Original Article

A Randomized Control Trial Comparing Buccal Infiltration of 4% Articaine with Buccal and Palatal Infiltration of 2% Lignocaine for the Extraction of Maxillary Premolar Teeth

Vikas Sandilya, Neelam Noel Andrade, Paul C. Mathai, Neha Aggarwal, Vyankatesh Sahu, Shibani Nerurkar

Department of Oral and Maxillofacial Surgery, Nair Hospital Dental College, Mumbai, Maharashtra, India

Abstract

Introduction: The use of articaine has been claimed to obviate the need for routine palatal local anesthetic injections on account of its better diffusion through soft and hard tissues as compared to other local anesthetic agents. **Objective:** The objective of the study is to evaluate the efficacy of 4% articaine (with 1:100,000 adrenaline) infiltrated only buccally in the extraction of maxillary premolars for orthodontic reasons. **Materials and Methods:** A double-blind randomized clinical trial with a split-mouth design, where each patient (n = 100) was part of two groups, was conducted. Experimental Group 1: single buccal infiltration of 4% articaine with 1:100,000 adrenaline (Septanest™ with adrenaline 1:100,000 by Septodont). Control Group 2: routine buccal and palatal infiltrations of 2% lignocaine with 1:200,000 adrenaline (Lox™ 2% with adrenaline 1:200,000 by Neon). The parameters studied were time to onset of anesthesia, pain during the extraction procedure (not during the injecting of the local anesthetic), and frequency of extra amount of local anesthetic injected. **Results:** The difference was not statistically significant ($P > 0.05$) between the two groups with respect to all three parameters. This proves that a single buccal infiltration of articaine can be used as an alternative to lignocaine for the extraction of the maxillary premolar teeth in most of the cases. **Conclusion:** This proves that a single buccal infiltration of articaine can be used as an alternative to lignocaine for the extraction of the maxillary premolar teeth in most of the cases.

Keywords: *Articaine, lignocaine, maxilla, premolar, single injection*

Introduction

Topical local anesthetics are commonly used to make needle penetration painless by providing surface anesthesia. However, palatal injections (e.g., local anesthetic infiltration for extraction of the maxillary teeth) continue to remain painful on account of the dense attachment of the palatal soft tissues to the underlying bone.[1,2] Badenoch-Jones and Lincoln,[3] in a systematic review, questioned the need for a palatal injection in the extraction of a maxillary tooth. Uckan *et al*.[4] was one of the first clinicians who claimed that articaine obviated the need for routine palatal injections on account of its better diffusion through soft and hard tissues as compared to other local anesthetic agents.

The purpose of this study was to evaluate the clinical efficacy of buccally infiltrated 4% articaine in comparison to routine buccal and palatal infiltration of 2% lignocaine during the extraction of maxillary premolars.

Materials and Methods

Study design

A double-blinded randomized clinical trial with a split-mouth design was carried out in the Department of Oral and Maxillofacial Surgery (Nair Hospital Dental College, Mumbai) from 2013 to 2016 after acquiring Institutional Ethics Committee approval for the same. The study group consisted of patients who attended the outpatient department for bilateral extractions of permanent noncarious maxillary first or second premolars for orthodontic reasons. The exclusion criteria were as follows: (a) known or suspected allergies or sensitivities to sulfites, amide-type local anesthetics, or any ingredients in the anesthetic solution, (b) concomitant cardiac or neurological disease, (c) pregnant/

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Address for correspondence:
Dr. Neelam Noel Andrade, Department of Oral and Maxillofacial Surgery, Nair Hospital Dental College, Room No. 107, A L Nair Road, Mumbai Central, Mumbai - 400 008, Maharashtra, India.
E-mail: drnnandrade@yahoo.co.in

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lactating mothers, (d) concomitant use of monoamine oxidase inhibitors, tricyclic antidepressants, phenothiazines, vasodepressor drugs, or ergot-type oxytocic drugs, (e) individuals who were on sedatives, (f) individuals who had taken aspirin, acetaminophen, or any other nonsteroidal anti-inflammatory drugs 24 h before administration of local anesthetic, and (g) individuals who had premolars with irreversible pulpitis.

Considering the mean and standard deviation (SD) values from literature, sample size was calculated using the formula $n = [2 (Z_\alpha + Z_\beta)^2 (s)^2]/[d^2]$ where Z_α is the Z variate of alpha error, that is, a constant with value 1.96, Z_β having a value of 0.84, "s" is the SD, and "d" is the mean difference, values of which are taken from the parent article. Other estimates were as follows: 80% power, Type I error to be 5%, Type II error to be 20%, true difference of at least 2 units (visual analog scale [VAS] as the primary outcome) between the groups and a pooled SD of 5.[5] Once the values were substituted in the above formula, the sample size was determined to be 98. Thus, a sample size of $n = 100$ was determined.

On account of the split-mouth design, each patient was a part of two groups. In Group 1, extractions were done under buccal infiltration of 4% articaine with 1:100,000 adrenaline (Septanest™ with adrenaline 1:100,000 by Septodont; Experimental group). In Group 2, extractions were done under buccal and palatal infiltrations of 2% lignocaine with 1:200,000 adrenaline (Lox™ 2% with adrenaline 1:200,000 by Neon; Control group).

The parameters studied were time to onset of anesthesia, pain during the extraction procedure (not during the injecting of the local anesthetic), and frequency of extra amount of local anesthetic injected [Figure 1].

Randomization

To avoid bias, a computer-generated randomization sequence was utilized. The first randomization was used to decide if articaine was injected before or after lignocaine. The second randomization was used to determine if articaine was injected on the right or left side.

Blinding

Author VYS was responsible for randomizing the sequence and side for injecting the two local anesthetics in the same patient using a computer-generated randomization model. Author VYS was also responsible for administering the local anesthetic. During the extraction, the patients were unaware of the contents of the syringes as they were loaded away from their eyesight. It is also worth mentioning that the informed consent did not mention the fact that one of the two groups required only a single buccal infiltration as compared to the other group that required both a buccal and palatal infiltration. The dental extraction and the recording of the study parameters were performed by author VKS (who was blinded to which side articaine and lignocaine solutions were deposited). Thus, the study can be considered to be double blinded.

Methodology

Bilateral extractions were carried out in the same appointment. As per the randomization sequence, every participant was administered buccal (1.75 ml) and palatal (0.5 ml) infiltration of 2% lignocaine with 1:200,000 adrenaline on one side and only buccal infiltration (1.75 ml) of 4% articaine with 1:100,000 adrenaline on the other side by author VYS. All injections were administered at a slow rate of approximately 1 ml/min to minimize trauma. A waiting period of at least 3 min was maintained from the time of injection. The time for onset of anesthesia was recorded by author VKS on confirming the presence of objective signs of local anesthesia followed by which the premolars were extracted using an extraction forceps. The participants were asked to score the pain experienced during extraction alone (not during injection of the anesthetic) for both sides on a 100-mm VAS. The follow-up had no association with the objectives of the study as pain response only during the intervention was recorded. The study was stopped once the sample size of 100 was reached.

During the above study, failure of the initial infiltration to produce adequate anesthesia was confirmed by author VKS if objective signs of local anesthesia were absent. In the above event, additional infiltrations of the local anesthetic were administered by author VYS as follows:

- Failure buccal local anesthesia in either of the groups – additional buccal infiltration of 1.75 ml of the local anesthetic (of the particular group) was administered
- Failure of palatal local anesthesia in the Articaine group – additional palatal infiltration of 0.5 ml of articaine was administered
- Failure of palatal local anesthesia in the Lignocaine group – additional palatal infiltration of 0.5 ml lignocaine was administered.

Data obtained were compiled on an MS Office Excel Sheet (v2010) and was subjected to statistical analysis using the Statistical Package for the Social Sciences (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). Intergroup comparison of outcome variables such as time to onset of anesthesia and VAS for pain was done using *t*-test. Comparison of the frequency of extra amount of local anesthetic was done using Chi-square test. For all the statistical tests, $P < 0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study as 80%.

Results

A total of 100 patients were included in the study, of which 64 were male and 36 were female. The mean age of the

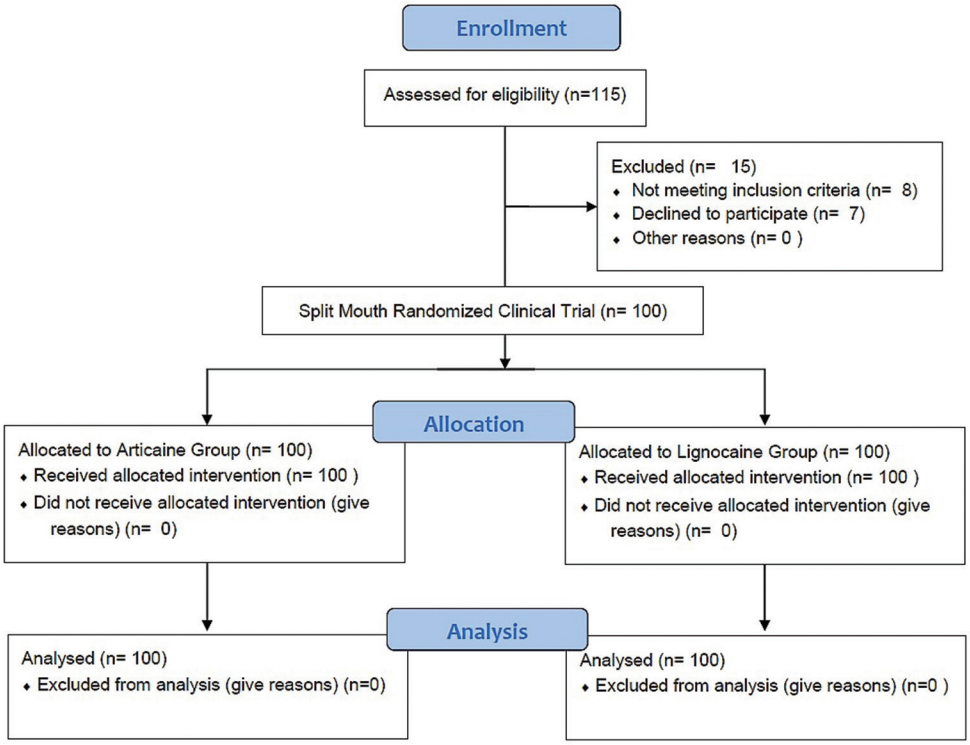

Figure 1: Flowchart outlining distribution of patients in the study

study sample was 18 years (age range of 12–30 years). A total of 128 first maxillary premolar extractions and 72 s maxillary premolar extractions were performed.

The mean time to onset of action was similar in both the groups (experimental group 4.43 min and control group 4.19 min) with a marginal difference which was not statistically significant ($P = 0.159$) [Table 1].

The pain responses during extractions recorded on VAS were similar for both the groups with marginal differences. None of the patients experienced unbearable pain. Most of the extractions in both the groups belonged to the VAS-1 category, followed by the VAS-0 and none of them in either group going beyond VAS-4. Hence, the difference was not statistically significant between the two groups with mean VAS scores of 1.07 for the experimental group and 1.04 for the control group and a $P = 0.784$ [Table 1].

Another parameter we looked upon for the comparison of efficacy of the two anesthetics was the additional anesthesia administered in each group. None of the patients required more than one additional buccal or palatal infiltrations. The number of additional palatal injections was 6 in the experimental group, thus being marginally higher as compared to 4 in the control group. Similarly, five patients required additional buccal infiltrations in the experimental group as compared to four in the control group. However, on applying the Chi-square test (Chi-square = 0.561, df = 2, $P = 0.755$), these differences did not reach statistical significance level [Table 2].

Discussion

Articaine is one of the most recently introduced anesthetic drugs and initially entered clinical usage in Germany in 1976. It is a unique amide local anesthetic with an additional ester linkage which allows it to be metabolized by both the cytochrome P450 enzymes in the liver and nonspecific esterases in the plasma. Majority of the articaine is metabolized by plasma esterases (approximately 90%) in a fairly fast process as compared to the slower metabolism that takes place in the liver (approximately 10%). On account of its dual metabolism, articaine has a half-life of 20 min which results in lower systemic toxicity, thereby making repeated injections and use of higher concentrations possible (commercial formulations have a 4% concentration). However, studies have proved that the anesthetic concentration (4% articaine vs. 2% articaine) had no statistically significant effect on clinical efficacy.[6,7]

Numerous clinical studies have the superior bone penetrating property of articaine.[8-14] Oertel *et al*. proved that higher concentrations of articaine were found in blood harvested from the alveolus as compared to lignocaine which corresponds to the better diffusibility and higher concentrations of the drug in both hard and soft tissues.[15,16] This property of bone penetration could be attributed to the local saturation of serum esterases, the higher concentration of articaine (4% articaine as compared to 2% lignocaine) being used on account of which a steeper concentration gradient is created and the intramolecular hydrogen bonding property of articaine.[16,17]

Table 1: Comparison of mean time to onset of action (minutes), visual analog scale for pain (mm), and duration of anesthesia (hours) between the groups using the unpaired *t*-test

Parameter	Groups	*n*	Mean	SD	SE mean	Mean difference	*t*	*P*
Onset of action (min)	1	100	4.43	1.265	0.127	0.240	1.412	0.159
	2	100	4.19	1.134	0.113			
VAS for pain (mm)	1	100	1.07	0.756	0.076	0.030	0.274	0.784
	2	100	1.04	0.790	0.079			

SD: Standard deviation; SE: Standard error; VAS: Visual analog scale

Table 2: Comparison of frequencies of additional local anesthetic injections between the groups

Groups	Extra amount of LA				Total
	No extra LA needed		Buccal	Palatal	
Articaine	89	11	5 (of 11)	6 (of 11)	100
Lignocaine	92	8	4 (of 8)	4 (of 8)	100
Total	181	19	9	10	200
χ^2			0.561		
df			2		
P			0.755		

LA: Local anesthetic

The above study was a double-blinded randomized clinical trial in which articaine was compared against the gold standard for local anesthetics, that is, lignocaine.[6] The same patient was a part of both groups; hence, it was assumed that the effect of age and gender on the results would be minimized. The parameters studied were duration for onset of action, pain during extraction, and frequency of extra amount of local anesthetic injected.

Pain measurement is difficult to establish because its perception and intensity are subjective. Although VAS may show deficiencies regarding understanding and perception, it provides a validated and meaningful measure of anesthetic efficiency.[18,19] In their study, Fan *et al*.[20] reported that according to the VAS scores, the pain of injection between buccal infiltration of articaine in permanent maxillary teeth without a separate palatal injection and routine buccal administration with additional palatal injection was statistically significant ($P < 0.05$). However, the VAS scores for permanent maxillary tooth extraction showed no significant difference between the two types of injection ($P > 0.05$). Malamed *et al*.[21] also proved that similar pain relief was obtained between 4% articaine and 2% lignocaine. In our study, we also found that there was no statistically significant difference in pain experienced during extractions with articaine and lignocaine with VAS scores lying between 0 and 4 in both the groups.

Onset of action must be considered when comparing two or more local anesthetics. An ideal agent should have a short onset and should last long enough to allow the completion of the procedure. Articaine is said to have a faster onset of action on account of its superior bone penetrating property and presence of a thiophene ring (as compared to the benzene ring of other amide anesthetics) which allows for greater lipid solubility and diffusion of a larger amount of the local anesthetic into the nerve.[6] A lower pKa of 7.8 (as compared to a pKa of 7.9 of lignocaine) allows for a larger fraction of uncharged base molecules that will be available to diffuse through the nerve sheath and can be said to contribute in a minor way to quicker onset of action. The present study recorded a mean onset of action of 4.43 min (articaine) as compared to 4.19 min (lignocaine) with a difference of approximately 15 s which was considered as statistically nonsignificant. Some studies attribute an increased duration to onset of action for articaine on account of the increased diffusion time to achieve adequate palatal anesthesia after a single buccal infiltration.[21] However, it must be noted that various factors (individual response to the drug, accuracy in deposition of the local anesthetic, status of tissue at the site of drug deposition, anatomical variation, and volume of the anesthetic used) exist that affect the above parameter.

The frequency of additional local anesthetic administered was the final parameter studied. The number of additional palatal infiltrations with articaine (in addition to routine buccal infiltration) is 6% while that of lignocaine (in addition to routine buccal and palatal infiltration) is 4%. No statistically significant difference was found between the two groups in this respect [Table 2].

In our study, both agents had a similar duration for onset of action of 4–5 min. The pain during extraction in both groups was similar with a VAS range of 0–4. A similar number of additional infiltrations were needed in both groups in case of incomplete anesthesia. Thus, the results of our study are similar to that of the available literature and indicate that articaine is equally effective and safe when compared to other local anesthetics.[21-24]

No study is without its limitations. The primary drawback of our study was the small sample size. The teeth extracted were restricted to maxillary premolars, and hence, no differentiation between maxillary anterior and posterior teeth was made. The age group studied was young with a mean age of 18 years (range of 12–30 years) as the teeth were primarily extracted for orthodontic purposes. Bone at a younger age tends to be more porous in nature which could be a contributing factor to the clinical success of the study. Another drawback of our study was that if articaine infiltration failed to provide adequate palatal anesthesia, a

palatal infiltration of articaine was made instead of giving a supplemental buccal infiltration and then observing for signs of adequate anesthesia.

The protocols suggested by the Badenoch-Jones and Lincoln[3] in their systematic review could help generate more accurate clinical data for a study of this nature: the use of saline palatal injection as the control, determining unsuccessful anesthesia by pain during the procedure rather than by probing of the mucosa and the protocol utilized for cases of failed initial anesthesia (supplemental buccal injection and if unsuccessful after 5 min and supplemental palatal injection).

The confounding factors of our study included the differing concentrations of adrenaline used in both anesthetic preparations (Loxt™ with 1:200,000 vs. Septanest™ with 1:100,000) and differing concentrations of anesthetic agent as well (4% articaine vs. 2% lignocaine). However, a review of the literature by Yapp *et al*.[6] stated that articaine preparations with 4% versus 2% concentrations and 1:100,000 or 1:200,000 concentrations of adrenaline had a similar clinical efficacy.[25,26] Similarly, there is no effect of varying concentrations of adrenaline on the clinical efficacy of lignocaine (apart from hemostasis).[27]

Conclusion

The results of our study prove that a single buccal infiltration of articaine can be used as an alternative to lignocaine for the extraction of maxillary premolar teeth in most of the cases. Further controlled clinical trials with larger sample size are essential to bring valuable contribution to this research area. Special attention could be paid to studying the age-wise clinical efficacy and degree of soft-tissue palatal anesthesia on buccal infiltration of 4% articaine.

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The cost of the local anesthetic was borne by the first author.

Conflicts of interest

There are no conflicts of interest.

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