Original Article

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Retrospective comparison of articaine buccal infiltration and lidocaine intraosseous anesthesia in carious mandibular molars

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Background: It is vital to identify more efficient anesthesia techniques for the restorative or endodontic treatment of mandibular molars. Both articaine buccal infiltration anesthesia (ABI) and lidocaine inferior alveolar nerve block anesthesia (LIANB) may not provide profound anesthesia, necessitating supplementary anesthesia. This study aimed to investigate whether lidocaine intraosseous lidocaine intraosseous anesthesia (LIO) is more suitable than ABI as primary anesthesia for caries treatment of mandibular molars.
Methods: This study retrospectively analyzed patients treated for advanced caries according to the International Caries Detection and Assessment System (ICDAS) 5 and 6. The study involved 48 patients, split evenly between those receiving ABI and LIO, and examined the anesthesia success rate, pain during anesthesia, onset time, duration, and post-anesthesia lower lip numbness using Chi-square and Independent T-tests.
Results: In the ABI group, 17 patients (70.8%) did not require additional anesthesia, whereas all 24 patients (100%) in the LIO group did not require additional anesthesia ($P < 0.001$). ABI was associated with significantly higher pain during anesthesia, slower onset time, and longer duration of anesthesia than LIO. There was no significant difference in post-anesthesia lower lip numbness between the two methods.
Conclusion: Intraosseous anesthesia using lidocaine is more effective for treating severe caries in the mandibular molars because of its higher success rate, decreased pain during anesthesia, faster onset, and shorter recovery time.

Keywords: Articaine; Dental Caries; Lidocaine; Local Anesthesia.

INTRODUCTION

Mandibular molars are surrounded by dense alveolar bone, which poses challenges for achieving complete anesthesia [1]. This difficulty is particularly pronounced in cases of advanced caries corresponding to International Caries Detection and Assessment System (ICDAS) 5 and 6, where decay extends into the inner 1/3 of the dentin, close to the pulp [1-3]. Achieving profound anesthesia with buccal and lingual infiltrations of lidocaine alone during conservative or endodontic treatments is difficult. Inappropriate levels of anesthesia may lead to treatment interruption, repeated anesthesia, prolonged treatment times, and patient dissatisfaction. Therefore, efficient anesthesia for mandibular molars during caries treatment remains a concern [4,5].

Despite its technical challenges and longer anesthesia times compared to infiltration anesthesia, many practitioners prefer inferior alveolar nerve block (IANB)

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for deep anesthesia of the mandibular molars [6,7]. Studies comparing articaine buccal infiltration (ABI) with lidocaine inferior alveolar nerve block (LIANB) have reported varying success rates. While Monteiro et al. found ABI success rates of 40%, surpassing LIANB's 10% for irreversible pulpitis, Ali et al. and Jung et al. reported similar success rates (53.8% and 54% for ABI vs. 61.5% and 43% for LIANB) [8-10]. Regardless of which anesthesia method is deemed more effective, it is crucial to consider supplemental anesthesia in both approaches to ensure a sufficient anesthetic effect [11].

Intraosseous anesthesia (IO) is important because of its rapid and profound effects [12]. However, its invasive nature, which involves cortical bone drilling, limits its primary use in routine dental practice [13]. Consequently, intraosseous injection is often considered a supplemental method to enhance pulpal anesthesia [11]. Recently, a computer-controlled intraosseous anesthesia device, the Quicksleeper5® system (DHT, Cholet, France), has been introduced. It employs a 30-gauge short Aiguilles® needle (DHT, Cholet, France) to penetrate through the alveolar bone in the attached gingiva of the interdental area, enabling direct injection into the bone marrow [14-16]. This leads to a less technique-sensitive process with controlled constant injection associated with a high success rate and reduced pain. However, intraosseous anesthesia has a shorter duration when used as a primary injection; therefore, its suitability for restorative treatment needs to be assessed [13].

No studies have compared the ABI and lidocaine intraosseous anesthesia (LIO) in the mandibular molars. An evaluation is needed to determine whether ABI or LIO is appropriate for anesthetizing a mandibular single molar tooth that requires caries treatment, as opposed to using a block anesthesia technique that numbs multiple teeth along the nerve pathway. This study aimed to compare the success rate, pain levels during anesthesia, onset, duration, and post-anesthesia lower lip numbness between the ABI and LIO for caries treatment (resin restoration, inlay restoration, and root canal treatment) of the mandibular first and second molars.

METHODS

1. Study design and patient selection

This retrospective study was conducted under Seoul National University Bundang Hospital (SNUBH) IRB approval (IRB No.: B-2403-891-103). The requirement for written informed consent from patients was waived, as all clinical data were sourced from the medical record and personal patient information was anonymized. No personal information of any patient was involved in using these data, in accordance with the Declaration of Helsinki for confidentiality and ethical standards. From May 1, 2021, to February 29, 2024, patients who visited the Department of Conservative Dentistry for the treatment of caries in the mandibular first and second molars were included in the study. The inclusion and exclusion criteria are presented in Table 1. Based on the extent of the caries, either direct or indirect restoration, or root canal treatment was performed using one of the anesthesia methods, either ABO or LIO. When the Quicksleeper5® system was available, LIO was used; otherwise, ABO was

Table 1. Inclusion/exclusion criteria

Inclusion criteria	Exclusion criteria
1) Teeth exhibiting extensive caries corresponding to ICDAS 5 and 6	1) Teeth with EPT negative
2) Showing positive responses in two EPT sessions	2) Presence of periapical lesions or tumors
3) Administration of local anesthesia by ABI or LIO	3) Those who had taken analgesics for tooth pain
4) Age > 19 years	4) Patients requiring treatment for more than one tooth
	5) Those who received block anesthesia
	6) Individuals with any neurologic syndrome or symptoms.

ABI, articaine buccal infiltration; EPT, electric pulp testing; LIO, lidocaine intraosseous; ICDAS, international caries detection and assessment system.

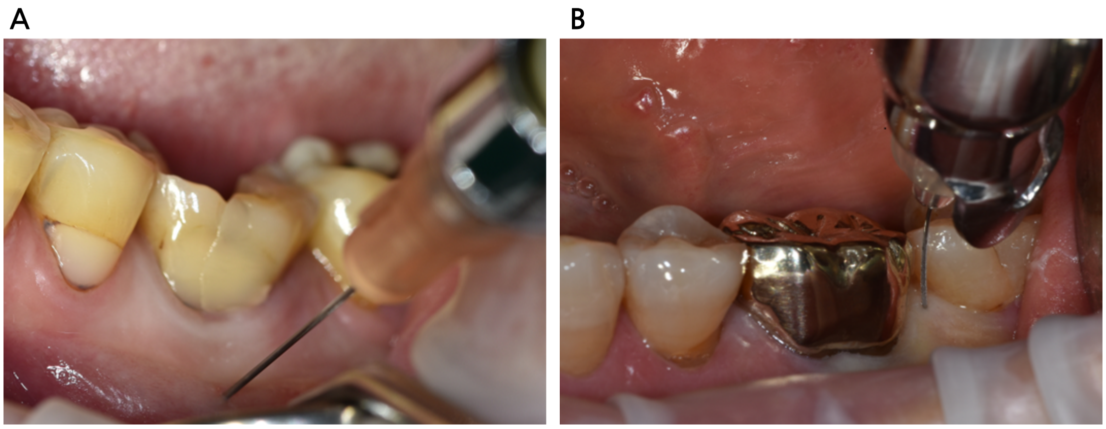

Fig. 1. Anesthesia methods: (A) Articaine buccal infiltration. With a dental syringe, the 30-gauge needles were inserted at the point bisecting the line connecting the apices of the mesial and distal roots. (B) Lidocaine Intraosseous injection. A short needle (16 mm, 30-gauge) was injected into the mesial or distal interdental alveolar bone using Quicksleeper5®

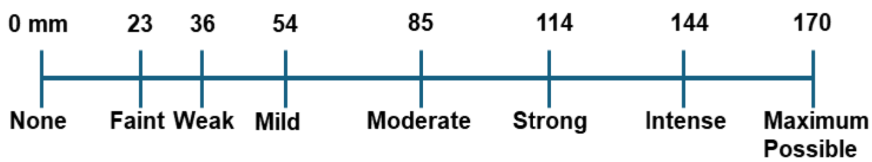

Fig. 2. Heft-Parker Visual Analogue Scale (VAS): Patients were asked to assess their pain levels using the Heft-Parker VAS specifically to evaluate the discomfort experienced from both needle insertion and anesthesia injection.

employed for the treatment of caries in the mandibular molars. The choice of the anesthesia method did not consider patient compliance or previous dental experience. A retrospective analysis was conducted using medical records that documented the type of anesthesia, anesthetic agents, and anesthetic effects observed during treatment.

2. Anesthesia methods

For ABI anesthesia (Fig. 1A), one cartridge (1.8 mL) of 4% articaine with 1:100,000 epinephrine(epi.) (Huons, Pangyo, Korea) was injected into the buccal mucosa adjacent to the tooth for 4 min using a dental syringe. The 30-gauge needles (J. Morita Corp., Osaka, Japan) were inserted at the point bisecting the line connecting the apices of the mesial and distal roots.

For LIO anesthesia (Fig. 1B), one cartridge (1.8 mL) of 2% lidocaine with 1:100,000 epi. (Huons, Pangyo, Korea) was injected into the mesial or distal interdental alveolar bone using a device called Quicksleeper5® with a 30-gauge Aiguilles needle for 4 min. The decision to inject into the mesial or distal roots was based on the area with a wider interproximal bone space observed on the periapical radiographs.

3. Data collection procedures

1) Gender, Age, Tooth position, ICDAS classification
2) Vitality status of the tooth before anesthesia: assessed for vital teeth only
3) Anesthesia method: ABI or LIO
4) Pain level during anesthesia (Heft-Parker Visual Analog Scale [VAS]) (Fig. 2): After treatment, the patient was shown the Heft-Parker VAS and asked to select the level of pain they experienced during anesthesia. With 0 representing no pain and 170 representing extreme pain, the level of pain intensity between these two points was explained to the patient, who was asked to select an appropriate level.
5) Onset: time taken for 64 readings on the electric pulp tester (EPT; PARKELL, Edgewood, NY, USA) at 1, 3, 5, 7, and 9 min after anesthesia.
6) Need for additional anesthesia: Periodontal anesthesia with 2% lidocaine containing 1:100,000 Epi. was

Table 2. General and teeth-related characteristics according to the anesthesia method

Variable		ABI M (SD) / N (%)	LIO M (SD) / N (%)	χ^2 / t	P
Age		46.07 (17.79)	49.71 (18.10)		
Gender	Male	8 (33.3)	11 (45.8)		
	Female	16 (66.7)	13 (54.2)		
ICDAS classification	5	14 (58.3)	18 (75.0)	1.50	.221
	6	10 (41.7)	6 (25.0)		
Tooth number (FDI system)	#36	8 (33.3)	10 (41.7)	2.31†	.678
	#37	7 (29.2)	5 (20.8)		
	#38	1 (4.2)	0 (0)		
	#46	2 (8.3)	4 (16.7)		
	#47	6 (25.0)	5 (20.8)		

†Fisher's exact test
ABI, articaine buccal infiltration; FDI, fédération dentaire internationale; ICDAS, international caries detection and assessment system; LIO, lidocaine intraosseous; M, median; N, number; P, P-value; SD, standard deviation.

Table 3. Difference in success rate according to the anesthesia method

Variable		ABI N (%)	LIO N (%)	χ^2	P
Additional anesthesia	No	17 (70.8)	24 (100)	8.20†	.009*
	Yes	7 (29.2)	0 (0)		

†Fisher's exact test
*Significant P value at 0.05.
ABI, articaine buccal infiltration; LIO, lidocaine intraosseous; N, number.

administered if the tooth remained positive on EPT after 9 min.

7) Occurrence of pain requiring additional anesthesia during treatment, even after starting with EPT-negative teeth
8) Post-anesthesia lower lip numbness
9) Time until complete anesthesia resolution: time taken for sensation to return to normal after post-anesthesia numbness
10) Whether there were complaints of increased heart rate

4. Statistical analysis

Data were analyzed using SPSS (version 27.0; IBM Corp., Armonk, NY). Chi-square tests (or Fisher's exact test) and t-tests were used to assess homogeneity in general characteristics and tooth-related features. Differences in success rates, pain during anesthesia, onset time, total duration, and soft tissue numbness according to the anesthesia method were also analyzed using chi-square (or Fisher's exact) and t-tests. Statistical significance was set at $P < 0.05$.

RESULTS

1. General and teeth-related characteristics

The study included 48 patients and teeth, evenly divided into ABI and LIO groups, with mean ages of 46.07 years (ABI) and 49.71 years (LIO), respectively. Both groups had similar sex distributions, with most participants in each group classified as having ICDAS 5 caries classification. The left mandibular first molar was the most common in both groups. Overall, there were no significant differences in demographic or dental-related characteristics between the two groups, indicating homogeneity (Table 2).

2. The local anesthesia success rates for LIO and ABI

The success rates of the anesthesia methods that resulted in unpainful treatment without supplemental anesthesia were compared. As shown in Table 3, 17 individuals (70.8%) in the ABI group did not require

Table 4. Difference in pain during anesthesia

Group	N	Pain during anesthesia	
		M ± SD	t (P)
ABI	24	32.0 ± 18.6	2.9 (.006)*
LIO	24	17.3 ± 17.3	

*Significant P value at 0.05.
ABI, articaine buccal infiltration; LIO, lidocaine intraosseous; M, median; N, number; P, P-value; SD, standard deviation.

Table 5. Difference in anesthesia onset time according to the anesthesia method

Variable		ABI N (%)	LIO N (%)	χ^2	P
Onset time	1 min	3 (12.5)	22 (91.7)	33.3	< .001*
	3 min	6 (25.0)	0 (0)		
	5 min	8 (33.3)	1 (4.2)		
	7 min	1 (4.2)	1 (4.2)		
	failure	6 (25.0)	0 (0)		

*Significant P value at 0.05.
ABI, articaine buccal infiltration; LIO, lidocaine intraosseous; N, number; P, P-value.

Table 6. Difference in the duration of anesthesia according to the anesthesia method

Group	N	Duration of anesthesia	
		M ± SD	t (P)
ABI	24	231.3 ± 79.7	5.8 (< .001)*
LIO	24	118.6 ± 52.2	

*Significant P value at 0.05.
ABI, articaine buccal infiltration; LIO, lidocaine intraosseous; M, median; N, number; P, P-value; SD, standard deviation.

additional anesthesia, while all of 24 individuals in the LIO group (100%) did not require additional anesthesia, which was a significant difference ($\chi^2 = 8.20$, $P < 0.01$). The seven patients requiring additional anesthesia included six patients with a positive EPT response after 9 min and one patient who experienced discomfort despite a negative response on the pulp tester.

3. Differences in pain, onset time, and duration of anesthesia between LIO and ABI

The pain levels during anesthesia and the onset and duration of anesthesia were evaluated to compare the effectiveness of each anesthesia method. Using the Heft-Parker VAS, the pain experienced during anesthesia in the ABI group was 32.0 (± 18.6), whereas in the LIO group, it was 17.3 (± 17.3) (Table 4). The ABI group showed significantly higher pain during anesthesia than the LIO group ($t = 2.9$, $P < 0.01$). In terms of onset time (Table 5), in the ABI group, anesthesia onset occurred in eight individuals (33.3%) at 5 min, six individuals (25.0%) at 3 min or failed, three individuals (12.5%) at 1 min, and one individual (4.2%) at 7 min. Conversely, in the LIO group, the majority (91.7%) experienced anesthesia onset at 1 min, showing a significant difference in these proportions ($\chi^2 = 33.3$, $P < 0.001$). Lastly, for comparing anesthesia duration (Table 6), the ABI method lasted for 231.3 minutes (± 79.7 minutes), whereas the LIO method lasted for 118.6 minutes (± 52.2 minutes), which was significantly shorter ($t = 5.8$, $P < 0.001$).

4. Comparison of post-anesthesia lower lip numbness between LIO and ABI

Post-anesthesia lower lip numbness, a common discomfort resulting from mandibular tooth anesthesia, was reported by all individuals (100%) in the ABI group and 83.3% in the LIO group. Despite the administration of LIO injections into the bone marrow, a notable percentage of the participants experienced lower lip numbness, with

Table 7. Difference in the occurrence of soft tissue anesthesia according to the anesthesia method

Variable		ABI N (%)	LIO N (%)	χ^2	P
Post-anesthesia lower lip numbness	No	0 (0)	4 (16.7)	4.36†	.109
	Yes	24 (100)	20 (83.3)		

†Fisher's exact test
ABI, articaine buccal infiltration; LIO, lidocaine intraosseous; N, number; P, P-value.

no statistically significant differences observed.

5. Effects of LIO and ABI on heart rate

In the LIO group, 8.33% (2 of 24 individuals) reported an increased heart rate, whereas no complaints were observed in the ABI group. The elevated heart rate returned to the baseline within minutes.

DISCUSSION

LIO guarantees a higher anesthesia success rate than the ABI by achieving comprehensive anesthesia and eliminating the need for supplementary anesthesia (Table 7). A study evaluating the efficacy of intraosseous injection using 2% lidocaine (1:100,000 epinephrine) as the primary anesthetic method for mandibular molars with irreversible pulpitis found a higher success rate of 87%, surpassing the reported 60% success rate of IANB [12]. Similarly, another study demonstrated a 74% success rate for intraosseous injection [17]. Many intraosseous anesthesia studies have reported high success rates [18,19], which was also confirmed in our study. Our study achieved 100% success with enhanced control and precision of intraosseous anesthesia using the QuickSleeper5® anesthesia device.

In contrast, ABI showed a lower success rate, requiring additional anesthesia, than LIO. The success rate of the ABI was 70.8%, which is similar to that reported in previous studies approximately 65% [20]. Recent studies have compared the success rates of ABI and LIANB in the treatment of irreversible pulpitis in mandibular molars. According to a study, ABI has been reported to have a success rate ranging from 64.5% to 70.4%, which is not significantly different from the success rate of lidocaine IANB, which ranges from 55.6% to 69.2% [20,21]. While ABI shows success rates comparable to those of IANB, it remains less efficient than intraosseous anesthesia, necessitating adjunctive anesthesia [22]. Nevertheless, buccal infiltration anesthesia is considered less invasive and simpler compared to techniques like intraosseous, as it does not involve cortical bone perforation, making it a less invasive option. Therefore, in the absence of a specialized anesthetic device for bone penetration, ABI can be considered for mandibular molar treatment instead of IANB.

The pain during local anesthetic deposition was significantly lower in the LIO group than in the ABI group. The primary cause of pain during anesthesia is attributed to the speed of injection [23,24] In the case of LIO, a slower and more controlled speed of deposition using Quicksleeper5® is possible, which can result in a reduced level of pain experienced by the patient. Furthermore, the patients did not report any specific discomfort during drilling under intraosseous anesthesia. This can be attributed to the technique of applying infiltration anesthesia to the drilling site with approximately 1/4 of an ampoule before drilling rather than immediately proceeding with drilling. Additionally, the use of thin needles rotating at high speed (15,000 rpm) for anesthesia further contributed to the absence of discomfort after the numbness wore off [14,15]. This study revealed no instances of discomfort at the injection site in patients with LIO. However, although ABI resulted in significantly higher pain than LIO, it was still manageable, especially considering the slow injection rate of 0.45 ml/min.

The efficacy of each method was evaluated based on onset and duration. Traditional intraosseous anesthesia is known for its rapid onset and short duration [11]. Vongsavan et al. reported a mean onset of IO of 2.4 minutes and mean duration of 38 min [25]. In our study, 91.7% of the patients with intraosseous anesthesia showed no response to the electric pulp tester after 1 min of anesthesia. Conversely, there were only three instances in which anesthesia was achieved within one minute with an ABI. According to a study investigating the buccal infiltration of 4% articaine or 2% lidocaine into the mandibular first molar, the time to achieve negative EPT readings was significantly faster with articaine, 4.2 minutes, than with lidocaine, which took 7.7 minutes [22]. The authors speculated that the higher lipid solubility of articaine, attributed to its benzene ring rather than its thiophene ring, allowed it to penetrate nerve cell lipid membranes more effectively. In our study, although 70.8% of patients achieved a negative reading on EPT within 5 min, this was significantly slower than intraosseous injection of lidocaine, which involves direct injection into the bone marrow. Consequently, the choice of anesthetic method plays a more crucial role in achieving faster anesthesia than the specific anesthetic used.

When measuring the time taken for anesthesia to wear off, articaine had an average duration of 231.25 minutes, while lidocaine took 118.63 minutes a significantly shorter time. According to previous studies, both articaine and lidocaine buccal infiltration anesthesia demonstrated recovery from pulpal anesthesia starting at approximately 25 to 30 min [21,26]. We retrospectively analyzed the anesthetic methods used in the treatment of mandibular molars based on medical record data. Unlike conventional randomized clinical trials, regular EPT was not conducted during anesthesia at post-injection intervals to record the time necessary for the recovery of pulpal sensory function, as indicated by the return of a positive response. Instead, the total duration of anesthesia was calculated based on the patients' recollection of the time when the sensation in their lips returned to normal, which they reported during their subsequent follow-up visits. Therefore, our results indicate that the mean total duration until the patients' subjective numbness wore off was 231.25 minutes, which was much longer than that of LIO.

Between the two anesthesia methods, there was an insignificant difference in post-anesthesia lower lip numbness . In the case of the ABI, 100% of the participants exhibited subjective post-anesthesia lower lip numbness, which is consistent with the findings of previous studies. According to these studies, when buccal infiltration was performed, the anesthetic solution spread through the mental foramen, leading to numbness in the lower region. Although the percentage of lower lip numbness decreases as the distance from the mental foramen increases, it still affects this area [21,27]. In a study on the efficacy of primary intraosseous injection of lidocaine in the mandibular first molar, 58% of the patients reported experiencing subjective numbness in the lower lip [19]. In our study, the LIO group showed 83.3% post-anesthesia lower lip numbness. The observation of a trend toward post-anesthesia lower lip numbness even in cases where only intraosseous anesthesia was administered, is noteworthy and deserves attention.

In this study, only two individuals (8.33%) complained of an increased heart rate during LIO, which differs from the findings of previous studies. According to Replogle et al., LIO containing 1:100,000 epi. was administered for 2 min, an increase in heart rate was observed in 67% of cases [28]. Another study reported that during a fast LIO injection (45 s), there was an increase in the heart rate, ranging from an average of 21 to 28 beats/min, whereas during a slow injection (4 min and 45 s), the heart rate increased from 10 to 12 beats/min. It has been suggested that an increase of approximately 10 beats/min is necessary for patients to subjectively perceive an increase in heart rate [29]. In our study, LIO anesthesia was administered over 4 min at a slow and controlled injection speed. Therefore, it is assumed that the frequency of subjective perception by patients with an increased heart rate would have been reported less frequently. Further research should be conducted using electrocardiogram monitoring for a more objective assessment.

The invasiveness typically associated with traditional intraosseous anesthesia can be mitigated to some extent by the development of new intraosseous anesthesia devices. However, in situations where barriers exist such as the cost of anesthesia equipment, ABI anesthesia may be considered an alternative. In such cases, it is essential to wait for anesthesia to take full effect, and if adequate anesthesia is not achieved, additional methods, such as supraperiosteal anesthesia, should be considered. Furthermore, to reduce potential selection bias and objectively evaluate the effects of different anesthetic methods, a randomized controlled trial is required. It would also be worthwhile to compare the effectiveness of these anesthesia methods based on the pulpal condition of the mandibular molars, such as in cases of reversible or irreversible pulpitis.

In conclusion, by comparing the two anesthesia methods, ABI and LIO, we aimed to propose a more effective and reliable anesthesia technique for the treatment of caries in mandibular molars. Within the limitations of this retrospective study, LIO significantly outperformed ABI in the mandibular molars, marked by a higher success rate without the need for additional anesthesia, less pain during administration, quicker onset, and shorter duration. While ABI may still serve as an alternative when LIO is not available, careful consideration of the potential need for supplementary anesthesia and patient management is required for effective outcomes.

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Bokyung Shin: Satistical analysis, Writing-review
Ji-Young Yoon: Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing

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