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Original Article

Dentistry Section

Comparative Evaluation of Single Buccal Infiltration of 4% Articaine versus Buccal and Palatal Infiltration of 2% Lignocaine in Patients with Symptomatic Irreversible Pulpitis in Maxillary Molars: A Randomised Controlled Trial

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ABSTRACT

Introduction: For pain management during dental treatment procedure, Local Anaesthesia (LA) is essential. In cases of maxillary teeth buccal and palatal infiltration of 2% lignocaine is commonly used anaesthetic technique. Palatal injection is usually painful due to thick palatal mucosa which often causes discomfort to the patient. Buccal infiltration of 4% articaine can be used as a solution to the above problem due to its higher diffusion ability and thus additional palatal injection can be avoided.

Aim: To evaluate and compare the pulpal anaesthesia with buccal infiltration of 4% articaine and buccal and palatal infiltration of 2% lignocaine in patients with Symptomatic Irreversible Pulpitis (SIP) in maxillary molars.

Materials and Methods: This single-blinded, parallel-arm randomised controlled trial was conducted in the Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College and Hospital, Sumandeep Vidyapeeth Deemed to be University, Piparia, Vadodara, Gujarat, India, from January 2024 to June 2024. Healthy male and female patients aged 18-60 years who provided informed consent and presented with moderate to severe preoperative pain were included. All selected patients were diagnosed with SIP in maxillary molars and had a Visual Analogue Scale (VAS) score of ≥4 on a 1-10 scale.

A total of 182 patients were enrolled and randomly allocated into two groups: Group-A (n=91) received buccal infiltration with 4% articaine, and Group-B (n=91) received combined buccal and palatal infiltration with 2% lignocaine. Patients were instructed on the use of the VAS and trained on how to record their pain levels accurately, after which the preoperative VAS scores were obtained. LA was administered, followed by pulp sensibility testing at three and five minutes using an Electric Pulp Tester (EPT) to assess anaesthetic efficacy. The need for supplemental anaesthesia was also documented. Statistical analysis was performed using the Chi-square test to compare EPT responses and additional anaesthesia requirements, with a significance threshold of $p<0.05$.

Results: When assessing VAS scores after access, the majority of participants in both groups reported no pain (VAS score of 0), in 85/91 patients (93.4%) in Group-A and 80/91 patients (87.9%) in Group-B and mean VAS Score in Group-A is (0.22±0.85) and in group B is 0.38±1.07. There was no significant association between VAS scores after access preparation (p=0.253). At three minutes, 49/91 patients in Group-A and 50/91 in Group-B showed no EPT response, increasing to 81/91 and 75/91, respectively, at five minutes at highest value of EPT at 10 points. No statistically significant difference was observed between the groups at either three minutes (p=0.882) or five minutes (p=0.204). The number of additional anaesthesia doses required showed no significant association in both groups. (p=0.183).

Conclusion: Single buccal infiltration of 4% articaine is equally effective as buccal and palatal infiltration of 2% Lignocaine in cases of SIP in maxillary molars.

Keywords: Anaesthesia, Electric pulp tester, Preoperative

INTRODUCTION

The primary aim of dental procedures is to alleviate patient discomfort. However, pain management during these procedures can be challenging due to various behavioural, pharmacological, and procedural factors. LAs are essential for inhibiting nociception during dental treatments [1].

In the maxilla, infiltration anaesthesia is commonly used, whereas the mandible requires an inferior alveolar nerve block [2]. Infiltration in the maxillary arch involves two injections: one buccal and another palatal. The palatal injection, due to its thick and tight mucoperiosteum, is very painful [3]. Fear of such injections often causes anxiety in patients, leading them to avoid dental treatment [2].

Lidocaine, a widely used amide LA developed in the 1940s, blocks sodium channels in nerve membranes to prevent depolarisation. Despite its rapid onset (pKa 7.7) [4], its efficacy is reduced in inflamed tissues due to factors like acidity and increased blood flow [5]. This has driven the search for more potent alternatives. Lidocaine's limited lipid solubility also results in medium-duration action and reduced potency [4].

Articaine, a newer LA, has a pKa of 7.8, which enhances its diffusion across nerve membranes. Its thiophene ring increases lipid solubility, while the ester group allows rapid hydrolysis in the plasma, minimising systemic toxicity. Articaine's higher lipid solubility and rapid breakdown allow for higher concentrations (up

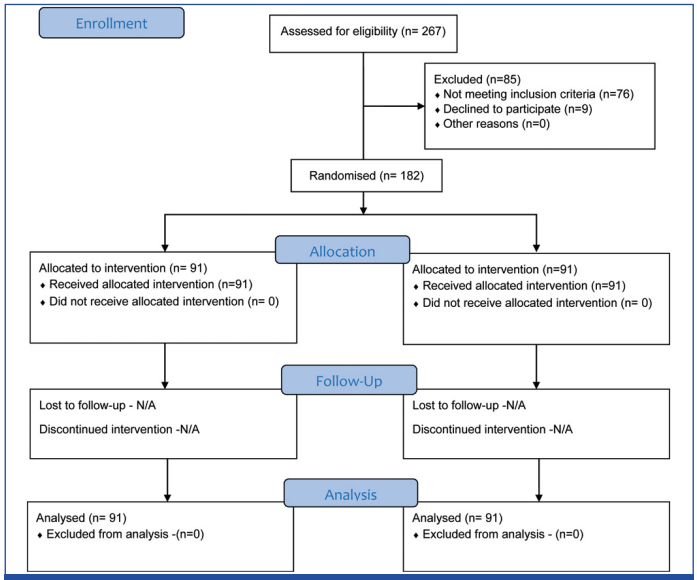
to 4%), and its superior diffusion across the thin maxillary bone allows palatal anaesthesia with just a buccal injection, eliminating the need for additional palatal injections, making it effective in achieving anaesthesia in the buccal and palatal regions of maxillary molars [6-9].

Previous studies have compared 2% lignocaine for buccal and palatal infiltration with 4% articaine for buccal infiltration in the extraction of maxillary premolars and molars [10,11]. However, research on pulpal anaesthesia for SIP is limited. Hence, the present study was conducted to evaluate and compare the pulpal anaesthesia with buccal infiltration of 4% Articaine and buccal and palatal infiltration of 2% Lignocaine in patients with SIP in maxillary molars.

The present study was designed with a null hypothesis stating that there was no significant difference between pulpal anaesthesia with buccal infiltration of 4% articaine and buccal and palatal infiltration of 2% Lignocaine in patients with SIP in maxillary molars, and the alternative hypothesis was that there was a statistically significant difference in both the treatment modalities.

MATERIALS AND METHODS

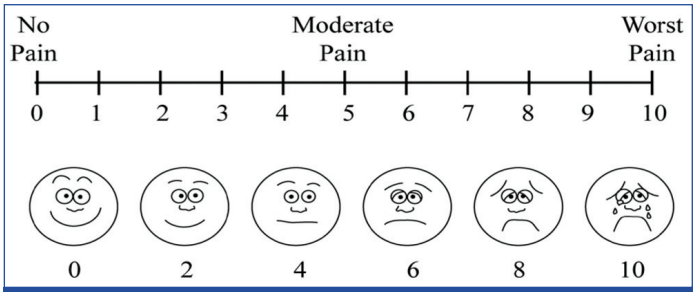
The present single-blinded, parallel-arm randomised controlled trial was carried out over six months, from January 2024 to June 2024, in the Department of Conservative Dentistry and Endodontics, K.M. Shah Dental College and Hospital, Sumandeep Vidyapeeth Deemed to be University, Piparia, Vadodara, Gujarat, India. The Institutional Ethics Committee (SVIEC/ON/Dent/SRP/Aug/23/12) granted prior ethical permission for the trial, and the protocols were entered into the Clinical Trials Registry - India (CTRI) database (CTRI/2024/01/061711). The Consolidated Standards of Reporting Trials (CONSORT) 2010 standards were followed in the study reporting [Table/Fig-1]. Patients were enrolled after written informed consent as per the eligibility criteria.



[Table/Fig-1]: CONSORT flow diagram.

Inclusion and Exclusion criteria: The study included systemically healthy male and female patients, ages 18 to 60 years, who were ready to give written informed consent, and encountered moderate to severe pain with VAS 4 or above (on 0 to 10 point, where 0 indicates no pain and 10 represents the highest pain, included) before treatment had been recognised as having SIP in their maxillary molars, with a VAS [Table/Fig-2] [12]. The study excluded people with severe gum diseases, compromised dental hygiene, those with allergies to LA, who were pregnant or nursing, and regularly took certain drugs, with liver disease and those with non vital teeth or sinus tracts.

Sample size calculation: Based on the study conducted by Sandilya V et al., which compared experimental Group-1 (single buccal infiltration of 4% articaine with 1:100,000 adrenaline) and control Group-2 (routine buccal and palatal infiltrations of 2% lignocaine with 1:200,000 adrenaline), the standard deviations for the key parameter- mean time to onset of action (minutes)- were taken as $\sigma 1 = 1.26$ for Group-1 and $\sigma 2 = 1.13$ for Group-2 [10]. The sample size was calculated by setting the study power at 80% and the alpha error at 5%. The formula used was



[Table/Fig-2]: VAS scale [12].

$$N = \frac{2(Z_1 - \frac{\alpha}{2} + Z_{1-\beta})^2 \sigma^2}{d^2}$$

A sample size of 91 per group was estimated. A total of 182 samples were included in the study.

Since there was no follow-up, drop-out was not considered. The whole study was conducted in the Department of conservative dentistry and endodontics in the Institute.

Using computer randomisation (www.randomizer.org), the participants were divided into two groups: Group-A received 4% articaine buccal infiltration (N=91), whereas Group-B received 2% lignocaine buccal and palatal infiltration (N=91). Allocation concealment was ensured with the SNOSE method with a 1:1 allocation/ratio. An independent researcher, not part of the experimental process, managed sequence creation and allocation concealment. The outcomes were assessed by two independent, blinded, and calibrated evaluators (kappa test score of 0.87), who were not involved in the experimental procedures.

Study Procedure

Preoperatively, the patient was informed about the VAS score, and the preoperative VAS score was recorded [12].

- 0-3 mild pain
- 4-6 moderate pain
- 7 and above severe pain

In this study, total of 267 participants were assessed; among these, 85 participants did not follow the inclusion criteria, and nine participants declined to participate in the study. A total of 182 participants participated in the study. So, in each group, 91 participants were assigned [Table/Fig-1].

Group-A: Buccal anaesthesia of 4% Articaine Hydrochloride (n=91): In a metal syringe, a 1.7 mL cartridge containing 1:100,000 epinephrine and 4% articaine hydrochloride (Septanest, Septodont, France) was added. The patient was instructed to recline in the dental chair in a semi-supine position, a few inches below the operator's elbow level. To increase patient comfort, a topically applied local anesthetic gel containing lignocaine (Lignospan-O, Septodont, France) was used at the injection site. According to Malamed's approach, one infiltration injection was administered at the buccal location [12]. The apex of the tooth being anesthetised was above the level of the mucobuccal fold, where a short, 27-gauge needle was placed. The injections were given slowly about 1 milliliter each minute. The tooth crown, root contour, and mucobuccal fold served as landmarks for infiltrations. The needle's point was angled in the direction of the bone. To make sure the needle point was outside of a blood vessel, a two-plane negative aspiration technique was used.

Group-B: Buccal and palatal infiltration of 2% lignocaine hydrochloride (n=91): Enrolled participants received 1.3 mL buccal

and 0.5 mL palatal infiltration of 2% lignocaine (Lignospan Special, Septodont, France) with 1:80,000 adrenaline. The same protocol as Group A was followed, with two injections: one on the buccal side and one on the palatal side, in accordance with Malamed's technique [13]. For the palatal infiltration, the needle was inserted perpendicular to the palatal mucosa, crossing the midline near the root apex.

Evaluation

After injecting LA, the onset was documented by a blinded co-investigator, who confirmed both subjective signs (numbness reported by the patient) and objective signs using Electrical Pulp Testing (EPT). At three minutes, the first EPT evaluation was performed. At five minutes, the second EPT score was again evaluated. After five minutes, access was gained using a medium-sized round diamond abrasive point under rubber dam isolation. Another VAS was recorded after gaining access to the pulp chamber. If the patient reported pain, additional injections were given, and complete chemo-mechanical preparation was done in the same appointment.

Clinical evaluation criteria: A VAS scale was recorded after gaining access to the pulp chamber for postoperative readings. If patients experienced pain, the same anaesthetic agents were administered according to the assigned groups, and the quantity of additional cartridges was recorded.

STATISTICAL ANALYSIS

Statistical analysis was done using IBM Statistical Package for Social Sciences (SPSS) software version 20.0. Inter-group comparison of the VAS score was done with an independent t-test. Chi-square test was used to compare pulp response with EPT and the requirement of additional anaesthesia.

RESULTS

Distribution of participant based on gender is seen in [Table/Fig-3]. The gender allocation between the two groups does not differ statistically significantly in this distribution with Chi-square test (p=0.765).

According to an independent t-test comparison of the two groups' in [Table/Fig-4] preoperative VAS ratings, which was statistically non significant (p=0.37). Group-B scored higher when comparing their VAS scores after access which was equally statistically non significant (p=0.253).

The intragroup comparison of preop VAS score and VAS score after access preparation with independent t-test for both Group-A (4% Articaine) and Group-B (2% Lignocaine) shows statistically significant reductions in pain levels after the administration of LA. In Group-A, the mean difference was 6.22±1.05, with a p-value of <0.001, indicating a highly significant reduction in pain after anaesthesia administration. Similarly, Group-B had a mean preoperative VAS score of 6.15±1.2, with a p-value of <0.001, also reflecting a statistically significant decrease in pain [Table/Fig-5].

These results demonstrate that both anaesthetic techniques are effective in significantly reducing pain during dental procedures.

The intergroup comparison was done with Chi-square test. There was no statistically significant difference between the groups in the present study (p=0.203, Chi-square=1.622), with six patients from Articaine group and 11 patients from the Lignocaine group reporting pain after access [Table/Fig-6].

Groups		Mean difference±SD	T value	p-value
Group-A	preop VAS	6.22±1.05	56.40	<0.001
	VAS after access			
Group-B	preop VAS	6.15±1.2	48.87	<0.001
	Vas after access			

[Table/Fig-5]: Intragroup preop VAS and VAS after access preparation comparison.
Test applied - Paired t-test (p<0.001), SD: Standard deviation, VAS: Visual analogue scale, p<0.05 set as statistically significant

	Categories	N	Group		Chi-square	p-value
			Group-A n (%)	Group-B n (%)		
Preop pain presence	Pain Absent	0	0	0	.	.
	Pain Present	182	91 (100)	91 (100)		
Pain after access	Pain Absent	165	85 (93.4)	80 (87.9)	1.622	0.203
	Pain Present	17	6 (6.6)	11 (12.1)		

[Table/Fig-6]: Comparison of the pain before and after anaesthesia.
Test applied - Chi-square test (p=0.203), n=number, SD: Standard deviation, p<0.05 set as statistically significant

In the pulp sensibility test, 42 teeth in the lignocaine group and 41 teeth in the articaine group responded after three minutes, and 10 teeth in the lignocaine group and 16 teeth in the articaine group responded after five minutes. (p=0.882 at three minutes and p=0.204 at five minutes). These results were not statistically significant. Additionally, there was no significant association between the need for additional anaesthesia dose. A total of 85 (93.4%) patients in Group-A and 80 (87.9%) patients in Group-B did not require additional anaesthesia (Chi-square=3.402, p=0.183) [Table/Fig-7].

Gender distribution							
Variables			Groups		Total	Chi-square test value	p-value (<0.05 is significant)
			Group-A	Group-B			
Gender	Female	Count	50	52	102	0.089	0.765
		% within Group	54.9%	57.1%	56.0%		
	Male	Count	41	39	80		
		% within Group	45.1%	42.9%	44.0%		
Total		Count	91	91	182		
		% within Group	100.0%	100.0%	100.0%		

[Table/Fig-3]: Gender-wise distribution in both the group.
Test applied- Chi-square test (0.089) with p-value (0.765), p<0.05 set as statistically significant.

Variables	Group-A (n=91) Mean±SD	Group-B (n=91) Mean±SD	T value	p-value
Preop VAS	6.44±0.75	6.54±0.74	-0.899	0.37
VAS during entering into the pulp	0.22±0.85	0.38±1.07	-1.147	0.253

[Table/Fig-4]: Intergroup comparison of VAS score.
Test applied- independent t-test (p=0.37, 0.253), n=number, SD: standard deviation; VAS: Visual analogue scale, p<0.05 set as statistically significant

DISCUSSION

The introduction of LA agents revolutionised pain-free dentistry, becoming essential in endodontics. These agents play a crucial role

Parameters	Categories	N	Groups		Chi-square	p-value
			Group-A (4% Articaine) N (%)	Group-B (2% Lignocaine) N (%)		
Preop EPT response	Absent	0	0	0	.	.
	Present	182	91 (100)	91 (100)		
After 3 minutes EPT response	Absent	99	49 (53.8)	50 (54.9)	0.022	0.882
	Present	83	42 (46.2)	41 (45.1)		
After 5 minutes EPT response	Absent	156	81 (89)	75 (82.4)	1.615	0.204
	Present	26	10 (11)	16 (17.6)		
No. of additional anaesthesia required	0	165	85 (93.4)	80 (87.9)	3.402	0.183
	1	16	5 (5.5)	11 (12.1)		
	2	1	1 (1.1)	0		

[Table/Fig-7]: Comparison of pulp testing and requirement of additional anaesthesia.
Test applied- Chi-square test; EPT: Electric pulp test; p<0.05 set as statistically significant

in minimising patient discomfort during routine procedures, ensuring they are performed efficiently. The effectiveness of anaesthesia is influenced by several factors, including anatomical variations, clinician expertise, and the composition of the anaesthetic.

The present study found no statistically significant difference between the two groups in terms of mean VAS score after gaining the access and pulp sensibility test with EPT leading to the acceptance of null hypothesis. This suggests that 2% lignocaine for both buccal and palatal infiltration is as effective as 4% articaine for buccal infiltration. Lignocaine, a commonly used anaesthetic in dentistry, remains highly effective in achieving adequate anaesthesia.

A recent systematic review and meta-analysis by Soysa SN et al., concluded that 2% lignocaine is effective for maxillary infiltration anaesthesia [14]. Lignocaine works by blocking voltage gated Na^+ channel in the nerve membrane. Due to the porous nature of maxillary bone, anaesthetic solutions can easily penetrate till the nerve membrane, resulting in high efficacy. So, lignocaine is highly successful as infiltration agents in maxillary molars with systematic irreversible pulpitis [2].

Numerous studies have concluded that maxillary palatal injections are highly painful [15,16]. This discomfort is primarily attributed to the close adherence of the palatal mucosa to the underlying periosteum and its rich nerve supply [17]. The pain seems to stem more from the displacement of the mucoperiosteum than from the needle penetrating the mucosa itself [18].

In an effort to minimise the pain associated with palatal anaesthesia, researchers have explored the use of single buccal infiltration. However, studies on symptomatic maxillary molars with irreversible pulpitis have demonstrated that buccal infiltration alone, without palatal injection using 2% lignocaine, results in lower success rates, particularly in maxillary first molars, where the success rate is only about 30% [19].

Furthermore, research indicates that maxillary molars with longer palatal roots are more likely to experience anaesthetic failure when only buccal infiltration is used [20]. It is recommended to utilise palatal infiltration to achieve appropriate anaesthesia during endodontic treatment of maxillary molars, as this is likely caused by the anaesthetic's inadequate diffusion from the buccal vestibule to the apex of the palatal root.

To address the limitations of lignocaine, articaine was introduced. While articaine shares a similar mechanism of action with lignocaine, its unique chemical structure with a thiophene ring and higher lipid solubility, 4% articaine offers greater diffusion ability compared to lignocaine. This makes it possible to provide enough anaesthetic in maxillary teeth with just one buccal infusion, even in situations where pulpitis is symptomatic [6]. In another similar study conducted by Kumar U et al., compared the anaesthetic efficacy of buccal infiltration versus combined buccal–palatal infiltration using 2% lidocaine and 4% articaine in maxillary first molars diagnosed with SIP [21]. A total of 117 patients were analysed across three groups: buccal infiltration with lidocaine, buccal plus palatal infiltration with lidocaine, and buccal infiltration with articaine. Pain levels during endodontic procedures were measured using the Heft-Parker VAS, with success defined as no pain or mild pain . The highest success rate was observed in the buccal plus palatal lidocaine group (85%), followed by articaine (74%) and buccal lidocaine (69%). However, these differences were not statistically significant. Gender showed no influence on anaesthetic success across all groups. But this study involved a smaller sample size. However, such studies are limited, making this research a valuable contribution to the field. Additionally, articaine has been studied in other areas of dentistry, such as extractions using only buccal infiltration in maxillary molars, further supporting the findings of the present study [9-11].

The present study paves the way for further research on the broader use of articaine in dental procedures. Future studies with larger, more diverse populations are needed to confirm these findings and enhance their generalisability. Long-term follow-up research will be valuable in assessing the sustained efficacy and potential side-effects of 4% articaine. Additionally, comparative studies of different concentrations of articaine and lignocaine in complex extractions or treatments for medically compromised patients could offer valuable insights. Finally, exploring patient-reported outcomes, such as comfort and satisfaction, will help optimise pain management strategies in dentistry.

Limitation(s)

Although no confounding factors were identified in the study, it is limited by a lack of control over variables such as operator differences, patient anxiety, and anatomical variations that could influence anaesthetic outcomes, and its conduct within a controlled clinical setting that may not fully represent real-world patient diversity and conditions.

CONCLUSION(S)

Within the limitations of the present study, it can be concluded that a single buccal infiltration of 4% articaine is as effective as the combined buccal and palatal infiltration of 2% lignocaine for achieving pulpal anaesthesia in maxillary molars with SIP, while also offering a less painful alternative by eliminating the need for a palatal injection. Based on these findings, 4% articaine can be recommended for single buccal infiltration; however, further research with larger sample sizes, varied patient groups, and comparisons involving additional anaesthetic techniques is necessary to validate and expand the clinical applicability of these results.

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