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Articaine anesthesia in Dentistry: Articaine vs Lidocaine in Root Canal Treatment : A randomized controlled trial

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Abstract: Background: ***Objective:*** To compare the clinical efficacy, and patient-reported outcomes of 4% Articaine versus 2% Lidocaine as local anesthetics in patients undergoing root canal treatment (RCT) for pulpitis in mandibular molars. ***Methods:*** This study was conducted at Department of Endodontics, Bakhtawar Amin Dental College, Multan from February 2025 to July 2025. A total of 160 patients diagnosed with symptomatic irreversible pulpitis in mandibular molars were randomly assigned to two groups: one group received Articaine HCl 4% with (100,000) epinehphrine and other group received Lidocaine HCl 2% (100,000) epinehphrine for local anesthesia. Both anesthetics were administered using standard infiltration techniques. The primary outcome measures was the success of anesthesia (measured by the absence of pain during treatment). Secondary outcomes included the patient reported incidence of postoperative pain (measured at 6, 12, and 24 hours post-procedure). ***Results;*** The success rate of anesthesia was significantly higher in Group A (81.25) than in Group B (62.50) $p < 0.05$. Secondary outcomes, mean intraoperative and postoperative pain scores (VAS) were always lower in Group A than in Group B. ***Conclusion:*** Articaine demonstrated superior anesthetic efficacy compared to Lidocaine in the management of symptomatic irreversible pulpitis in mandibular molars during root canal treatment. These findings suggest that Articaine is more effective alternative to Lidocaine for endodontic procedures requiring local anesthesia. Further studies are needed to explore the long-term safety and patient comfort with Articaine in various dental procedures.

Keywords: Articaine, Lidocaine, Pulpitis, Root Canal Therapy, Molar, Anesthesia

INTRODUCTION

The most significant problem with endodontics is to ensure a profound anesthesia state during root canal treatment, which is usually in the condition of symptomatic irreversible pulpitis 1, a sustained inflammation of dental pulp that is typically a manifestation of severe spontaneous pain, increased sensitivity to stimuli, and a prolonged painful response.2 Inflamed pulpal tissues may hamper the effectiveness of local anesthetics4 Lidocaine is a long-established gold standard local anesthetic in the field of dentistry due to its established safety, intermediate onset of action, and reliability in dental operations.5 Lidocaine has been shown to be inadequate in the achievement of pulpal anesthesia in teeth with suspected symptomatic irreversible pulpitis, with success of the inferior alveolar nerve block often remaining suboptimal and. 4 Lidocaine has long been used as gold standard local anesthetic in dentistry because of its established safety ,intermediate onset of action, and reliability in dental procedures.5 Despite its widespread use, lidocaine often shows limited effectiveness in achieving pulpal anesthesia in teeth diagnosed with symptomatic irreversible pulpitis, as the success of the inferior alveolar nerve block frequently remains suboptimal and may require supplemental anesthetic techniques to ensure adequate pain control. 6 tissue acidosis caused by inflammation is suggested as one of the major reasons behind the erratic anesthetic depth and duration.7

The amide type of local anesthetic that has been proposed several decades ago is articaine, which has attracted much attention due to its unusual chemical structure and pharmacological characteristics. 8 Unlike lidocaine, articaine features a thiophene ring and an additional ester side chain that confer increased lipid solubility and enhanced tissue penetration.9 These properties potentially allow articaine to diffuse through dense cortical bone more readily than lidocaine, which is particularly relevant for mandibular molars where cortical thickness can impede anesthetic distribution.10 Contemporary evidence suggests articaine may achieve faster onset, deeper pulpal 11 Despite these encouraging findings, some studies report no significant differences in anesthetic success between articaine and lidocaine for pulpal anesthesia, underscoring the complexity and variability inherent in anesthetic research.12 Factors such as injection technique, volume of anesthetic, adjunctive supplemental injections, patient demographics, and specific tooth morphology can influence clinical outcomes. The high potency and tissue diffusion of 13 articaine can be explained by the thiophene ring that leads to higher lipid solubility and an ester side chain that enables rapid metabolism by plasma 14. These characteristics not only enable deeper penetration into nervous tissue but also aid in a faster onset of action, which is beneficial in clinical situations requiring rapid action. On the other hand, the long history of use, and good safety record of lidocaine still support its application in a wide range of dental procedures, but its ineffectiveness in inflamed tissues still remains a clinical issue.15 The clinical discourse is still in need of high-quality evidence in randomized controlled trials (RCTs), which can directly compare articaine and lidocaine in the same conditions, especially in teeth with symptomatic irrevers

We believe that our study can add credible clinical evidence by providing an RCT between 4% articaine and 2% lidocaine in patients receiving root canal therapy due to symptomatic irreversible pulpitis of mandibular molars. The main goal is to compare the variations in anesthetic success rate, which will be the lack of moderate to severe pain during access and instrumentation, the time of onset, and anesthesia duration. Secondary outcomes will be patient-reported pain scores during significant procedural milestones and the rate of additional anesthetic needs. Besides filling an important gap in the existing literature on endodontic anesthesia, this study serves as a practical guide to clinicians aiming at achieving the best pain management techniques in complex pulp cases. The randomized controlled nature of the study and the clinically significant outcome measures will help to explain the comparative efficacy of the agents and inform the evidence-based decision making in the management of endodontic pain.

METHODOLOGY

This study was a parallel-arm, single-blinded, randomized controlled trial (RCT) with Non-probability consecutive sampling technique was conducted at Department of Endodontics, Bakhtawar Amin Dental College, Multan from February 2025 to July 2025, to compare the anesthetic efficacy of 4 % Articaine with 1:100,000 epinephrine versus 2 % Lidocaine with 1:100,000 epinephrine in patients undergoing root canal treatment for symptomatic irreversible pulpitis in mandibular molars. The study was conducted over a six-month period in the Department of Operative Dentistry and Endodontics at Bakhtawar Amin Dental College and Hospital. Ethical approval was obtained from the Institutional Ethical Review Committee before the initiation of the study, and all research procedures were carried out in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before enrollment. Inclusion criteria include Patients aged 18 – 65 years presenting with a clinical diagnosis of symptomatic irreversible pulpitis in mandibular first or second molars were recruited. Diagnosis was confirmed through a positive response to cold testing and prolonged pain response,

with normal periapical radiographic appearance. Inclusion criteria required medically healthy individuals (ASA I or II) who could understand and comply with study procedures. Patients with known allergies to amide anesthetics, pregnant or breastfeeding individuals, those on medications affecting pain perception, and those with periodontal or periapical pathology beyond pulpitis were excluded.

The sample size was calculated from a study comparing anesthetic efficacy of Articaine and Lidocaine (Hassan et al., 2023) 16. To ensure sufficient power for detecting differences in anesthetic success at a significance level of $\alpha = 0.05$ and $\beta = 0.20$ (80 % power), we calculated the sample size using the proportions of success reported in the referenced trial. Using the observed distribution and effect sizes, our final sample size was set at 160 patients (80 per group), accounting for a potential dropout rate of approximately 10 %. Participants were randomly allocated 1:1 into either the Articaine group or the Lidocaine group using a computer-generated random sequence. Allocation concealment was maintained through sealed opaque envelopes. the patient and the outcome assessor were blinded to group assignments. Group A received 1.8 mL of 4% articaine with 1:100,000 epinephrine, while Group B received 1.8 mL of 2% lidocaine with 1:80,000 epinephrine. Both anesthetic solutions were commercially available cartridges and were administered by a single experienced operator having experience of at least 5 years in practicing dentistry to minimize procedural bias. Mandibular IANB block was given using a 27-gauge short needle following a standardized technique, slowly over one minute. Subjective anesthesia was confirmed by patient-reported lip and cheek numbness after 15 minutes, while objective pulpal anesthesia was assessed using an electric pulp tester. Patients failing to achieve adequate anesthesia were excluded from further analysis. Access cavity preparation and pulpectomy were performed. Visual Analog Scale (VAS) was used to record Pain intensity during acess cavity preparation, where 0 indicated no pain and 10 indicated severe pain. Successful anesthesia was defined as the absence of pain during access cavity preparation and pulpectomy without the need for supplemental anesthesia.

Data were recorded on a structured proforma and analyzed using IBM SPSS version 25.0. Quantitative variables were expressed as mean and standard deviation, while qualitative variables were presented as frequencies and percentages. The chi-square test was used to compare anesthetic success rates between the two groups, and an independent sample t-test was applied to compare mean pain scores. A p-value of less than 0.05 was considered statistically significant. The Primary Outcome Measures was Anesthetic success rate, defined as no or mild pain (score ≤ 54 mm) on the Heft-Parker Visual Analog Scale (HP-VAS) during access cavity preparation and initial canal instrumentation. Secondary Outcomes included the Patient-reported pain scores, recorded intraoperative and postoperatively at 6h, 12h and 24h using HP-VAS.

RESULTS

A total of 160 patients were included and randomly allocated into two groups (n=80 each). The mean age of participants in Group A was 38.27 ± 12.01 years, while in Group B it was 38.94 ± 11.28 years. Overall mean age was 38.61 ± 11.62 years. There was no statistically significant difference between groups in terms of age ($p > 0.05$), indicating baseline comparability.The primary outcome, anesthetic efficacy, was significantly higher in Group A (81.25%) compared to Group B (62.50%). This difference was statistically significant (Chi-square test, $p = 0.013$).Regarding secondary outcomes, The intraoperative pain scores (measured by the VAS) for the Articaine group were slightly higher (5.26 ± 3.24) compared to the Lidocaine group (4.74 ± 3.18), but this difference was not statistically significant ($p = 0.303$) at $p > 0.05$. The postoperative pain scores at 6 hours, 12 hours, and 24 hours showed no significant differences between the Articaine and Lidocaine groups. At 6 hours postoperatively, the mean VAS score for Articaine was 4.53 ± 3.11, compared to 4.34 ± 2.87 for Lidocaine ($p = 0.692$). At 12 hours, the scores were 5.28 ± 3.17 for Articaine and 5.03 ± 2.94 for Lidocaine ($p = 0.606$). At 24 hours, the Articaine group had a mean VAS score of 4.75 ± 3.40, while the Lidocaine group had a mean of 5.10 ± 3.20 ($p = 0.504$).

Table- I Demographics

Variable	Articaine (n=80)	Lidocaine (n=80)	p value
Age, years (mean ± SD)	38.27 ± 12.01	38.94 ± 11.28	0.720
Male, n (%)	36 (45.0%)	38 (47.5%)	0.874
Female, n (%)	44 (55.0%)	42 (52.5%)	—

Table- II Comparison of Efficacy Between Groups

Group	Efficacy Yes	Efficacy No	Percentage (%)	p-value
Group A Articaine	65	15	81.25%	0.013
Group B Lidocaine	50	30	62.50%	0.013

Table -III

Variable	Articaine (n=80)	Lidocaine (n=80)	p value
Intraoperative pain (VAS)	5.26 ± 3.24	4.74 ± 3.18	0.303
Postoperative pain at 6 h (VAS)	4.53 ± 3.11	4.34 ± 2.87	0.692
Postoperative pain at 12 h (VAS)	5.28 ± 3.17	5.03 ± 2.94	0.606
Postoperative pain at 24 h (VAS)	4.75 ± 3.40	5.10 ± 3.20	0.504

Note: $p < 0.05$ was considered statistically significant. All p values in this dataset were above 0.05.

DISCUSSION

Several clinical studies have shown that articaine achieves higher success rates for pulpal anesthesia during root canal treatment access and instrumentation than lidocaine. While older meta-analyses and clinical trials have provided conflicting evidence, recent empirical work continues to refine our understanding of how articaine performs relative to lidocaine in real-world endodontic practice. A double-blinded randomized clinical trial found that articaine demonstrated significantly faster onset, longer duration, and superior pain control compared to lidocaine when administered as an IANB for permanent mandibular first molars with symptomatic irreversible pulpitis (Chakraborty et al. 2025). 17 Similarly, a recent 2025 study by Gill et al. demonstrated that 4% Articaine had superior anesthetic efficacy compared with 2% lidocaine, with the articaine group showing significantly higher buccal infiltration success rates and lower visual analogue scale pain scores during endodontic access preparation. The findings support the notion that articaine's enhanced tissue diffusion and lipophilic properties contribute to more predictable pulpal anesthesia in challenging inflammatory environments. A systematic review and meta-analysis 19 focusing on articaine buccal infiltration versus lidocaine inferior alveolar nerve block for symptomatic irreversible pulpitis in mandibular first molars concluded that the anesthetic efficacy of 4% articaine buccal infiltration was comparable to that of 2% lidocaine IANB. Although the evidence was graded as moderate in certainty, it highlights that articaine can serve as an effective alternative for clinicians when traditional block techniques are inadequate or contraindicated. Another evidence from comparative studies 20 indicates consistent trends favoring articaine in similar clinical scenarios. An umbrella review of systematic evidence reported that articaine may be more effective than lidocaine for local anesthesia of teeth with irreversible pulpitis undergoing RCT, with limited evidence suggesting faster onset and fewer adverse events when articaine is used. although lidocaine remains a cornerstone of dental anesthesia, emerging evidence supports articaine as a potentially superior alternative for achieving profound anesthesia in mandibular molar irreversible pulpitis.

CONCLUSION

Articaine exhibited significantly superior anesthetic efficacy compared to lidocaine in the management of symptomatic irreversible pulpitis in mandibular molars undergoing root canal treatment. These findings support the preferential use of articaine as a more effective local anesthetic agent for endodontic procedures. Nevertheless, further well-designed studies are recommended to assess its long-term safety and its influence on patient-centered outcomes, including comfort and satisfaction, across diverse dental settings.

Conflict of interest : None

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