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Buccal versus buccal palatal infiltration for pulpal anesthesia using 2% lidocaine and 4% articaine: A randomized controlled trial

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ABSTRACT

Background: The inability in achieving complete pulpal anesthesia with standard buccal infiltration especially in cases with SIP used for maxillary teeth. The study aimed to compare the anesthetic efficacy of buccal and buccal plus palatal infiltration technique using 2% lidocaine and 4% articaine in permanent maxillary first molars with the diagnosis of symptomatic irreversible pulpitis (SIP).

Material and method: One hundred and twenty-three patients with clinical diagnosis of SIP, aged 18–50 years were randomly allocated to three treatment groups (N = 41). Group 1(BIL): Buccal infiltration technique using 2% lidocaine with 1:80,000 adrenaline. Group 2(BPIL): combination of buccal plus palatal infiltration using 2% Lidocaine with 1:80,000 adrenaline. Group 3(BIA): Buccal infiltration using 4% articaine with 1:100,000 adrenaline. Pain intensity of patients were recorded before and after the administration of local anesthesia during endodontic procedure that is during caries removal, access preparation and pulp removal using Heft-Parker Visual Analog Scale (HP-VAS). Success was defined by "no pain (0 mm)" or "mild pain (0–54 mm)" during endodontic procedure. The anesthetic efficacy rates were analyzed using chi-square tests, age differences using one-way ANOVA.

Results: The final analysis included total of 117 patients. Higher success was observed in group II (85%) in comparison to group I (69%) and group III (74%), but the difference was statistically nonsignificant ($p > 0.05$). Our results demonstrated a nonsignificant difference between genders in all three groups ($p > 0.05$).

Conclusion: The use of buccal plus palatal infiltration and 4% articaine can provide effective anesthesia as standard buccal infiltration and 2% lidocaine for patients with SIP in maxillary first molars.

1. Introduction

Dental professionals face profound challenge in obtaining proper pulpal anesthesia especially, while treating teeth with symptomatic irreversible pulpitis (SIP). Study reported lower success rate and eight-fold higher risk of failure in teeth with irreversible pulpitis in comparison to normal pulps.[1,2] Mandibular molars are the most difficult in terms of achieving anesthesia for teeth with SIP, followed by mandibular premolars, maxillary molars, maxillary premolars, and mandibular anterior teeth.[3] This difference can be attributed to the anatomical variations in the cortical plate thickness and density over the maxillary and mandibular teeth.[4]

Several studies have reported success rates ranging from 72% to 100% when standard buccal infiltration technique is used for maxillary teeth. Evans et al.,[5] Mason et al.,[6] and Katz et al.[7] reported success rates of 72%, 97% and 83% respectively when buccal infiltration was done using 1.8 mL of 2% lidocaine in cases with non-inflamed pulps. These findings suggest that there might be some hindrance in the diffusion of local anesthesia (LA) solution from buccal to palatal root apex area of the maxillary posterior teeth which might explain the inability in achieving complete pulpal anesthesia with single buccal infiltration especially in cases with SIP.

Furthermore, Premdas and Pitt Ford et al.[8] and Lee et al.[9] have demonstrated that the pulpal anesthesia of the first premolar could also be achieved through only palatal infiltration using 1 ml of 2% lignocaine with 1:80,000 adrenaline which indicates that some degree of pulpal

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anesthesia can be achieved by palatal approach (using Electric Pulp Tester). Study by Guglielmo et al.[10] found a nonsignificant difference in the success rates between buccal infiltration (88%) and combination of buccal and palatal infiltration technique (95%) using 2% lidocaine in cases with unaffected and asymptomatic maxillary first molars. There are lack of studies comparing the anesthetic efficacy with different techniques in maxillary teeth with SIP.

Articaine is another amide LA agent which is known for providing a prolonged local anesthetic effect. This can be attributed to its higher lipid solubility as compared to Lidocaine because of the presence of an additional thiophene ring in its chemical moiety. Additionally, this agent has a strong affinity for proteins, which allows it to diffuse through bony tissues.[11] Reported success rate of buccal infiltration using 4% Articaine with 1:100,000 adrenaline in healthy maxillary first molars is 78%.[12]

To the best of our knowledge, no prospective studies have evaluated and compared the standard buccal infiltration with buccal plus palatal infiltration and efficacy of Articaine with Lidocaine for buccal infiltration only in maxillary first molars with SIP.

Thus aim of this clinical trial was to compare the efficacy of buccal infiltration with buccal plus palatal infiltration and 2% Lidocaine with 4% Articaine in SIP maxillary first molars.

2. Materials and methods

2.1. Study design

A triple-blinded, randomized clinical trial was conducted on patients with SIP in maxillary first molars in which the patients, clinician administering the LA solution and the outcome assessor were blinded.

2.2. Ethical approval and informed consent

In accordance with the Helsinki Declaration, Ethical approval for the study was obtained from the Institute Ethics Committee (IEC-12/2020-1874) and the study protocol was registered with the database of Clinical Trials Registry-India (CTRI/2021/05/033,659). Informed consent was taken from all the eligible participants after a detailed explanation of the procedure.

2.3. Sample size calculation

A total of 123 subjects (n = 41 in each group) were included in the present study. Taking a 95% confidence level, anticipated proportional difference of 20% in anesthetic success and design effect of 1, it was estimated to enrol 37 patients in each group with 80% power. Considering the dropout rate of 10%, it was decide to recruit at least 41 patients in each group.

2.4. Inclusion criteria

Healthy patients between the age group of 18–50 years with SIP in maxillary first molars and who were able to understand the use of pain scales,[13] with a history of moderate to severe pain gauged using the Heft-Parker Visual Analog Scale (HP-VAS)[14] and a prolonged response to cold pulp testing using Endofrost (Roeko, Coltene, Germany).

2.5. Exclusion criteria

Patients of age lesser than 18 years and more than 50 years, pregnant patients, known allergies to LA, patients under medications (sedatives, anti-anxiety drugs, antidepressants, and analgesics) that could influence pain perception, patients experiencing active pain in tooth other than maxillary first molar, teeth with periapical radiolucency having periapical index >2 (PAI>2) and no response to cold pulp testing, failure on buccal infiltration injection, non-restorable teeth, tooth with extreme curvature of root canals and subjects who are unable to provide informed written consent were excluded.

2.6. Pain assessment and categorization

The patient was informed to mark the response against the suitable category on the scale if any pain experienced during the clinical procedure (preoperatively, conventional access opening with dentin penetration, entry in the pulp chamber space, and during negotiation of the root canals till working length).

Success was determined by 'no pain experienced (0 mm)' or 'mild pain (0–54 mm) during access cavity preparation and file insertion till full working length.

2.7. Randomization and allocation concealment

The clinician was blinded for the allocation and sequencing of groups. 123 participants were randomly allocated to 3 groups (n = 41) using stratified random sampling with a 1:1:1 allocation ratio.

i. **Group I (Control Group):** Buccal infiltration anesthesia (BIL) using 2% Lidocaine with 1:80,000 adrenaline (Lignospan, Septodont, France).
ii. **Group II:** Combination of Buccal and Palatal infiltration (BPIL) using 2% Lidocaine with 1: 80,000 adrenaline (Lignospan, Septodont, France).
iii. **Group III:** Buccal infiltration using 4% Articaine (BIA) with 1:100,000 adrenaline (Septanest; Septodont, France).

2.8. Blinding

Investigator responsible for screening and recruiting the subjects was not allowed to intervene in the subsequent steps of the trial. Clinician administering the LA solution along-with intervention and the outcome assessor were blinded.

2.9. Intervention

Topical anesthetic gel (Benzocaine 20% jel, ProGel B, Septodont,[15] was applied over the injection site with cotton swab applicator tip and left for 60 s. For all the patients, Buccal infiltration was done using a 30 G, 0.35 X 25-inch needle attached to a self-aspirating syringe (Septoject, Septodont, France). The needle was carefully inserted into the alveolar mucosa ensuring the bevel of needle is facing towards the bone and pushed ahead till the center point between the mesiobuccal and distobuccal root apices of maxillary first molar is reached. Approximately 1.8 ml of anesthetic solution (2% Lidocaine with 1:80,000 adrenaline for group I) was administered over a period of 1 min. After buccal infiltration, a palatal saline infiltration was used as a placebo after an interval of 2 min to ensure subjects blinding in Group I and Group III.

The needle insertion for palatal infiltration was halfway between the mid-palatine raphe and gingival margin of maxillary first and second molars. A 30 G, 0.35 X 25-inch needle was gently inserted into the palatal mucosa with the bevel facing towards the bone surface and advanced till a gentle contact with the bone was made and approximately 0.5 ml of 2% lidocaine with 1:80,000 adrenaline was deposited over a period of 30 s.

Pain measurements were recorded before and 7 min after administering the LA. It was performed by a third clinician who was not involved in the pain measurements during and after the endodontic procedure.

Patients received the access cavity preparation under rubber dam isolation only if the patient experienced no pain(0 mm) or mild pain (≤54 mm) on VAS. All the patients were instructed to report pain by raising their left hand, if present, during any step of the endodontic procedure. Anesthesia success was confirmed clinically and was reported as "no or mild pain"(reading of 0–54 on HP-VAS) during access

cavity preparation and canal negotiation till working length. Presence of intraoperative pain was considered as an aesthetic failure and was managed by an additional intra-pulpal injection before proceeding with the further treatment. Single visit endodontic treatment was completed, and analgesic Ibuprofen 400 mg at a dosage of 1 tablet 6 hourly for pain relief was given post-operatively.

2.10. Statistical analysis

Statistical analysis were done using Microsoft Office Excel 2003, Microsoft, Seattle, WA and BioEstat program, version 4.0 (Mamiraua Institute, Belem, Brazil). Descriptive statistics included Mean and standard deviation which summarized patient's age and pre-injection and post-injection pain measurements for all groups. Since data was not normally distributed, checked using Kolmogorov-Smirnov test. Intergroup differences of the mean scores were determined using Kruskal Wallis (one way-analysis of variance) and Independent t-tests with the level of significance fixed at 5%. Chi-square test was used for the intergroup comparison of the categorical variables.

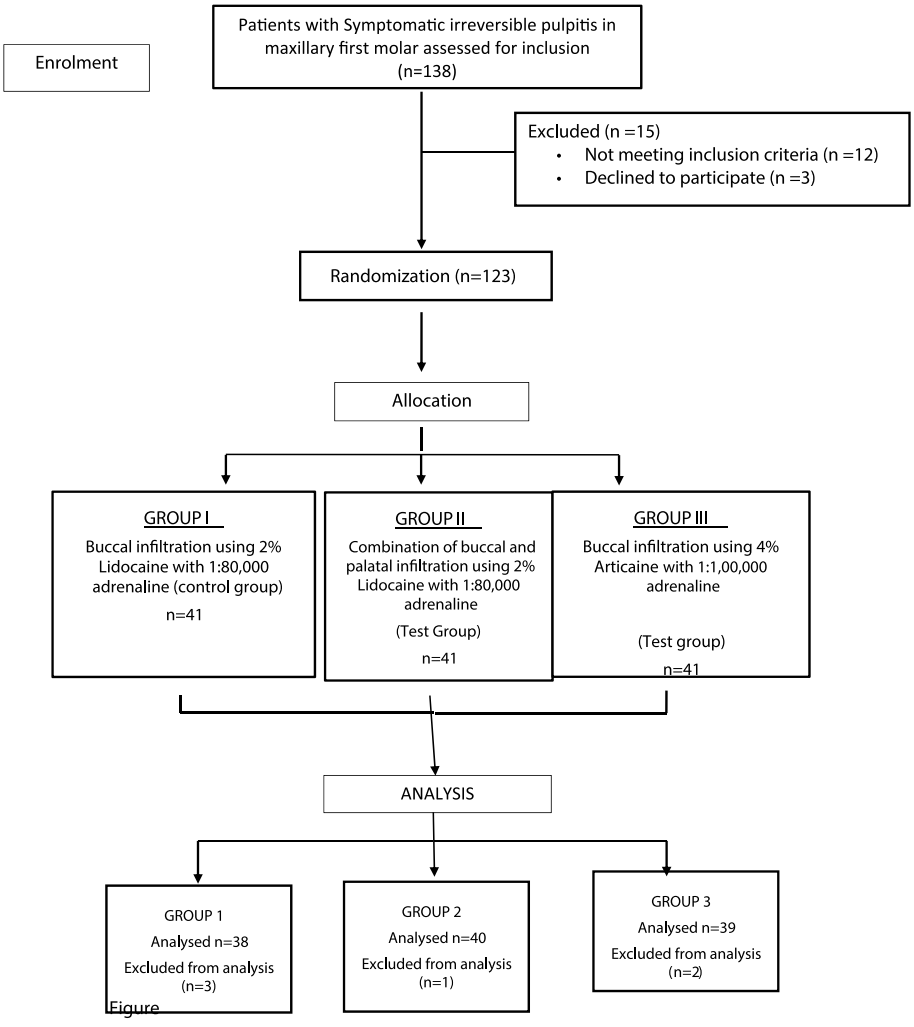
3. Results

A total of 138 patients were recruited for the study. 15 patients were excluded from the study for not meeting the inclusion criteria or they declined to participate. 123 patients were participated in the trial with 41 in each group. 3 patients in group I, 1 patient in group II and 2 patients in group III discontinue the treatment due to intolerable pain during access preparation even after infiltration. The final analysis included a total of 117 patients (60 males and 57 females) with mean age of 33 years. Group I, II, III consisted of 38, 40 and 39 patients respectively (Fig. 1).

The demographic details on age, gender and initial VAS scores are outlined in Table 1. Group I, II, III consisted of 38, 40 and 39 patients with a mean age of 30 ± 7, 29 ± 9 and 31 ± 6 respectively as mentioned

Table 1
Comparison of age, sex, and initial and post-injection pain.

	GROUP I control (buccal infiltration with 2% Lidocaine) (n = 38)	GROUP II (buccal and palatal infiltration with 2% Lidocaine) (n = 40)	GROUP III (buccal infiltration with 4% Articaine) (n = 39)
Age (in years) (mean ± SD)/Range	30 ± 7 (25–39)	29 ± 9 (21–37)	31 ± 6 (24–36)
Males (n %)	21 (55)	19 (47)	20 (51)
Females (n %)	17 (45)	21 (53)	19 (49)
Initial pain (mean ± SD)	104 ± 42	110 ± 36	112 ± 38
Post Injection Pain (after 15mins.) (mean ± SD)	12 ± 8	4 ± 6	8 ± 6



Figure

Fig. 1. CONSORT Flow diagram.

in flow chart (Fig. 1& Table 1). Regarding sex distribution, the group I had 17 females (45%) and 21 males(55%), while the group II had 21 females (47%) and 19 males (53%) and group III had 19 females (49%) and 20 males (51%), with no significant difference. The VAS scores before and after the infiltration injection of the three groups was recorded where the mean ± SD was 104 ± 42 and 12 ± 8 in the group I, 110 ± 36 and 4 ± 6 in the group II and 112 ± 38, 8 ± 6 in group III. There was a significant reduction in active pain after LA infiltration in all three groups.

Success rates (determined by absence of pain-HP-VAS ≤54 during access cavity preparation and palatal canal instrumentation) for Group I, II and III were 69%, 85% and 74% respectively with a nonsignificant difference between the three groups ($p > 0.05$) (Table 2). There was also a nonsignificant difference between the three groups regarding the incidence of pain and discomfort (failure of anesthesia) during the palatal canal negotiation ($p > 0.05$) (Table 3). There was a nonsignificant difference in the success rates between the genders in all the three groups. However, pain experienced by females was relatively higher in group II during palatal canal negotiation (Fig. 2).

4. Discussion

The predictable technique for pulpal anesthesia in maxillary molars is buccal infiltration.[16] This approach can provide adequate soft tissue anesthesia but may be insufficient in anaesthetizing pulpal tissues completely in the palatal canals of maxillary molars.[1] Anatomical variations among individuals such as bone density, tooth anatomy, tooth position longer root length and divergent palatal roots along with irreversible pulpitis of maxillary molars may have an increased rate of anesthetic failure after a single buccal infiltration.[5,17,18]

However, no clinically useful cut-off point for root length was determined. So, it seems logical to supplement the buccal infiltration with an additional palatal infiltration for effective pain management during the endodontic procedure.

So, a triple blinded, randomized clinical trial was conducted to compare any advantage of supplementing palatal infiltration with buccal infiltration injection using 2% Lidocaine and buccal infiltration injection using 4% Articaine over a single buccal infiltration injection using 2% Lidocaine in patients with a diagnosis of SIP in maxillary first molars.

Maxillary first molars were chosen to standardize anatomical variations in root morphology as Rouhani et al.[19] reported 96.8% of Indians have three distinct roots in maxillary first molars and as the maxillary sinus lining curves most between buccal and palatal roots, which may result in less diffusion of LA solution to palatal roots because of substantial distance from the buccal cortical plate.[20]

In the present study, difference was statistically nonsignificant between the success rates of different groups, which was 69% for group I (buccal infiltration using 2% Lidocaine), 85% for group II (combination of buccal and palatal infiltration injection using 2% Lidocaine) and 74% for group III (buccal infiltration using 4% Articaine). Although statistically nonsignificant, supplementation of buccal infiltration injection with a palatal infiltration increased the success rate by 16%.

The success rate for buccal infiltration (69%) in the present study is similar to Nusstein et al.[21] who found a success rate of 68% when a higher dosage of 3.6 ml of 2% lidocaine with 1:1,00,000 adrenaline concentration was used. Contrastingly, Mikesell et al.[22] reported a relatively higher success rate ranging from 97% to 100% for maxillary molars when 1.8 ml and 3.6 ml dosage of LA solution was used respectively. Gross et al.[23] found a success rate of 82% when 1.8 ml of 2% Lidocaine with 1:100,000 adrenaline was used. The reason for the reported higher success rate may be due to the subjects recruited with only healthy pulpal status with no signs of pulpal inflammation in comparison to SIP patients taken in the present study.

Although a lower success rate was reported for group I-buccal infiltration (69%) in comparison to group II- buccal plus palatal infiltration (85%), there was a nonsignificant difference between the two groups in

Table 2
Comparison of percentage of successful versus failure anesthesia in different groups.

	GROUP I (Control Group) (buccal infiltration with 2% Lidocaine) (n = 38)	GROUP II (Test Group) (buccal and palatal infiltration with 2% Lidocaine) (n = 40)	GROUP III (Test Group) (buccal infiltration with 4% Articaine) (n = 39)
Successful pulpal anesthesia (n %)	26 (69)	34 (85)	29 (74)
Unsuccessful/ failure pulpal anesthesia (n %)	12 (31)	06 (15)	10 (26)

Table 3
Comparison of number of unsuccessful anesthesia in test groups.

GROUPS	Step of endodontic procedure	HP VAS measurements	
		54-114 (Moderate Pain) (n)	>114 (Severe Pain (n)
GROUP I (buccal infiltration with 2% Lidocaine with mock palatal infiltration) **n = 12**	Within dentin (n = 02)	02	00
	Within pulpal space (n = 03)	02	01
	Instrumentation of palatal canals (n = 07)	05	02
GROUP II (buccal and palatal infiltration with 2% Lidocaine). **N = 6**	Within dentin (n = 03)	02	01
	Within pulpal space (n = 02)	01	00
	Instrumentation of palatal canals (n = 03)	03	00
GROUP III (buccal infiltration with 4% Articaine with mock palatal infiltration). **N = 10**	Within dentin (n = 03)	02	01
	Within pulpal space (n = 03)	03	00
	Instrumentation of palatal canals (n = 04)	04	00

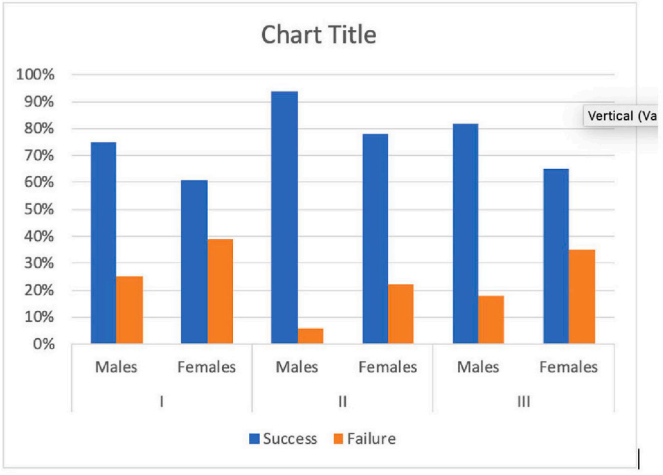


Fig. 2. Success rates between the genders.

the present study. This is similar to the finding by Guglielmo et al.[10] who used similar dosage and concentration of LA solution as our study, reported a lower success rate for buccal infiltration (88%) in comparison to the combination of buccal and palatal infiltration (95%), but this difference was statistically nonsignificant. Relatively higher success rates may be because of the case selection with only healthy pulp status. Similarly, Aggarwal et al.[24] found a nonsignificant difference between the success rate of buccal infiltration injection (54%) and combination of buccal and palatal infiltration injection (70%) using 2% Lidocaine with 1:200,000 adrenaline. However, current evidence suggests the same anesthetic efficacy with different concentrations of adrenaline.[25]

In the present study, the success rates of group I (69%) and group III (74%) have a statistically nonsignificant difference. Our findings are in conformity with several studies[5,26,27] finding a nonsignificant difference between a buccal infiltration with 2% Lidocaine and 4% Articaine. Contrary to these findings, Shrinivasan et al.[28] observed a complete success rate in each patient (100%) with 4% Articaine in comparison to 2% Lidocaine (30%) for maxillary buccal infiltration with SIP and postulated that higher levels of Articaine were found in the alveolus blood than lidocaine because of the varying drug concentration but the results should be extrapolated with caution because of their small sample size with only 10 subjects per group.

In the present study, pain incidence during palatal canal negotiation was reported by 31%, 15% and 26% of patients in group I, II and III respectively. Also, more discomfort was experienced (as indicated by VAS scores) during placement of first file in the palatal canal in comparison to the buccal canals. This infers inadequate pulp tissue anesthesia in the palatal canal.

Females experienced relatively more discomfort in group II, while negotiating palatal canal. It may be attributed to varying female hormonal levels associated with the increase in levels of noradrenaline and serotonin leading to higher pain experience during menstruation and in females on oral contraceptives.[29]

5. Limitation

In the present study, possible limitation could be the use of LA solutions with different epinephrine concentrations. These LA preparations are commercially available and subsequently used in the region where study was conducted.

6. Conclusion

Within the limitations of this study, The use of buccal plus palatal infiltration and 4% articaine can provide effective anesthesia as standard buccal infiltration and 2% lidocaine for patients with SIP in maxillary first molars. The anesthetic efficacy using different techniques with different dosages needs further investigation.

Ethics declaration

The authors have no relevant financial or non-financial interests to disclose. Ethical approval for the study was obtained from the Institute Ethics Committee.(IEC-12/2020-1874).

Protocol Registry

The study protocol was registered with the database of Clinical Trials Registry-India (CTRI/2021/05/033,659).

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The authors deny any conflicts of interest related to this study.

References

1. Hargreaves KM, Keiser K. Local anesthetic failure in endodontics:. Mechanisms and Management. *Endod Top*. 2022;1(1):26–39.
2. Boopathi T, Sebeena M, Sivakumar K, et al. Supplemental pulpal anesthesia for mandibular teeth. *J Pharm BioAllied Sci*. 2013; Jun;5(Suppl 1):S103–S108.
3. Reader A, Nusstein J. Local anesthesia for endodontic pain. *Endod Top*. 2002;3(1):14–30.
4. Mittal R, El-Swiah JM. Anaesthetising painful pulp in Endodontics-A review. *J Oral Health Community Dent*. 2011;5(3):145–148.
5. Evans G, Nusstein J, Drum M, et al. A prospective, randomized double-blind comparison of articaine and lidocaine for maxillary infiltrations. *J Endod*. 2008;34:389–393.
6. Mason R, Drum M, Reader A, et al. A prospective, randomized, double-blind comparison of 2% lidocaine with 1:100,000 and 1:50,000 epinephrine and 3% mepivacaine for maxillary infiltrations. *J Endod*. 2009;35:1173–1177.
7. Katz S, Drum M, Reader A, et al. A prospective, randomized, double-blind comparison of 2% lidocaine with 1:100,000, 4% prilocaine with 1:200,000 epinephrine and 4% prilocaine for maxillary infiltrations. *Anesth Prog*. 2010;57:45–51.
8. Premdas CE, Pitt Ford TR. Effect of palatal injections on pulpal blood flow in premolars. *Endod Dent Traumatol*. 1995;11:274–278.
9. Lee S, Reader A, Nusstein J, et al. Anesthetic efficacy of the anterior middle superior alveolar (AMSA) injection. *Anesth Prog*. 2004;51:80–89.
10. Guglielmo A, Drum M, Reader A, Nusstein J. Anesthetic efficacy of a combination palatal and buccal infiltration of the maxillary first molar. *J Endod*. 2011 Apr;37(4):460–462.
11. Becker DE, Reed KL. Local anesthetics: review of pharmacological considerations. Summer *Anesth Prog*. 2012;59(2):90–101. quiz 102-3.
12. Martin E, Nimmo A, Lee A, et al. Articaine in dentistry: an overview of the evidence and meta-analysis of the latest randomised controlled trials on articaine safety and efficacy compared to lidocaine for routine dental treatment. *BDJ Open*. 2021;7:27–31.
13. Azim AA, Merdad K, Peters OA. Diagnosis consensus among endodontic specialists and general practitioners: an international survey and a proposed modification to the current diagnostic terminology. *Int Endod J*. 2022 Nov;55(11):1202–1211.
14. Heft MW, Parker SR. An experimental basis for revising the graphic rating scale for pain. *Pain*. 1984;19(2):153–161.
15. Nair M, Gurunathan D. Comparative evaluation of the efficacy of two anesthetic gels (2% lignocaine and 20% benzocaine) in reducing pain during administration of local anesthesia - a randomized controlled trial. *J Anaesthesiol Clin Pharmacol*. 2019 Jan-Mar;35(1):65–69.
16. Atasoy Ulusoy Ö İ, Alaçam T. Efficacy of single buccal infiltrations for maxillary first molars in patients with irreversible pulpitis: a randomized controlled clinical trial. *Int Endod J*. 2013;47(3):222–227.
17. Reader A, Nusstein JM, Hargreaves KM. Local anesthesia in endodontics. In: Hargreaves KM, Cohen S, eds. *Pathways of the Pulp*. tenth ed. Missouri, USA: Mosby Elsevier; 2011:691–719.
18. Moradi Askari E, Parirokh M, Nakhaee N, Hosseini HR, Abbott PV. The effect of maxillary first molar root length on the success rate of buccal infiltration anesthesia. *J Endod*. 2016 Oct;42(10):1462–1466.
19. Rouhani A, Bagherpour A, Akbari M, Azizi M, Nejat A, Naghavi N. Cone-beam computed tomography evaluation of maxillary first and second molars in Iranian population: a morphological study. *Iran Endod J*. 2014 Summer;9(3):190–194. Epub 2014 Jul 5.
20. Fry RR, Patidar DC, Goyal S, Malhotra A. Proximity of maxillary posterior teeth roots to maxillary sinus and adjacent structures using Denta scan®. *Indian J Dent*. 2016 Sep;7(3):126–130.
21. Nusstein J, Reader A, Nist R, Beck M, Meyers WJ. Anesthetic efficacy of the supplemental intraosseous injection of 2% lidocaine with 1:100,000 epinephrine in irreversible pulpitis. *J Endod*. 1998;24:487–491.
22. Mikesell A, Drum M, Reader A, Beck M. Anesthetic efficacy of 1.8 mL and 3.6 mL of 2% lidocaine with 1:100,000 epinephrine for maxillary infiltrations. *J Endod*. 2008 Feb;34(2):121–125.
23. Gross R, McCartney M, Reader A, Beck M. A prospective, randomized, double-blind comparison of bupivacaine and lidocaine for maxillary infiltrations. *J Endod*. 2007 Sep;33(9):1021–1024.
24. Aggarwal V, Singla M, Miglani S, Ansari I, Kohli S. A prospective, randomized, single-blind comparative evaluation of anesthetic efficacy of posterior superior alveolar nerve blocks, buccal infiltrations, and buccal plus palatal infiltrations in patients with irreversible pulpitis. *J Endod*. 2011 Nov;37(11):1491–1494.
25. Berberich G, Reader A, Drum M, Nusstein J, Beck M. A prospective, randomized, double-blind comparison of the anesthetic efficacy of two percent lidocaine with 1:100,000 and 1:50,000 epinephrine and three percent mepivacaine in the intraoral, infraorbital nerve block. *J Endod*. 2009;35:1498–1504.

26. Syed GA, Mulay SA. Comparative evaluation of anesthetic efficacy of 4% articaine and 2% lidocaine for buccal infiltration in adult patients with irreversible pulpitis of maxillary first molar: a prospective randomized study. *Contemp Clin Dent*. 2022 Jan-Mar;13(1):61–68.
27. Sherman MG, Flax M, Namerow K, Murray PE. Anesthetic efficacy of the Gow-Gates injection and maxillary infiltration with articaine and lidocaine for irreversible pulpitis. *J Endod*. 2008;34:656–659.
28. Srinivasan N, Kavitha M, Loganathan CS, Padmini G. Comparison of anesthetic efficacy of 4% articaine and 2% lidocaine for maxillary buccal infiltration in patients with irreversible pulpitis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2009; 107:133–136.
29. Ali SG, Mulay S, Palekar A, Sejpal D, Joshi A, Gufran H. Prevalence of and factors affecting post-obturation pain following single visit root canal treatment in Indian population: a prospective, randomized clinical trial. *Contemp Clin Dent*. 2012;3, 459–63.