve is located about 2.28–2.75 mm below the crest of the lingual plate and 0.58–2.53 mm inward. There is approximately a 10–15 % chance that the position of the lingual nerve will be higher than the crest of the lingual plate and around a 25 % chance that it will directly contact the lingual plate or the dental follicle of the wisdom tooth.[10,11] In the 26 cases of buccal-lingual infiltration anesthesia with Articaine in this study, no cases of lingual nerve anesthesia were observed. However, cautious and slow administration of anesthesia is still necessary during the procedure to avoid potential nerve needle injuries and the possible nerve toxicity of the anesthetic, which could result in neurosensory damage to the lingual nerve.

Regarding efficacy parameters, the designed dose of initial anesthesia injection differed between the two groups. In the Articaine group, one cartridge of anesthesia (1.8 mL) was administered for buccal-lingual infiltration anesthesia,

Table 2 The heart rate, systolic blood pressure, diastolic blood pressure, oxygen saturation, and maximal intraoperative fluctuation of the two groups.

	Anesthetics and technique				*P*-Value
	Articaine infiltration		Lidocaine block		
	Mean	Standard deviation (SD)	Mean	Standard deviation (SD)	
Heart rate (beats/min)					
Before anesthesia	80.9	10.8	82.7	15.0	0.501
Immediate after anesthesia	85.2	13.5	84.5	13.0	0.959
5 min after anesthesia	85.6	12.8	85.2	14.0	0.656
After tooth removal	77.9	9.7	80.8	13.0	0.206
Maximal fluctuation	16.5	7.7	12.8	6.6	0.022*
Systolic blood pressure (mmHg)					
Before anesthesia	123.4	12.3	123.2	11.3	0.959
Immediate after anesthesia	124.3	15.3	122.7	12.2	0.668
5 min after anesthesia	128.6	18.7	125.9	13.8	0.886
After tooth removal	125.2	15.0	124.7	11.4	0.753
Maximal fluctuation	12.7	7.1	12.8	4.2	0.686
Diastolic blood pressure (mmHg)					
Before anesthesia	72.4	10.0	74.2	7.9	0.331
Immediate after anesthesia	73.3	9.9	71.7	8.3	0.402
5 min after anesthesia	73.8	10.5	71.8	8.8	0.373
After tooth removal	73.5	9.5	73.5	9.2	0.786
Maximal fluctuation	9.5	4.5	9.3	6.0	0.840
Oxygen saturation (%)					
Before anesthesia	99.1	1.0	99.3	0.8	0.308
Immediate after anesthesia	99.3	0.7	99.4	1.0	0.715
5 min after anesthesia	99.4	0.8	99.4	0.6	0.819
After tooth removal	99.3	0.8	99.4	0.8	0.518
Maximal fluctuation	0.7	0.8	0.8	1.0	0.659

*$P < 0.05$ means statistical significance.

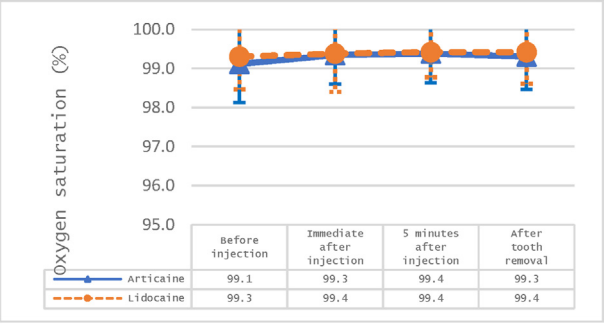

Figure 6 Oxygen saturation variations of participants at four time points.

while the Lidocaine group received one cartridge of anesthesia (1.8 mL) for inferior alveolar nerve and lingual nerve blocks, and 0.3 cartridge (0.6 mL) for long buccal nerve block. Additionally, depending on the intra-operative situation and the patient's response, 0.3 mL of anesthesia was supplemented during the surgery for the second and third stages of anesthesia. This study showed a significant difference in anesthesia dosage between Articaine and Lidocaine (1.5 ± 0.4 cartridges vs. 2.2 ± 0.5 cartridges, $P < 0.001$). This demonstrated that when using Articaine anesthesia, the dosage can be reduced by around 25 %.

Furthermore, in the Articaine group, 73.1 % (19/26) of cases required a dosage of 1.5 cartridges or less to complete the tooth extraction. In contrast, in the Lidocaine group, only 3.8 % (1/26) of cases needed 1.5 cartridges or less to complete the procedure (Fig. 7). This revealed that despite the Lidocaine group initially receiving a higher dosage (1.3 cartridges), most cases still required an additional dose of anesthetic for pain control to complete the tooth extraction. On the other hand, although the initial anesthesia dosage in the Articaine group was lower (1 cartridge), the additional dosage needed was not as much as in the Lidocaine group, suggesting that the actual required anesthesia dose might indeed be lower in the Articaine group compared to the Lidocaine group.

Other parameters, such as operation time (16.7 ± 10.9 min vs. 17.7 ± 10.2 min, $P = 0.594$), pain score (2.4 ± 1.9 vs. 2.4 ± 1.4, $P = 0.986$), and satisfaction (3.8 ± 1.0 vs. 3.8 ± 1.0, $P = 0.985$), were comparable and showed no significant differences in the Articaine and Lidocaine groups. This indicated that using the buccal-lingual infiltration anesthesia approach with Articaine in lower wisdom tooth extraction procedures could achieve anesthesia effectiveness similar to using Lidocaine for nerve blocks while reducing the amount of anesthetics required.

Two main factors likely influenced why Articaine demonstrated such a superior outcome. First, compared to

Table 3 The amount of anesthetic, operation time, pain score, and satisfaction of two groups.

	Anesthetics and technique				*P*-Value
	Articaine infiltration		Lidocaine block		
	Mean	Standard deviation (SD)	Mean	Standard deviation (SD)	
Amount of anesthetic (cartridges)	1.5	0.4	2.2	0.5	<0.001*
Operation time (minutes)	16.7	10.9	17.7	10.2	0.594
Pain score[a]	2.4	1.9	2.4	1.4	0.986
Satisfaction[b]	3.8	1.0	3.8	1.0	0.985

*$P < 0.05$ means statistical significance.
[a] Pain score: NRS (Numerical rating scale), from 0 to 10.
[b] Satisfaction: 1(bad), 2(low), 3(acceptable), 4(good), and 5 (excellent).

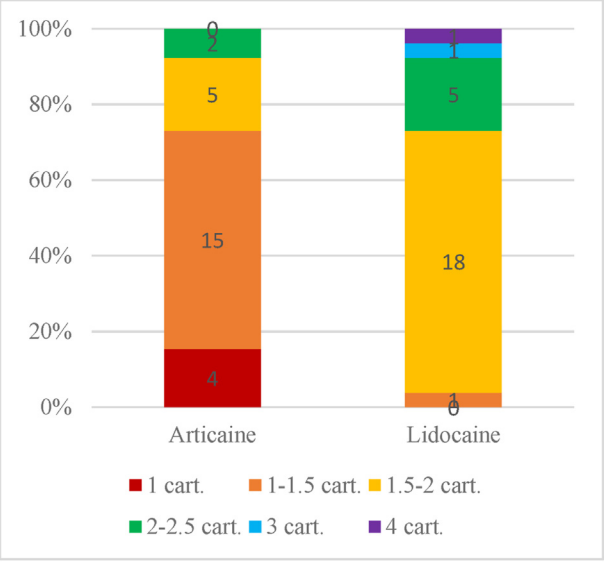

Figure 7 The amount of local anesthetic used. Cart: cartridges.

Lidocaine, Articaine possesses higher potency and exceptional diffusion ability through tissue due to its higher lipid solubility and unique chemical structure. This characteristic could contribute to its ability to achieve adequate pain control by simple infiltration anesthesia in the posterior mandible, which consists of thick cortical bone and dense cancellous bone. Second, the thickness of buccal and lingual plates around the third molars. Most lower wisdom teeth have a thin lingual plate, and the overall tooth position is relatively close to the lingual plate. This proximity allows the anesthetic to effectively penetrate the surrounding bone and periodontal ligament, increasing the chances of achieving anesthesia through lingual infiltration. Conversely, relying solely on buccal infiltration might not achieve a similar effect. However, this assumption requires further research to provide more conclusive evidence.

A study by Ge et al., in 2016 involving cone-beam computed tomography analysis of 110 cases of deeply impacted or completely impacted lower wisdom teeth found that in 87.3 % of cases, the teeth were positioned more towards the lingual side, while only 1.8 % were more towards the buccal side.[12] This suggests that the lingual infiltration approach might be critical, as the lingual bone plate is often thinner in most cases, making lingual infiltration more effective for tooth anesthesia. Similarly, cases, where teeth are positioned centrally, might present challenges in achieving effective penetration of anesthesia around the tooth, which could affect the success rate of infiltration anesthesia.

While this study demonstrated that using 4 % Articaine for buccal-lingual infiltration anesthesia in mandibular third molar extraction procedures can achieve results similar to using 2 % Lidocaine for nerve blocks, it is essential to note that not all patients might be suitable for this type of anesthesia technique. Some cases in this study required higher doses of Articaine for effective anesthesia. This might be due to factors such as the tooth being positioned centrally or having a thicker surrounding bone, making pure infiltration anesthesia less effective. In these cases, an inferior alveolar nerve block might be considered. Conversely, there might be cases where nerve block anesthesia with Lidocaine is not as successful, possibly due to anatomical variations or technical challenges. In such cases, using Articaine for supplementary infiltration anesthesia could be considered.

In conclusion, this clinical study demonstrated that using 4 % Articaine for buccal-lingual infiltration anesthesia resulted in similar pain control to using 2 % Lidocaine for inferior alveolar nerve block anesthesia. Articaine required nearly 25 % less anesthetic dosage while maintaining similar safety performance and no reported cases of nerve damage, reflecting that Articaine possesses higher potency and concentration. Therefore, in the mandibular third molar extraction, infiltration anesthesia by Articaine is a suitable, less invasive alternative to block anesthesia by Lidocaine.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Acknowledgments

This study was supported by the Department of Medical Research, National Taiwan University Hospital (113-CTC0021), and the Ministry of Health and Welfare (MOHW113-TDU-B-211-114006).

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