ORIGINAL RESEARCH

Comparative Evaluation of 4% Articaine and 2% Lignocaine Anesthetic Agents in Children: A Split-mouth Randomized Control Trial

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Abstract

Aim: The objective of the present study is to assess and compare the effectiveness of two different anesthetic agents, namely, 4% articaine and 2% lignocaine, in the extraction of primary molar teeth in children.

Materials and methods: The study included 25 children requiring bilateral extractions of primary molar, with extraction performed on one side with 4% articaine and the contralateral side extraction with 2% lignocaine at two separate appointments. The anesthetic efficacy was evaluated objectively by assessing pain and the child's behavior at baseline, during injection and during extraction using the sound, eye, and motor (SEM) scale objectively, and subjectively using the faces pain rating scale (FPS). The data were then compiled and subjected to statistical analysis.

Results: On statistical analysis, there was no statistically significant difference found between the two anesthetic agents during extraction of primary molar teeth, whereas a statistically significant difference was present between articaine and lignocaine during local anesthesia administration on the FPS scale. Also, there was no statistically significant difference found on SEM scale during the procedure between the two anesthetic agents.

Conclusion: Articaine can effectively be used as an alternative to lignocaine and inferior alveolar nerve block (IANB) where a long-term procedure is required.

Clinical significance: In pediatric dentistry, articaine and lignocaine play a very important roles as local anesthetic agents, offering clinicians effective tools to manage pain and discomfort during dental procedures for children.

Keywords: Articaine, Children, Lignocaine, Local anesthesia, Pediatric population.

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Introduction

Local anesthesia is a crucial component of pediatric dentistry, ensuring that children undergo dental procedures with minimal pain and discomfort. By effectively numbing the affected area, local anesthesia not only enhances comfort but also reduces anxiety and trauma for both children and adults.

Administering local anesthesia to children requires careful consideration of various factors. Age, weight, and the specific dental procedure all influence the type and dosage of anesthesia used. Dentists typically employ two primary forms: topical anesthesia and injectable anesthesia.

Topical anesthesia, often in the form of a gel or ointment, is applied to oral tissues before administering injectable anesthesia. This initial step helps numb the surface, making the subsequent injection less uncomfortable. Injectable anesthesia, delivered via syringe and needle, may take the form of infiltration or block anesthesia, targeting specific areas as required by the procedure.

Ensuring a painless application of anesthesia involves employing techniques such as distraction and positive reinforcement, alongside non-pharmacological behavior management methods. Vigilant monitoring of the child's vital signs throughout the procedure is essential for their safety. Precise dosage calculation, based on weight and age, is crucial to avoid complications from over-administration.

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While local anesthesia is generally safe, potential side effects such as temporary numbness or swelling at the injection site may occur, though these typically dissipate quickly.

In dentistry, lignocaine and articaine are the two most commonly used anesthetic agents for children. Lignocaine, considered the gold standard, was first synthesized by Löfgren in 1943 and is often used in a 2% concentration due to its favorable pharmacokinetics and safety profile. It can be administered as either a local infiltration or nerve block, depending on the procedure.[1–3]

Articaine, introduced in the mid-1970s in Germany and Switzerland and later in the United States in 2000, is another commonly used amide-type local anesthetic solution. It offers advantages such as high lipid solubility and penetrating ability, making it an effective alternative to nerve blocks in children due to its longer-lasting effects.[4–6]

Articaine undergoes biotransformation into articainic acid, its inactive primary metabolite, during metabolism, which helps reduce its systemic toxicity. These properties contribute to Articaine's efficacy as an anesthetic agent in dentistry.[5,6]

But the main problem arises while giving nerve blocks to the children using lignocaine, as this is a great challenge and many times the procedure fails due to failed nerve block. This was mainly due to the lignocaine less potential to cross the hard cortical plate barrier of mandible as compared with articaine which can easily penetrate the cortical bone, giving greatest anesthetic efficacy. Hence, the anesthetic agent with better diffusion ability like articaine is required to overcome these limitations. Also, it has been seen that articaine as buccal infilteration the procedure can be performed effectively and painlessly in children.[3,4] Despite the advancements in anesthesia, critical gaps in knowledge persist. Many dentists still resort to lidocaine, contending with the persistent challenge of nerve blocks and painful procedures in pediatric patients.

Given the importance of effective pain management in pediatric dental procedures using articaine buccal infilteration with equal safety to that of lignocaine, the present study aimed to evaluate and compare the anesthetic efficacy of 4% articaine and 2% lignocaine during the extraction of primary molar teeth in children, as well as their respective pain perception and acceptance by children.

Materials and Methods

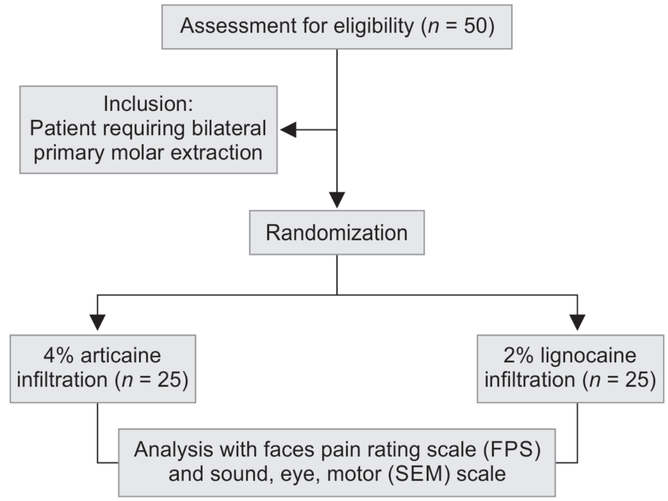
The present randomized control split-mouth study was conducted in Sri Guru Ramdas Institute of Dental Sciences and Research, Amritsar over a period of 18 months from July, 2022 till January, 2024 after getting approval from the Institutional Ethical committee of Sri Guru Ramdas Institute and Health Sciences, performed on 25 Children requiring bilateral extraction of primary molars in two subsequent appointments.

The inclusion criteria encompass children aged over 5 years who were capable of communication, with ASA physical status I and II, and a Frankl behavior rating of 3 and 4, while exclusion criteria comprise a history of allergy to local anesthetic agents, presence of teeth with dentoalveolar abscess and sinus tract, and evident infection near the injection site, which could potentially affect the efficacy of the anesthetic agent used.

After the case selection, the consent was taken from the guardian of the patient which included the whole information of the study and the process was also verbally explained to the parents prior to the beginning of the procedure (Flowchart 1).

Topical anesthetic gel (Lox 2% gel, neon marketing, Amritsar) was applied using cottontipped applicator at the site of injection. After a waiting period of 45–90 seconds for the topical anesthetic agent to act, local anesthesia was delivered as per the technique opted. 4% articaine (Septanest 1:100,000, 1.7 mL, Septodont, France) buccal infiltration (Fig. 1) was delivered for extraction of primary

Flowchart 1: Flowchart for CONSORT criteria



molar at the level of primary molar apex. The onset of action of the anesthetic agent was determined through the assessment of both subjective and objective symptoms. Subjective symptoms involved evaluating sensations reported by the patient, such as numbness or tingling in the affected area. Objective symptoms included observations such as changes in skin color or temperature at the injection site, muscle relaxation, and reduced responsiveness to pain stimuli. Extraction was then performed which was followed by control of hemostasis and post-extraction instructions. After a washout period of at least 1 week between the two appointments, the extraction procedure on the contralateral side was conducted using 2% lignocaine (1:80,000, concentration 1.7 mL) via buccal infiltration technique (Fig. 2).

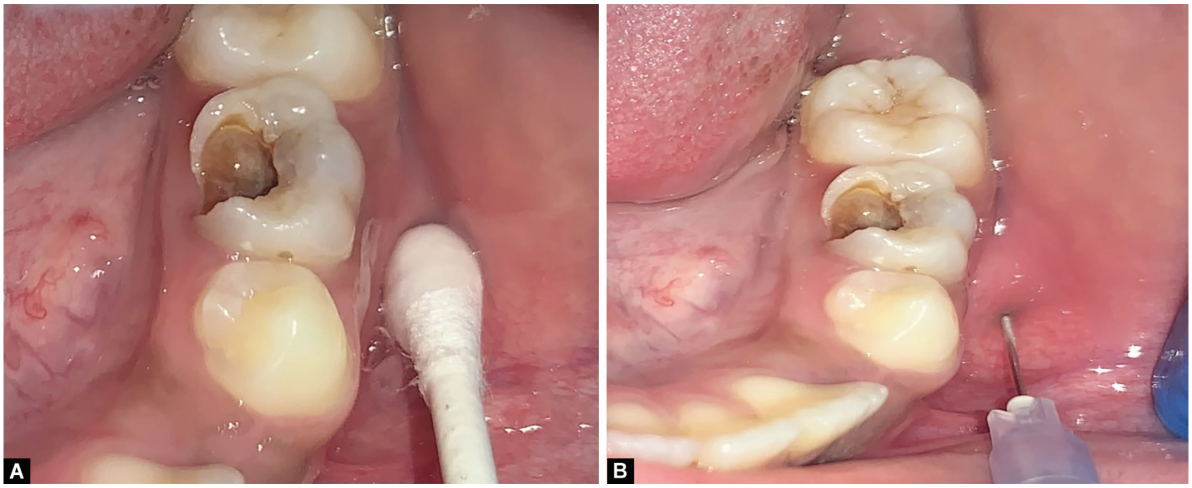
A total of 1.7 mL of both the anesthetic agents was delivered on both sides at the rate of 1 mL/min. The readings were taken for objective measurement using SEM scale (sound, eye and motor) (Table 1) and subjective scale using faces pain rating scale (FPS) at baseline, during local anesthesia administration and during extraction by two different investigators who were recording the scores from start of the experiment till the completion of the procedure and were blinded to eliminate the bias in the results.

The scales used in the present study were according to the scales previously used in studies by Jain K et al. and Shehab LA et al. in which for objective analysis SEM scale was used where the sound eye and motor responses of child was checked from the beginning of the procedure till completion by the investigator who was previously trained to take the scores and was blinded to eliminate the bias during procedure. Similarly, the subjective symptoms of the child was checked by using the FPS scale and asking the child to mark the amount of pain he felt during the procedure on facial analogue scale.[6,7]

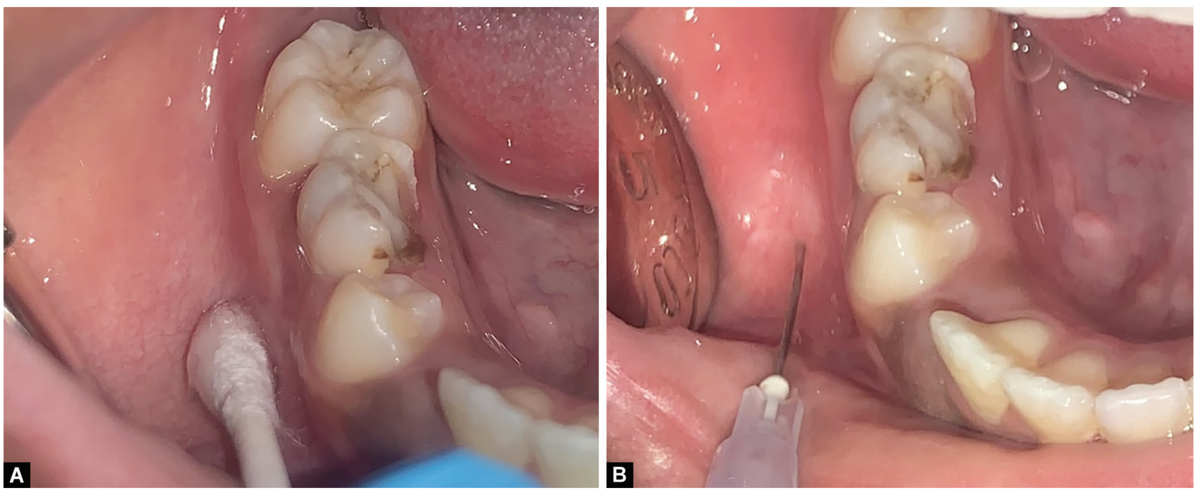
The means and standard deviation of the measurements per group were used for statistical analysis using SPSS 22.00 for windows version 24; SPSS Inc., Chicago, USA software. The difference between the two groups were analyzed using *t*-test at the level of significance (p-value was set at < 0.05).

Results

A total 25 number of children were selected as the study population requiring bilateral extractions out of which there were 12 females



Figs 1A and B: Articaine infiltration. (A) Topical anesthetic application; (B) Buccal infiltration



Figs 2A and B: Lignocaine infiltration. (A) Topical anesthetic application; (B) Buccal infilteration

Table 1: Sound, eye, motor scale (SEM) {7}

Parameter	*Comfort 1*	*Mild discomfort 2*	*Moderate discomfort 3*	*Severe discomfort 4*
Sound	No sound	Non-specific sound	Verbal complaint, louder sound	Verbal complaint, shouting, crying
Eye	No sign	Dilated eyes without tears (anxiety sign)	Tears, sudden eye movements	Crying, tears covering the face
Motor	Relaxed body and hand status	Muscular contraction, contraction of hands	Sudden body and hand movements	Hand movement for defence, turning the head to opposite side

and 13 males of 5–10 years of age. According to results as seen in Table 2 and Figure 3 for FPS, the mean value of lignocaine and articaine at baseline was seen as 0.24 and 0.24, respectively. During local anesthesia administration, the mean value of lignocaine and articaine was seen to be 1.52 and 0.88, respectively which when compared showed statistically significant difference between the two anesthetic agents. Whereas during extraction, the mean value for lignocaine and articaine was seen to be 1.76 and 1.36, respectively, though the mean value of articaine was less as compared with lignocaine showing better results of articaine but the results were statistically non-significant during extraction.

Whereas when lignocaine and articaine were compared on SEM scale as seen in Table 3 and Figure 4, the mean value at baseline for lignocaine and articaine was seen as 1.08 and 1.08, respectively. During local anesthesia administration, the mean value scores were seen to be 1.72 and 1.40 for lignocaine and Articaine respectively whereas during extraction, the mean value score for lignocaine and articaine were seen to be 1.68 and 1.64, respectively. Although, results showed that children exhibited a higher preference for articaine, but when the results were compared on statistical analysis between lignocaine and articaine, they were statistically non-significant.

Table 2: Faces pain rating scale between lignocaine and articaine group at various intervals

	Lignocaine		*Articaine*			
Intervals	*Mean*	*SD*	*Mean*	*SD*	*t-test*	*p-value*
Baseline	0.24	1.20	0.24	1.20	0	1
During LA	1.52	1.85	0.88	1.74	3.17	0.036*
During extraction	1.76	1.67	1.36	1.60	2.32	0.14

*Statistically significant

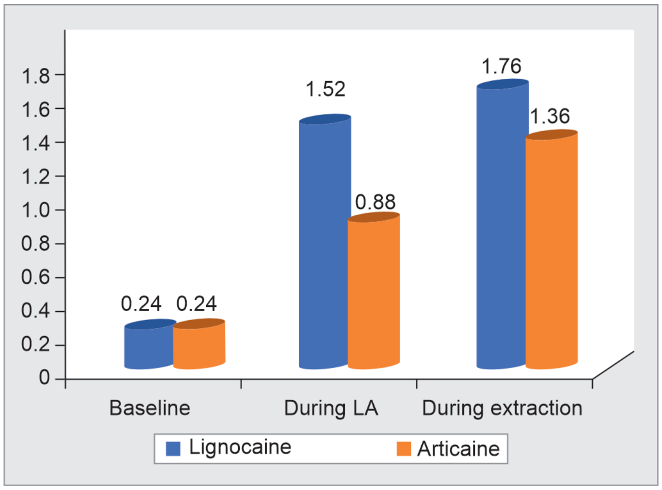


Fig. 3: Faces pain rating scale between lignocaine and articaine

Table 3: Sound, eye and motor scale between lignocaine and articaine group at various intervals

	Lignocaine		*Articaine*			
Intervals	*Mean*	*SD*	*Mean*	*SD*	*t-test*	*p-value*
Baseline	1.08	0.40	1.08	0.40	0	1
During LA	1.72	0.68	1.40	0.71	2.19	0.23
During extraction	1.68	0.69	1.64	0.76	0.42	0.81

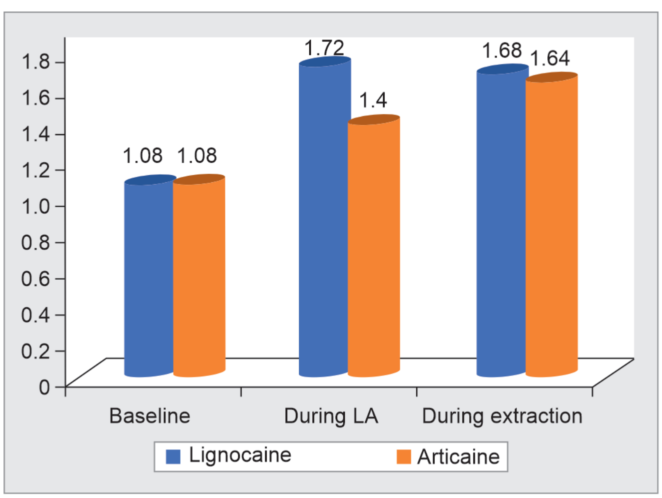


Fig. 4: Sound, eye and motor scale between lignocaine and articaine

Discussion

The present study aimed to assess the effectiveness of two anesthetic agents, 4% articaine and 2% lignocaine, in children undergoing bilateral extraction of primary molars. Pain, being a complex subjective experience, was evaluated using both subjective and objective scales, as recommended by Tomlinson et al. Children aged ≥5 years were selected to ensure their ability to rate pain accurately, although to mitigate potential bias, pain was assessed using both subjective (FPS) and objective (SEM - sound, eye, and motor) scales.[2–7]

In the mandibular region, where dense cortical bone limits the efficacy of infiltration techniques, nerve blocks are typically necessary. However, the inferior alveolar nerve block (IANB) technique has drawbacks, including a high failure rate in children and risks of intravascular injury leading to complications such as trismus and hematoma. To overcome these challenges, the buccal infiltration technique was employed in the present study, comparing the efficacy of 2% lignocaine and 4% articaine during primary molar extraction.

Articaine was selected for buccal infiltration due to its superior diffusion into hard tissues, attributed to its unique chemical structure with a thiophene ring replacing the aromatic ring, resulting in increased lipid solubility and potency compared with lignocaine.[1–6] Articaine's ability to diffuse reliably from soft and hard tissues, along with its strong protein binding, facilitates enhanced penetration into bone, requiring lower dosages for desired effects compared with lignocaine. Moreover, articaine's longer duration of soft tissue anesthesia (~4–5 hours) may offer advantages in some cases, though it also raises concerns about potential postoperative injuries due to prolonged numbness. However, articaine's safety profile is enhanced by its lower required dosage and biotransformation into an inactive form, articainic acid, reducing systemic toxicity.[6]

In the present study, 2% lignocaine solution with 1:80,000 epinephrine was utilized, differing from some studies employing a 1:1,00,000 epinephrine concentration. Despite this variation, existing evidence suggests that epinephrine concentration does not significantly impact efficacy. The choice of epinephrine concentration in the present study was based on standard solutions availability.

The study conducted by Arrow P on comparing 4% articaine and 2% lignocaine in block and infiltration technique also said that on buccal infilteration though the success rate of articaine was 71% as compared with lignocaine with 64% but the results were statistically non-significant, hence, the study concluded both Articaine and lignocaine were equally efficacious in buccal infilteration technique.[1]

Erfanparast L et al. also compared the efficacy of 4% articaine buccal infilteration with 2% lgocaine IANB nerve block in children and concluded that the 4% articaine buccal infilteration was equally efficacious as that of 2% lignocaine IANB nerve block, hence articaine can be effectively used as an alternative to nerve block in children.[3] Kanaa MD et al. when compared the efficacy of 4% articaine and 2% lignocaine in achieving pulpal anesthesia in maxillary teeth with irreversible pulpitis stated that both the anesthetic agents were equally effective when buccal infilteration was given.[4]

Although no statistically significant differences in successful anesthesia or pain-free treatment were observed in the present study between articaine and lignocaine buccal infiltration, the mean difference suggests that articaine can be more efficacious.

Thus, articaine infiltration could serve as a viable alternative to IANB for mandibular anesthesia, particularly when prolonged effect is desired. However, parents should receive proper post-extraction instructions to prevent potential complications.[3] The possible reason for non-significant could be the small sample size and the evaluation of effectiveness of the solution in extraction of deciduous teeth which requires less anesthetic agent to act. The study's limitation lies in its small sample size, warranting future studies with larger cohorts to validate and further explore the accuracy and effectiveness of these anesthetic agents.

The future direction of local anesthesia in pediatric dentistry may involve continued research and innovation aimed at improving efficacy, safety, and patient experience by using better anesthetic agent like articaine. Also, the development of novel formulations or delivery methods that enhance the onset and duration of anesthesia while minimizing discomfort during administration. Additionally, advancements in technology, such as the use of computer-assisted anesthesia delivery systems or virtual reality distraction techniques, could further improve the delivery and acceptance of local anesthesia in pediatric patients. Furthermore, there may be a focus on personalized approaches to anesthesia management, taking into account individual patient factors, such as age, medical history, and anxiety levels. Overall, the future direction of local anesthesia in pediatric dentistry is likely to prioritize optimizing patient comfort and satisfaction while ensuring the highest standards of safety and efficacy.[7–15]

Conclusion

This can be concluded that the present study findings highlight the efficacy of both articaine and lignocaine in providing adequate anesthesia during dental procedures in pediatric patients. Through careful evaluation and comparison, the present study revealed that both agents exhibit favorable onset of action and duration, with articaine demonstrating deeper tissue penetration and potential advantages in certain clinical scenarios. These findings underscore the importance of considering individual patient needs and characteristics when selecting the most appropriate local anesthetic agent in pediatric dentistry. Overall, the findings of the present study serve as a valuable resource for clinicians seeking to optimize anesthesia management and improve outcomes in pediatric dentistry.

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