The Effectiveness of Buffered and Non-buffered Local Anaesthetics in Maxillary Infiltration during Root Canal Treatment: A Randomised Study

*Amidu Omotayo SULAIMAN, **Rufai JAAFARU, ***Mujtaba BALA, ***Ramat Oyebunmi BRAIMAH, ***Abdurrazaq Olanrewaju TAIWO, Sanusi Abubakar MAYANA

[*Deparment of Restorative Dentistry, University College Hospital, Ibadan and University of Ibadan, Nigeria, **Department of Restorative Dentistry, Usmanu Danfodiyo University Teaching Hospital, Sokoto, Sokoto State, Nigeria, ***Department of Dental & Maxillofacial Surgery, Usmanu Danfodiyo University Teaching Hospital, Sokoto, ****Field office, World Health Organization, Kano State, Nigeria.

Correspondence
Dr AO Sulaiman.
Deparment of Restorative Dentistry, University college hospital, Ibadan and University of Ibadan, Nigeria
E-mail: tavooia@vahoo.co.uk

ABSTRACT

Objective: To investigate the effectiveness of buffered and non-buffered local anaesthetics in maxillary infiltration during root canal treatment (RCT).

Methods: This was a randomised double-blinded controlled study conducted over fifteen months (January 2024 to March 2025). Ethical approval was obtained from the research and ethics committee of the institution. Included were patients aged 18 years and above who presented for RCT of maxillary molars. A simple random sampling method was used to administer buffered and non-buffered LA to subjects in groups A and B, respectively. Information recorded includes: demographics, indication for the RCT, pain at the injection site, time for the onset, and comfort during the RCT. Data were analysed using SPSS version 25.

Results: There were 39 (48.7%) males, 41(51.3%) females in the age range of 19-69 years with a mean±SD of 38.34±13.44. Most of the subjects were in the category of 31- 60 years with no statistical significant difference ($\chi 2=1.064$, p=0.587). Comparison of pain at the buccal and palatal injection sites showed that group A had a lower mean pain score on injection than group B, which was statistically significant. The mean onset time for group A was lower than that of group B, with a statistical significant difference. Group A subjects reported more comfortable procedure 3.18(±1.66) compared to group B 4.48(±1.60) with a statistically significant difference t=-3.562, p=0.0001.

Conclusion: Buffered LA was found to have a lower pain mean score, shorter onset time, and provide more comfort during root canal therapy than the non-buffered LA.

Keywords: Root canal therapy, Buffering, Local anaesthesia, Pain

Amidu Omotayo Sulaiman.
https://orcid.org/0000-0002-2988-5645
Rufai Jaafaru
https://orcid.org/0000-0002-8117-9393
Mujtaba Bala
https://orcid.org/0000-0002-0699-7118
Ramat Oyebunmi Braimah
https://orcid.org/0000-0002-7608-1965
Abdurrazaq Olanrewaju Taiwo
https://orcid.org/ 0000-0002-2311-4196
Sanusi Abubakar Mayana
https://orcid.org/0009-0005-4911-5591

Received; 29-January-2026
Revision: 23-April-2026
Accepted : 22-June-2026

Citation : Sulaiman AO, Jaafaru R, Bala M, Braimah OR, Taiwo AO, Mayana SA. The effectiveness of buffered and non-buffered local anaesthetics in maxillary infiltration during root canal treatment: A randomised study. Nig J Dent Res 2026; 11(2):121-126. https://dx.doi.org/10.4314/njdr.v11i2.3

INTRODUCTION

Root canal therapy, also known as root canal treatment, is a dental procedure that aims at the removal of infected or inflamed pulp from inside a tooth to prevent further infection and save the tooth from extraction.[1] The process involves cleaning and disinfecting the root canals, filling them with a material, and sealing them off against fluid and bacterial permeation.[2] Root canal therapy is one of the conservative dental procedures indicated in painful dental conditions affecting teeth such as irreversible pulpitis, apical periodontitis, periapical abscess, and dentoalveolar abscess.[3,4] To carry out this procedure successfully, an effective local anaesthesia is required, especially during the first step of the root canal therapy. Quite often, maxillary buccal and palatal infiltrations anaesthesia are the techniques commonly used for the root canal therapy of maxillary teeth, and several factors were found to affect the maxillary infiltration anaesthesia, including type and concentration of the anaesthetic solution, the pH of the local anaesthetic (LA) solution, as well as the tissues condition.[5]

The commonly used LA solution in dental practice has been lignocaine in combination with a vasoconstrictor; commonly adrenaline.[6] This solution is usually supplied and marketed in acidic form to maximize its stability, solubility as well and shelf-life.[7,8] As such, the solution is injected in acidic form. Studies have revealed that pain from LA injection has been exacerbated due to the burning sensation caused by the acidic LA solution.[8,9,10] It was also known to have a lower onset of action, especially when injected in tissues in acidic environments such as in apical periodontitis, periapical abscess, and dentoalveolar abscess.[11]

Many studies have found that buffering of local anesthetics before injection reduces pain during injection, shortens onset time, and enhances the quality of anesthesia.[12-14] This is achieved by raising the pH of the anesthetic solution, making it closer to the body's natural pH and increasing the availability of the non-ionized, lipid-soluble form of the anesthetic that can cross nerve membranes.[8,11] This leads to a more comfortable and effective anesthetic experience. Despite this report, several other studies found no difference in pain experience and comfort treatment even when the LA is buffered.[15,16] Therefore, this study aimed to investigate the effectiveness of buffered and non-buffered LA in maxillary infiltration during root canal therapy.

MATERIALS AND METHODS

This was a randomised double-blinded controlled study conducted at the Restorative Dentistry unit of Usmanu Danfodiyo University Teaching Hospital, Sokoto, over fifteen months (January 2024 to March 2025). Ethical approval was obtained from the research and ethics committee of the institution. Included in the study were patients aged 18 years and above who presented for root canal therapy of permanent maxillary molars irrespective of gender. Excluded were patients who did not give consent to participate in the study and those who had a history of allergy or hypersensitivity to any of the components of the anaesthetic solution.

The sample size was calculated using $N = 2SD2\ \underline{(Z_{\alpha/2}+Z_{\beta})\ 2}/d2$, where SD is the standard deviation from a previous study.[17] $Z_{\alpha/2}$ is 1.96 (from the Z table) at a type 1 error of 5%, $Z_{\beta \text{ is } 0.84}$ (from the Z table) at 80% power, and d is the difference between the mean values. A previous similar study by Saatchie *et al*.[17] reported an SD of 9.0 and a mean difference of 1.4. Therefore, sample size N = 51, approximately 51 participants.

The local anaesthetic solution administered was either 2 mls of a freshly prepared mixture of 2% lignocaine with 1:100,000 adrenaline buffered with 0.18mls of 8.4% sodium bicarbonate (Group A) or 2mls of non-buffered 2% Lignocaine with 1:100,000 adrenaline (Group B).

A proforma was used to collect the desired information such as age, gender, tooth type involved, indication for the root canal therapy, pain at the injection site, time for the onset of action, and level of discomfort during the root canal therapy.

The pain at injection site (buccal and palatal regions) and the level of discomfort during the root canal treatment was assessed using the numerical rating scale; a 10-point scale with zero as no pain and 10 as the maximum pain or discomfort. The onset of action was obtained by objective and subjective assessment following the infiltration.

RESULTS

Overall, a total of 80 subjects, 40 in each group, were recruited; there were 39 (48.7%) males, 41(51.3%) females in the age range of 19-69 years with a mean±SD of 38.34±13.44 years. The distribution of the age category of the subjects includes: ≤ 30 years, 29(36.3%), 31- 60 years, 46(57.4%) and >60years 5(6.3%) and there was no statistically significant difference when tested using chi-square ($\chi 2=1.064$, $p=0.587$) (Table 1). The gender distribution was also

tested, and no statistically significant difference was found across the two groups ($\chi 2$=0.777, p=0.378) (Table 1). The indication for the root canal therapy include; irreversible pulpitis 35(43.7%), apical periodontitis 25(31.3%), periapical abscess 12(15.0%), and dentoalveolar abscess 8(10.0%). The maxillary right first molar 42 (52.5%) was the most common tooth involved, followed by left maxillary first molar 19 (23.8%), left maxillary second molar 16(20%), and right maxillary second molar 3(3.7%).

Comparison of pain at injection at the buccal injection site between the two groups showed that group a had a lower mean pain score (3.10±1.66) on injection than group b (4.53±1.71) which was statistically significant (t=-3.764 p=0.000). Furthermore, comparison of pain at injection at the palatal injection site between the two groups showed that Group A had a lower mean pain score (5.28±2.32) on injection than group B (6.78±1.90) which was also statistically significant (t=-3.16 p=0.020) (Table2).

The mean±SD onset time of the local anaesthesia by subjective testing for groups A and B were 126(±31.7) seconds and 201(±66.8) seconds respectively, and Group A had a significantly higher mean value than Group B (t=-6.093 p=0.000) (Table 2).

The mean onset time of the local anaesthesia by objective testing for groups A and B was 186 (±41.0) seconds and 287 (±85.0) seconds, respectively, and Group A had a significantly higher mean value than Group B (t=-6.321, p=0.000) (Table 2). The comfort during the first visit root canal treatment was also assessed using a numerical rating scale. Group A subjects reported a more comfortable procedure, 3.18(±1.66), compared to group B, 4.48(±1.60), with a statistically significant difference, t=-3.562, p=0.0001

Table 1: Analysis of Demographic characteristics of the study population

Variables	Study group n(%)		Total n (%)	Test statistics	P-value
	Group A	Group B			
≤ 30years	17(21.3)	12(15)	29(36.3)		
31-60years	22(27.5)	24(30)	46(57.5)	$\chi 2$=1.064,df=2	p =0.567
>60years	1(1.3)	4(5.0)	5(6.2)		
	40(50)	40(50)	80(100)		
Gender					
Male	22(27.5)	17(21.3)	39(48.3)	$\chi 2$=0.777,df=1	p=0.378
Female	18(22.5)	23(28.2)	41(51.2)		
Total	40(50)	40(50)	80		

Table 2: Comparison of pain at the injection site, the onset of action, and duration of local anaesthesia between the study groups A and B

Variable	Group A Mean (±SD)	Group B Mean (±SD)	Test statistics	Level of Significance
Pain at buccal injection site	3.10(±1.66)	4.53(±1.72)	t=-3.764	*P=0.000**
Pain at the palatal injection site	5.28(±1.66)	5.25(±2.32)	t=-3.163	P=0.020*
Onset time by subjective testing (seconds)	127(±31.0)	201(±66.8)	t=-6.093	*P*=0.000*
Onset time by Objective testing (seconds)	187 (±41.0)	280(±83.0)	t=-6.321	*P*=0.000*
Comfort during the procedure	3.18(±1.66)	4.48(±1.60)	t=-3.562	*p*=0.001*

*Indicate statistically significant

DISCUSSION

This study investigated the effectiveness of sodium bicarbonate buffered lignocaine with adrenaline and compared it with non-buffered lignocaine with adrenaline in maxillary buccal and palatal infiltration during routine conventional root canal therapy by evaluating pain at the injection site, the onset of action, and comfort during the procedure. There was no attempt made to balance the patients concerning gender in this study. Given the relatively limited subject pool and the need to have a sample size as large as possible, all qualified and consenting patients were enrolled, regardless of gender. Thirty-nine (48.7%) males, forty-one (51.3%) females were included. The gender and age categories of participants in the two groups of this study were, however, found not to be statistically significant, which implies that both are unlikely to be

confounders in the analysis of the results of the study. The larger proportion of females in this study supports the findings of some previous studies.[18] This conservative treatment, such as root canal therapy, rather than teeth extraction, as previously observed by some authors.[19,20]

Local anesthetic (LA) infiltration in the maxilla has been commonly employed for achieving pulpal anaesthesia during root canal therapy of the maxillary molars. However, there are frequently reported incidences of inadequate anaesthesia, especially in the presence of unresolved infection in the tissues surrounding the teeth.[21] Inadequate local anesthesia could lead to various consequences, including pain during procedures, increased anxiety and distress for the patient, and potential complications related to the procedure itself.[22] Additionally, inadequate anesthesia can prolong procedures, require additional injections, or even lead to nerve injury or other systemic effects.[1] This study recorded faster onset anaesthesia with buffered LA during maxillary infiltrations, which agrees with Al-sultan et al.[23] and Malamed et al.[14] A quicker onset of local anaesthesia is beneficial since it eliminates pain more immediately, reducing patient suffering during the treatment. This makes it possible to start procedures more quickly, which could reduce treatment time overall and lessen patient stress. Better patient cooperation can also result from a quicker onset. Some studies, including Bala et al.[24] and Shyamala et al.[25], have raised questions as to whether the gain in time due to faster onset is an advantage, since the time gain is lost during the buffering of the solution.

This study revealed a lower mean pain score with buffered LA compared to the non-buffered LA, which is in tandem with Lingraj et al.[9] and Kashap et al.[15] Another study was conducted by Gupta et al.[26] to evaluate the effect of buffered 2% lignocaine with 1:80,000 adrenaline for the extraction of maxillary teeth with periapical infections. Specifically, the interest of the researcher was on the pH increase of a buffered formulation that potentially could increase the anesthetic effectiveness in a localized dental infection. The authors concluded that buffered LA has a lower mean pain score upon injection than the non-buffered LA.

Comfort during a dental procedure can be achieved through various strategies, among which pain elimination constitutes the most important. Quite often, patients avoid treatment due to discomfort, usually caused by inadequate anaesthesia.[27] This study revealed a more comfortable root canal procedure with buffered compared to non-buffered LA. The findings of this study are similar to what was reported by Rana et al.[28] and Falkel et al.[29] Comfort during dental treatment with buffered LA has been attributed to shorter onset, lesser pain at the injection site, and, in some reports.[24], the longer duration of anaesthesia. Comfort during treatment can drastically improve dental practice, make more patients accept root canal therapy, and reduce the failure rate.

CONCLUSION

Buffered LA was found to have lower pain mean score, shorter onset time and provide more comfort during root canal therapy than the non-buffered LA.

Source of Support

Nil.

Conflict of Interest

None declared

REFERENCES

1. Kumar G, Jena S, Manila N, Fareed M, Karobari MI. Incidence of postoperative pain after single-visit and multiple-visit root canal therapy: a systematic review. BMC Oral Health. 2025 Jan 8;25(1):47. doi:10.1186/s12903-024-05412-1.
2. Anagha CS, Koshy M, Varghese R, Anirudhan S. Comparison of postoperative pain following single-visit and two-visit root canal therapy in controlled diabetic patients with irreversible pulpitis: a randomized control trial. J Conserv Dent 2022; 25(4):392–397.
3. Patel R, Bansal N, Dudulwar DG, Gupta D, Dodwad R, Saidath K. Evaluation of post-obturation pain after single-visit versus multiple-visit non-surgical endodontic treatments. Int J Curr Res Rev 2021; 13(5):66–69.
4. Gupta NK, Mantri SP, Paul B, Dube KA, Ghosh S. Incidence of postoperative pain after single-visit and multiple-visit root canal therapy: A randomized controlled trial. J Conserv Dent. 2021; 24(4):348-353.doi: 10.4103/jcd.jcd_216_21
5. Parirokh M, Abbott PV. Various strategies for pain-free root canal treatment. Iran Endod J. 2014; 9(1):1–14.
6. Mikesell A, Drum M, Reader A, Beck M. Anesthetic efficacy of 1.8 mL and 3.6 mL of 2% lignocaine with 1:100,000 epinephrine for

maxillary infiltrations. J Endod 2008; 34(2):121–125.
7. Gordon SM, Mishenko AV, Dionne RA. Long-acting local anesthetics and perioperative pain management. Dent Clin North Am. 2010;54(4):611–620.
8. Satılmış T, Gönül O, Garip H, Göker K. A new and enhanced version of local anesthetics in dentistry. Open Access J. 2012;23(5):1–8.
9. Lingaraj JB, Anjali D, Vijaya K. A randomized control study to compare the efficacy of carbonated lignocaine with lignocaine hydrochloride in mandibular nerve blocks. IOSR J Med Dent Sci 2018; 7:13–16.
10. Agarwal A, Jitendra KD, Sinha A, Garg M, Sharma S, Singh A. To evaluate the anesthetic efficacy of sodium bicarbonate buffered 2% lignocaine with 1:100,000 adrenaline in inferior alveolar nerve blocks: a prospective, randomized, double-blind study. Arch Dent Med Res. 2015; 1(3):17–23.
11. Mackay J. Combating inadequate anesthesia in periapical infections with sodium bicarbonate: a clinical double-blind study. J Oral Maxillofac Surg. 2019; 17:11–15.
12. Kashyap VM, Desai R, Reddy PB. Effect of alkalinization of lignocaine for intraoral nerve block on pain during injection and speed of onset of anesthesia. Br J Oral Maxillofac Surg 2011; 49(8):72–75.
13. Gupta S, Mandlik G, Padhye MN, Kini YK, Kakkar S, Hire AV. Combating inadequate anesthesia in periapical infections with sodium bicarbonate: a clinical double-blind study. Oral Maxillofac Surg. 2014; 18(3):325–329.
14. Malamed SF, Tavana S, Falkel M. Faster onset and more comfortable injection with alkalinized 2% lignocaine with epinephrine 1:100,000. Compend Contin Educ Dent. 2013;34(1):10–20.
15. Radhika M, et al. Double-blind crossover study to compare pain experience during inferior alveolar nerve block administration using buffered two percent lignocaine in children. Pediatr Dent J. 2016; 38(1):25–29.
16. Kurien RS, Goswami M, Singh S. Comparative evaluation of anesthetic efficacy of warm, buffered, and conventional 2% lignocaine for the success of inferior alveolar nerve block in mandibular primary molars: a randomized controlled clinical trial. J Dent Res Dent Clin Dent Prospects 2018; 12(2):102–109. doi:10.15171/joddd.2018.016.
17. Saatchi M, Khademi A, Baghaei B, Noormohammadi H. Effect of sodium bicarbonate-buffered lidocaine on the success of inferior alveolar nerve block for teeth with symptomatic irreversible pulpitis: a prospective, randomized double-blind study. J Endod. 2015; 41:33–35.
18. M M A, Khatri A, Kalra N, Tyagi R, Khandelwal D. Pain perception and efficacy of local analgesia using 2% lignocaine, buffered lignocaine, and 4% articaine in pediatric dental procedures. J Dent Anesth Pain Med. 2019 Apr;19(2):101–109. doi:10.17245/jdapm.2019.19.2.101.
19. Uguru N, Onwujekwe O, Uguru C, Ogu U, Okwuosa C, Okeke C. Oral health-seeking behavior among different population groups in Enugu, Nigeria. PLoS One. 2021; 16(2):e0246164.
20. Okoye LO, Ekwueme OC. Prevalence of dental caries in a Nigerian rural community: a preliminary local survey. Ann Med Health Sci Res. 2011; 1(2):187–195.
21. Weitz D, Ordinola-Zapata R, McClanahan SB, Shyne M, Law AS, Nixdorf DR; National Dental Practice-Based Research Network Collaborative Group. Preoperative factors associated with anesthesia failure for patients undergoing nonsurgical root canal therapy: a national dental practice-based research network study. J Endod. 2021; 47(12):1875–1882. doi:10.1016/j.joen.2021.09.005.
22. Drum M, Reader A, Nusstein J, Fowler S. Successful pulpal anesthesia for symptomatic irreversible pulpitis. J Am Dent Assoc. 2017; 148:267–271.
23. Al-Sultan FA, Fathie WK, Hamid RS. A clinical evaluation of the alkalization of local anesthetic solutions in periapical surgery. Al-Rafidain Dent J. 2006;6(1):71–77.
24. Bala M, Taiwo AO, Ibikunle AA, Olasoji HO, Sulaiman AO, Chukwuma BC, Braimah RO, Ile-Ogedengbe BO. Effectiveness of buffered and non-buffered local anaesthetic in inferior alveolar nerve block: a randomised study. Br J Oral Maxillofac Surg 2023; 61(5):351–355. doi:10.1016/j.bjoms.2023.03.015.
25. Shyamala M, Ramesh C, Yuvaraj V, Suresh V, Sathyanarayanan R, Balaji TS, Neil DM, Jude BNJ. A comparative study between bupivacaine with adrenaline and carbonated bupivacaine with adrenaline for surgical removal of the

impacted mandibular third molar. J Maxillofac Oral Surg. 2016; 15:99–105.
26. Gupta S, Mandlik G, Padhye MN, Kini YK, Kakkar S, Hire AV. Combating inadequate anesthesia in periapical infections with sodium bicarbonate: a clinical double-blind study. Oral Maxillofac Surg. 2014; 18(3):325–329.
27. Lipp K, Casamassimo P, Griffen A, Smiley M, Bryant J, Draper J, Kumar A. Effect of intrapapillary local anesthetic on postoperative pain following dental treatment under general anesthesia in pediatric patients. Anesth Prog. 2021; 68(4):206–13. doi:10.2344/anpr-68-02-06.
28. Rana R, Kaushik M, Kaushik R, Sharma R. Comparative evaluation of pain on injection and during root canal treatment using buffered versus non-buffered lignocaine: a randomized clinical study. J Conserv Dent. 2016; 19(5):472–475. doi:10.4103/0972-0707.190015.
29. Falkel M, Pashley D, Matthews R. Buffering local anesthetics in dentistry: a review of the literature. J Am Dent Assoc. 2012; 143(9):929–935. doi:10.14219/jada.archive.2012.0305.