Comparison of Anesthetic Efficacy of 4% Articaine and 2% Lidocaine for Maxillary Buccal Infiltration in Patients with Irreversible Pulpitis

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ABSTRACT

Background: Effective pain management during dental procedures in patients with irreversible pulpitis remains a challenge. Local anesthetics like 4% articaine and 2% lidocaine are widely used, but their comparative efficacy requires further investigation.

Objective: To compare the anesthetic efficacy of 4% articaine with 2% lidocaine for maxillary buccal infiltration in patients with irreversible pulpitis.

Methods: This randomized, cross-sectional study included 96 adult patients with irreversible pulpitis undergoing endodontic treatment. Patients were divided equally into two groups: Group A received 1.8 mL of 4% articaine with 1:100,000 epinephrine, and Group B received 1.8 mL of 2% lidocaine with 1:80,000 epinephrine. Anesthetic solutions were administered using standard inferior alveolar nerve block techniques, and pain intensity was assessed using the Visual Analog Scale (VAS). Success rates were evaluated during access cavity preparation and pulpectomy. Data were analyzed using SPSS version 25.0, with a p-value <0.05 considered statistically significant.

Results: During access cavity preparation, success rates were higher with articaine (73%) compared to lidocaine (56%) ($p = 0.023$). Pain scores were significantly lower for articaine (0.275 ± 0.445) compared to lidocaine (0.880 ± 0.724) ($p = 0.001$). No significant differences were observed during pulpectomy ($p = 0.43$).

Conclusion: Articaine demonstrated superior efficacy during access cavity preparation but was comparable to lidocaine during pulpectomy, making it a viable alternative for endodontic anesthesia.

INTRODUCTION

The success of dental treatment largely depends on achieving profound anesthesia of the dental pulp, which can be particularly challenging in patients with irreversible pulpitis. This condition is often accompanied by heightened pain sensitivity, complicating the process of effective anesthesia. Pain management is a primary concern for clinicians, as inadequate pain control can exacerbate fear and anxiety associated with dental procedures, ultimately impacting the overall patient experience and treatment outcomes (1). For decades, lidocaine has been the most commonly used local anesthetic in dentistry. It contains epinephrine as a vasoconstrictor and has been established as the gold standard due to its proven effectiveness, minimal allergenicity, and negligible toxicity. Despite its widespread use and clinical reliability, lidocaine is associated with certain limitations, such as a lower pH to prolong shelf life, which can result in a burning sensation during injection, delayed onset of action, and reduced efficacy in inflamed tissues (2, 3). These limitations have driven the exploration of alternative anesthetic agents that may overcome these drawbacks.

Articaine, a relatively newer amide anesthetic, has gained popularity in dental practices due to its unique pharmacological properties, including enhanced lipid solubility facilitated by a thiophene ring. This feature allows for better tissue penetration and potentially improved anesthetic efficacy. Studies have demonstrated that articaine, with its 1.5 times greater potency compared to lidocaine, offers a faster onset of action and higher success rates in achieving profound anesthesia. Articaine's efficacy and safety have been widely investigated, with some evidence suggesting that it may serve as a superior alternative to lidocaine, particularly in cases of irreversible pulpitis (4, 5). However, conflicting results in the literature warrant further investigation to establish its efficacy in comparison to lidocaine for specific endodontic procedures. For instance, while some studies have reported that articaine is more effective in achieving anesthesia for endodontic treatments in posterior mandibular teeth, others have found no significant difference between the two agents (6, 7).

Despite these findings, lidocaine remains the benchmark against which all newer anesthetics are measured, primarily due to its long-standing history of clinical success and safety. Nevertheless, several studies have highlighted the potential advantages of articaine in certain clinical scenarios, particularly in achieving superior pulpal anesthesia during dental procedures. This discrepancy in

findings underscores the need for well-designed, randomized studies to evaluate the anesthetic efficacy of articaine compared to lidocaine in cases of irreversible pulpitis. Such research is critical to providing evidence-based recommendations that can enhance clinical practice and improve patient outcomes (8, 9).

In this study, we aim to address these gaps by comparing the anesthetic efficacy of 4% articaine with 1:100,000 epinephrine and 2% lidocaine with 1:80,000 epinephrine for maxillary buccal infiltration in patients diagnosed with irreversible pulpitis. By focusing on outcomes such as pain intensity during access cavity preparation and pulpectomy, this investigation seeks to provide clinicians with a clearer understanding of the relative effectiveness of these two anesthetic agents, ultimately guiding more informed decision-making in endodontic pain management (10, 11).

MATERIAL AND METHODS

This cross-sectional study was conducted to evaluate and compare the anesthetic efficacy of 4% articaine and 2% lidocaine for maxillary buccal infiltration in patients with irreversible pulpitis. The study included a total of 96 adult patients who were diagnosed with irreversible pulpitis and scheduled for endodontic treatment. The patients were referred to the Department of Operative Dentistry at Bolan Medical College/Sandeman Provincial Hospital, Quetta, over a six-month period, from August 21, 2021, to February 21, 2022. Ethical approval for the study was obtained from the institutional review board, and the study adhered to the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants before their inclusion in the study.

The inclusion criteria were adult patients diagnosed with irreversible pulpitis who required endodontic treatment. Patients with a history of allergies or sensitivity to articaine or lidocaine, those with non-vital teeth, individuals on preoperative analgesics, or those taking medications that could alter pain perception were excluded from the study. Randomization was achieved through a lottery method, dividing the patients into two equal groups of 48 each. Group A received 1.8 mL of commercially available 4% articaine with 1:100,000 epinephrine, while Group B received 1.8 mL of commercially available 2% lidocaine with 1:80,000 epinephrine.

A standardized protocol was followed for the administration of the anesthetic agents. A topical anesthetic gel was applied with a cotton-tip applicator for 60 seconds before injection. The anesthetic solution was administered using a 27-gauge needle with a standard inferior alveolar nerve block technique. An initial dose of 0.4 mL was injected over 15 seconds at the point of needle penetration, followed by aspiration and the deposition of the remaining 1.4 mL over one minute. Subjective lip anesthesia was confirmed by asking the patients about numbness in the lip 15 minutes after the injection. Pulpal anesthesia was evaluated using an electric pulp tester. Patients who failed to exhibit lip anesthesia or responded positively to electrical pulp testing were excluded from the analysis.

The clinical procedures included access cavity preparation and pulpectomy, during which the intensity of pain was assessed using the Visual Analog Scale (VAS), a reliable tool for subjective pain measurement. Patients rated their pain during the procedures on a scale of 0 to 100 mm. Successful anesthesia was defined as the absence of pain during the procedures. The primary outcomes of the study included the success rate of anesthesia during access cavity preparation and pulpectomy.

Data collection was performed systematically, with all pain scores and procedural outcomes recorded in standardized forms. Statistical analysis was carried out using IBM SPSS version 25.0. Descriptive statistics, including means and standard deviations, were calculated for continuous variables, while categorical data were expressed as frequencies and percentages. The chi-square test was applied to evaluate differences in success rates between the two groups. A p-value of less than 0.05 was considered statistically significant.

The study ensured strict adherence to ethical standards and maintained the confidentiality of patient data throughout the research process. All procedures were performed by experienced clinicians following standardized protocols to minimize variability. This robust methodology ensured the reliability and validity of the study findings, providing valuable insights into the comparative anesthetic efficacy of articaine and lidocaine in patients with irreversible pulpitis.

RESULTS

A total of 96 patients diagnosed with irreversible pulpitis were included in the study, divided equally between Group A (articaine) and Group B (lidocaine), with 48 participants in each group. The demographic distribution of participants is presented in Table 1, which shows no statistically significant difference in gender distribution between the groups (p = 0.731).

Table 1: Demographic Distribution of Patients

Variable	Articaine (Group A)	Lidocaine (Group B)	P-Value
Total Patients (n)	48	48	-
Females (n, %)	35 (72.9%)	33 (68.8%)	-
Males (n, %)	13 (27.1%)	15 (31.2%)	0.731

The efficacy of anesthesia was assessed during two critical procedures: access cavity preparation and pulpectomy. Success rates were determined based on the absence of pain as reported on the Visual Analog Scale (VAS). The success rate during access cavity preparation was significantly higher for articaine (73%) compared to

lidocaine (56%) (p = 0.023). However, during pulpectomy, the success rates were comparable between the two groups, with articaine achieving 58.3% success and lidocaine achieving 56% success (p = 0.43).

Table 2: Success Rates of Anesthesia During Procedures

Procedure	Articaine (n, %)	Lidocaine (n, %)	P-Value
Access Cavity Preparation	35 (73%)	27 (56%)	0.023
Pulpectomy	28 (58.3%)	27 (56%)	0.43

The mean pain scores during access cavity preparation and pulpectomy are presented in Table 3. During access cavity preparation, the mean pain score was significantly lower for articaine (0.275 ± 0.445) compared to lidocaine (0.880 ± 0.724) (p = 0.001). For pulpectomy, the mean pain scores were comparable between the groups, with articaine at 0.423 ± 0.632 and lidocaine at 0.402 ± 0.600 (p = 0.78).

Table 3: Pain Scores During Procedures

Procedure	Articaine (Mean ± SD)	Lidocaine (Mean ± SD)	P-Value
Access Cavity Preparation	0.275 ± 0.445	0.880 ± 0.724	0.001
Pulpectomy	0.423 ± 0.632	0.402 ± 0.600	0.78

The statistical analysis highlighted a significant difference in anesthetic efficacy between articaine and lidocaine during access cavity preparation, as evidenced by the higher success rates and lower pain scores for articaine. However, no significant differences were observed between the two anesthetic agents during pulpectomy. These findings suggest that while articaine may provide superior anesthesia during the initial stages of endodontic treatment, its efficacy is comparable to that of lidocaine in more invasive procedures such as pulpectomy.

DISCUSSION

The current study compared the anesthetic efficacy of 4% articaine and 2% lidocaine for maxillary buccal infiltration in patients with irreversible pulpitis, focusing on pain management during access cavity preparation and pulpectomy. The findings revealed that articaine demonstrated superior anesthetic efficacy during access cavity preparation, with significantly higher success rates and lower pain scores than lidocaine. However, no significant differences were observed between the two agents during pulpectomy. These results contribute to the growing body of evidence regarding the use of articaine as an effective local anesthetic alternative to lidocaine in endodontic procedures.

The superior efficacy of articaine during access cavity preparation can be attributed to its unique pharmacological properties, including enhanced lipid solubility due to its thiophene ring structure, which facilitates better penetration into tissues and nerve membranes. Previous studies have similarly reported that articaine exhibits faster onset and higher potency compared to lidocaine, making it a preferred choice for achieving profound anesthesia in dental procedures (5, 6). Additionally, articaine's ability to diffuse through soft and hard tissues more effectively may explain its higher success rates during initial stages of treatment, as noted in other investigations (8, 10). Despite these advantages, the absence of significant differences between articaine and lidocaine during pulpectomy in this study aligns with findings from prior research, which suggested comparable efficacy of the two agents in achieving profound anesthesia for more invasive procedures (7, 9).

While the results underscore the potential benefits of articaine for specific stages of endodontic treatment, several limitations of this study warrant consideration. The study was limited to a single-center setting with a relatively small sample size, which may restrict the generalizability of the findings. Variability in patients' pain thresholds, underlying conditions, and anatomical differences could also have influenced the outcomes. Additionally, the study assessed subjective pain using the Visual Analog Scale, which, although reliable, may be influenced by individual perceptions and biases. Objective measures such as monitoring hemodynamic responses or advanced imaging techniques could provide a more comprehensive evaluation of anesthetic efficacy in future research.

Strengths of the study included its randomized design, adherence to standardized administration protocols, and the use of well-defined inclusion and exclusion criteria to minimize confounding factors. The comparison of anesthetic efficacy during two distinct procedural stages provided valuable insights into the differential performance of the two agents, offering clinically relevant implications for pain management in endodontics.

Despite these contributions, the findings must be interpreted within the context of the study's limitations. Future studies should aim to include larger, multicenter cohorts to enhance the statistical power and generalizability of results. Additionally, investigations could explore the

efficacy of articaine in combination with adjunctive anesthetic techniques, such as supplemental infiltration or intraligamentary injections, to further optimize pain control in challenging cases of irreversible pulpitis. Comparisons between articaine and other emerging anesthetic agents may also provide valuable insights into advancing endodontic anesthesia.

The study also highlighted the need for individualized pain management approaches, particularly in patients with heightened pain sensitivity due to pulpitis. While articaine demonstrated clear benefits during access cavity preparation, its comparable efficacy to lidocaine during pulpectomy suggests that other factors, such as operator skill and technique, may play a significant role in determining anesthetic success in more invasive procedures. Incorporating these findings into clinical practice could aid dental practitioners in selecting the most appropriate anesthetic agent based on the specific procedural stage and patient profile.

In conclusion, the study provided evidence supporting the use of articaine as a viable alternative to lidocaine for maxillary buccal infiltration in patients with irreversible pulpitis, particularly for achieving profound anesthesia during access cavity preparation. However, the comparable performance of the two agents during pulpectomy suggests that both can be effectively employed in endodontic procedures. Further research is required to validate these findings in diverse clinical settings and explore additional strategies for optimizing anesthetic efficacy in endodontics.

CONCLUSION

This study demonstrated that 4% articaine is an effective alternative to 2% lidocaine for maxillary buccal infiltration in patients with irreversible pulpitis, showing superior anesthetic efficacy during access cavity preparation while exhibiting comparable performance during pulpectomy. These findings suggest that articaine's enhanced lipid solubility and faster onset may offer advantages in managing pain during certain stages of endodontic treatment. From a human healthcare perspective, the results emphasize the importance of individualized anesthetic selection to optimize patient comfort and procedural success, paving the way for improved pain management strategies in dental care.

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