ISSN (O) : 2582-3271
PubMed-National Library of Medicine - ID: 101766917

International Journal of Dental Science and Clinical Research (IJDSCR)

Dr. Angel Vaidic Publication

Available Online at: http://www.ijdscr.org

Volume 3, Issue 3, May - 2021, Page No. : 34 - 42

In Vitro Assessment of Interaction Between 4% Articaine Hydrochloride and Sodium Hypochlorite on Root Canal Dentin before and After Chemomechanical Instrumentation Procedures

[1]Dr. Rajakeerthi R, Senior Lecturer, Department of Conservative Dentistry and Endodontics, Saveetha Dental College and Hospital, Chennai, India

[2]Dr. Nivedhitha M S, HOD, Department of Conservative Dentistry and Endodontics, Saveetha Dental College and Hospital, Chennai, India

[3]Dr. Kavya Basker N, Senior Lecturer, Department of Conservative Dentistry and Endodontics, Indira Gandhi Institute of Dental Sciences, Pondicherry, India

[4]Dr. Vigneshwari S K, Senior Lecturer, Department of Conservative Dentistry and Endodontics, Indira Gandhi Institute of Dental Sciences, Pondicherry, India

Citation of this Article: Dr. Rajakeerthi R, Dr. Nivedhitha M S, Dr. Kavya Basker N, Dr. Vigneshwari S K, "In Vitro Assessment of Interaction Between 4% Articaine Hydrochloride and Sodium Hypochlorite on Root Canal Dentin before and After Chemomechanical Instrumentation Procedures", IJDSCR – May - 2021, Vol. – 3, Issue - 3, P. No. 34-42.

Corresponding Author: Dr. Rajakeerthi R, Senior Lecturer, Department of Conservative Dentistry and Endodontics, Saveetha Dental College and Hospital, Chennai, India

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Introduction

To investigate the effect of resultant precipitate formed on interaction between 2% lidocaine hydrochloride with adrenaline (LA) and 2.5% sodium hypochlorite (NaOCl) on root canal dentin before and after chemomechanical preparation, using scanning electron microscopy (SEM).

Methods

Sixty mandibular premolars were decoronated, and the root length was standardized. All specimens were randomly distributed into the following three groups: Group I (control): 2% LA mixed with sterile water without root canal instrumentation, Group II: 2% LA with 2.5% NaOCl and no instrumentation, and Group III: 2% LA with 2.5% NaOCl, followed by mechanical instrumentation with rotary files. Teeth samples were sectioned into three parts, split and SEM analysis of the root canal wall was done at cervical, middle, and apical root thirds.

Results

SEM images revealed patent dentinal tubules with no precipitate occlusion in the control group,

whereas there was occlusion of dentinal tubules with a precipitate in all the specimens in Group II and Group III at all the three root levels studied.

Conclusions

The precipitate formed on the interaction between 2% LA solution and 2.5% NaOCl tends to occlude the dentinal tubules at the coronal, middle, and apical root thirds. The chemomechanical rotary instrumentation procedure did not effectively remove the precipitate from all the three levels of the root specimens studied. LA/sterile water group did not result in any precipitate formation on root canal dentin.

Keywords

Hot pulp; intrapulpal anesthesia; articaine hydrochloride; precipitate; sodium hypochlorite

Introduction

Achieving profound pulpal anesthesia in endodontics is mandatory for successful completion of the root canal treatment. Fear and anxiety associated with root canal therapy are significantly reduced with effective pain management.[1,2] The most commonly used local anesthetic solution in endodontics is 4% articaine hydrochloride with adrenaline (LA) in 1:100,000 concentration because of its improved efficacy at low concentrations and decreased allergenic characteristics.[2]

Inferior alveolar nerve block (IANB) is the primary standard technique to achieve mandibular anesthesia, whereas local infiltration is used to anesthetize the maxillary teeth. However, studies have been reported that the failure rate of IANB is 30%–45%, despite the use of an appropriate standardized technique in healthy lower molars and premolars.[3] It was also reported that the anesthesia of mandibular molars with symptomatic irreversible pulpitis was more difficult than the healthy pulps.[4] Anesthetic success in case of maxillary buccal infiltrations is reported to be 72%–100%.[5] Many factors such as the individual variations in response to the drug administered, operator differences, and anatomical variations, apart from decreased pH, altered membrane excitability of peripheral nociceptors, and increased tetrodotoxin-resistant sodium channels are responsible for the reduced anesthetic effect in clinical cases of inflamed teeth.[6-11] Following the failure of these conventional methods, adjuvant anesthetic techniques such as supplemental injection with 4% articaine hydrochloride with adrenaline, intraligamentary, intraosseous methods, and/or intrapulpal injections are usually employed to ensure profound anesthetic effect.[10]

The intrapulpal injection technique (IPI) is one of the most commonly employed supplemental anesthetic techniques, particularly in situations such as "hot tooth," where patients encounter severe pain or discomfort during access cavity preparation and pulp tissue removal.[11] In general, administration of LA directly into the pulp chamber provides complete analgesia for effective pulp extirpation and root canal instrumentation. The most significant factor contributing to the success of IPI is that its administration must be done under pressure.[12] After pulp deroofing procedure, IPI is further administered into the root canal orifices with adequate back pressure to facilitate complete removal of pulp remnants from the canal. Following IPI, sodium hypochlorite (NaOCl) (in concentrations ranging from 0.5% to 5.25%) is usually employed in routine cleaning and shaping procedures which is considered the gold standard irrigant for pulp tissue dissolution in endodontics.[13] However, Vidhya et al.[14] evaluated the chemical interaction between LA and NaOCl using nuclear magnetic resonance (NMR) spectroscopy and reported the formation of a precipitate, 2,6-xylidine, which is a known carcinogen.

To date, there are no published reports on the effect of this precipitate on root canal dentin and its subsequent removal following the routine endodontic instrumentation procedure. Hence, the aim of the present in vitro study was to evaluate the effect of the combination of LA and NaOCl and the resultant precipitate on root canal dentin before and after chemomechanical rotary instrumentation procedure using scanning electron microscopic (SEM) evaluation. The null hypotheses tested were: (1) LA/NaOCl combination does not result in any precipitate formation on root canal walls and (2) conventional chemomechanical instrumentation will completely remove the precipitate formed (if any) following LA and NaOCl use from the coronal-, middle-, and apical-thirds of the root canal.

Methods

Specimen Preparation

Sixty freshly extracted mandibular premolars with straight roots were used in this study. Radiographs of each tooth were obtained to confirm the presence of a single canal and mature root apex. Teeth with caries, cracks, fractures, resorption, previous restorations, and root dilacerations were excluded from this study. The teeth were cleaned carefully of debris and calculus and stored in 0.2% sodium azide solution at 4°C until their use. All the teeth were then decoronated at or near the cementoenamel junction using a high-speed diamond disc) with an adequate cooling system to obtain a standardized root length of 14 mm. The foraminal opening was sealed with resin composite to prevent the extrusion of experimental solutions from the apical foramen. A glide path was established using #10- and #15-size K-files (Mani Inc, Tochigi Ken, Japan). All specimens were initially rinsed with 5 ml of 17% EDTA (Prime Dental Products Pvt Ltd, Thane, India) for 1 min. 0.5 mL of 2% LA was administered by inserting a 27-gauge stainless steel beveled needle into the orifices of the root specimens, and the solution was injected into the pulpal space under pressure.

Grouping

The specimens were then randomly distributed into three groups based on the test solutions employed and whether instrumentation was done. After LA administration, Groups I and II were irrigated with each 2 mL of sterile water and 2.5% NaOCl (Prime Dental Products Pvt Ltd, India) for 1 min, respectively. The canals were dried immediately with sterile #15 absorbent paper points (ISO 0.02 size, Dentsply, Maillefer) and were left uninstrumented.

Specimens in Group III were treated similar to that of Groups I and II; however, an additional step of root canal instrumentation was employed. Following irrigation with NaOCl, working length (WL) was determined by inserting 10 size K file into each canal, until it was just visible at the apical foramen and then reducing 1 mm from the recorded length. The canals were prepared with rotary endodontic instruments (Mtwo files, VDW, Munich, Germany) in a sequential manner 10/0.04, 15/0.05, 20/0.06, and 25/0.06. Irrigation was performed with 2 mL of 2.5% NaOCl for 1 min between each instrument change. The final irrigation sequence involved the use of 5 mL of 17% EDTA for 1 min. Irrigation was performed using 29-gauge stainless side vented needles (Vista Dental Inc., Racine, WI, USA), and the needle tip was inserted to 1 mm short of WL. Final irrigation was done with 5 mL distilled water. The canals were later dried with sterile absorbent paper points.

Scanning Electron Microscopy Evaluation

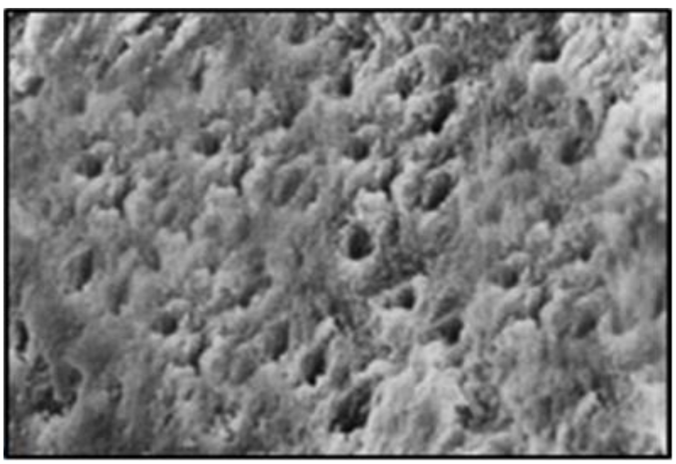
The specimens of all the three groups were grooved buccolingually along the entire length, with the help of a #168-L high-speed bur, without perforating into the root canal space. The roots were then split carefully along the length of the groove with an enamel chisel. One half of the split root was randomly selected, sputter coated, and subjected to SEM evaluation. Root samples were scanned at the cervical, middle, and apical root third levels using SEM at 15 kv and observed under ×2000 and ×5000.

Results

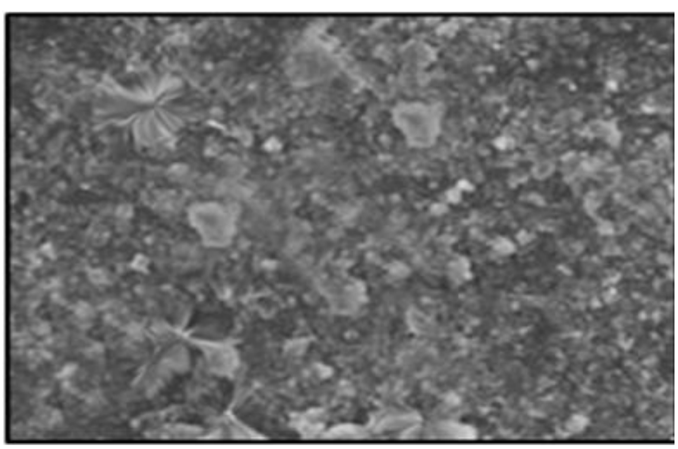
Figure 1 illustrates the representative SEM images of the coronal, middle, and apical root thirds of the Groups I and II at ×500 and ×5000. Figure 2 illustrate the representative TEM images taken at 1900x Group I (i.e., LA/sterile water and no instrumentation group) revealed patent dentinal tubules with no precipitate formation throughout the entire extent of the root canal surface, whereas specimens in Group II revealed precipitate occlusion at all the three root thirds of the specimens studied. Moreover, chemomechanical instrumentation procedure following the use of LA/NaOCl (Group III) also revealed the presence of precipitate in the dentinal tubules at coronal, middle, and apical root thirds, as depicted in Figure 2. Fig 2d reveals there is presence precipitate formation in group III compared to Groups I and II.

Fig 1. SEM Images of root canal surface taken at 5000x magnification. scale bar -10µM

A



B



C

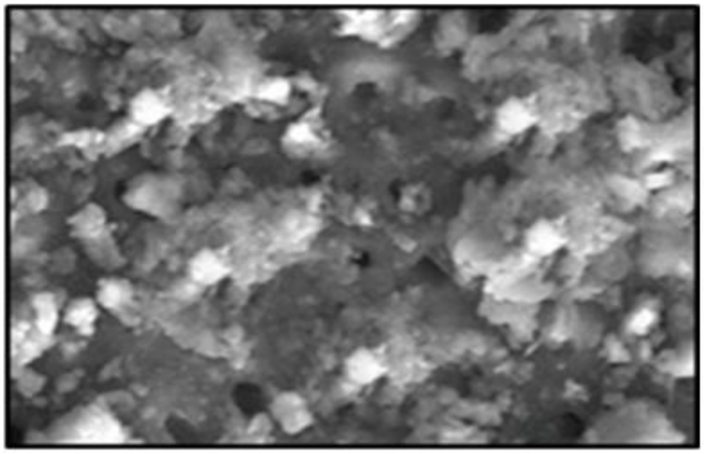


Image A - Group I showed dentinal tubules with less precipitate occlusion, Image B- Group II showed dentinal tubules with moderate precipitate occlusion, Image C- Group III showed dentinal tubules with more precipitate formation fig 1

Score 0: Absence of residues

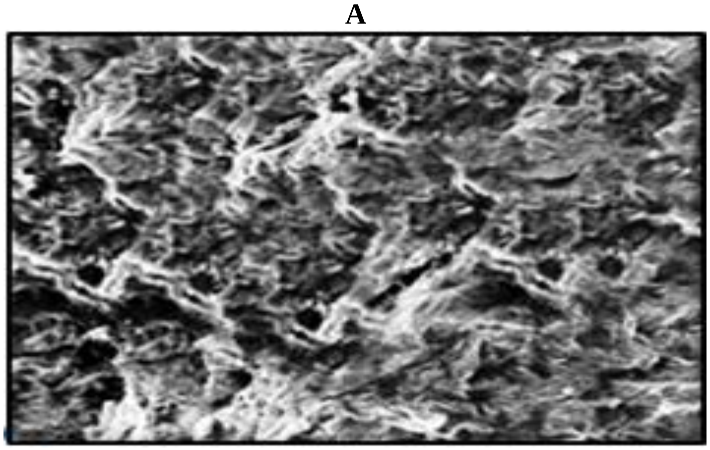
Score 1: Small amount of residues (<20%) (Figure A)

Score 2: Moderate amount of residues (>50%) (Figure B)

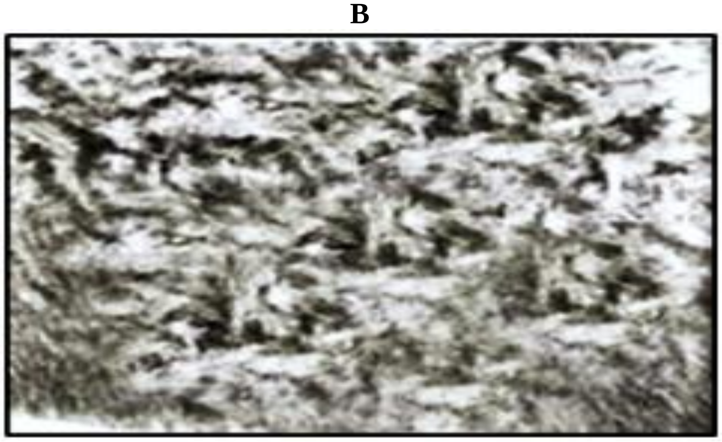
Score 3: Large amount of residues (<50%) (Figure C)

Fig 2. TEM Images of root canal surface taken at 19000x magnification. scale bar -1μM

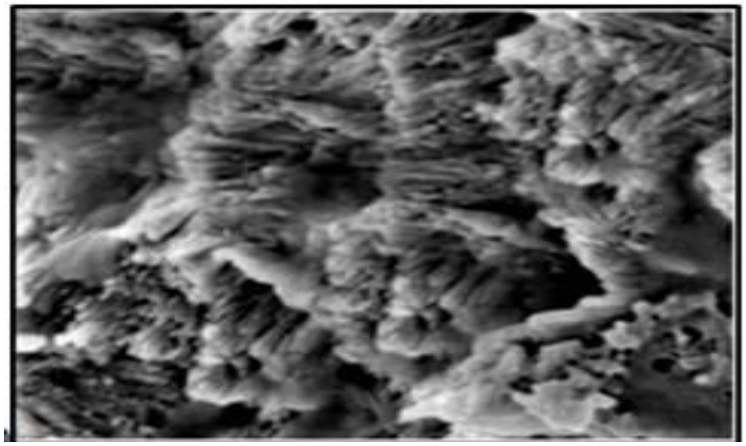
A



B



C



D

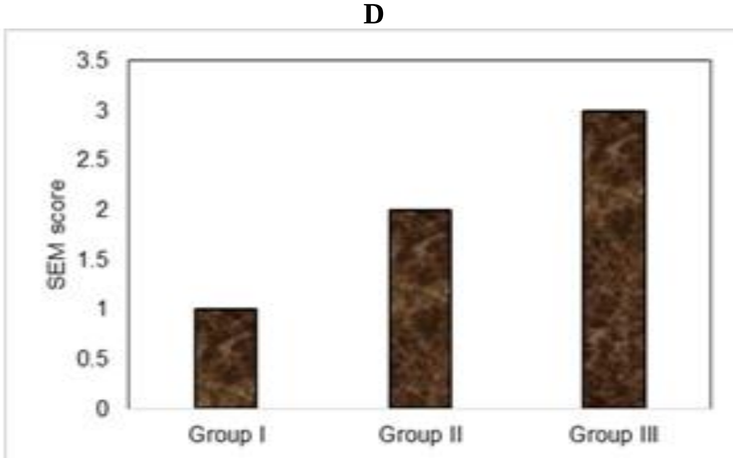


Image A - Group I showed lesser outer root canal surface damage, Image B- Group II showed small pits and on root canal surface crysals were noticed, Image C- Group III showed crystals with severe disturbances of structure

Discussion

Mechanical shaping and cleaning greatly remove the majority of the inflamed pulp remnants and infected dentin from the root canal system. However, owing to its anatomical complexities, organic and inorganic residues including bacteria cannot be completely removed from the canal and do often persist.[15,16] Hence, chemical debridement in the form of various irrigants is required in addition to the mechanical preparation of the root canal system for achieving optimal results.[17]

The most commonly employed irrigants in endodontics such as NaOCl, EDTA, and chlorhexidine (CHX) are always used in conjunction to achieve the desired therapeutic effects.[13] As a result, these irrigants routinely come into contact with each other during the root canal therapy. Basrani et al.[18] in an earlier study reported that the interaction between NaOCl and CHX resulted in the formation of parachloroaniline (PCA) precipitate, which is a known carcinogen. Although Orhan et al.[19] in a recent study proved that the precipitate did not contain free PCA, the authors claimed that there was a definite formation of a brown precipitate on mixing NaOCl and CHX. Rasimick et al.[20] also reported the formation of a white precipitate when 17% EDTA and 1% CHX were mixed, but this was reported to be nontoxic.

Although the interactions between various endodontic irrigants are quite well known, the interaction between LA solution (employed for IPI) and subsequently used irrigants are often overlooked in a clinical scenario. Vidhya et al.[14] evaluated the interaction between lidocaine hydrochloride (with or without adrenaline) and commonly used irrigants such as NaOCl, CHX, and EDTA using NMR spectroscopy. The authors proved that NaOCl and LA combination resulted in the formation of a precipitate, whereas EDTA and CHX, when admixed with LA solution, did not result in any precipitate formation.[14] The present study is one of the first investigation reports to evaluate the presence of LA/NaOCl precipitate on the root canal walls even after cleaning and shaping procedures. The general presumption is that such a precipitate, even when formed, will be removed from the root canal following the subsequently employed chemomechanical preparation. In the present study, 17% EDTA was used as an initial rinse in all the samples of the test groups prior to the experiment. This was done for an effective removal of the smear layer, thereby resulting in demineralization of peritubular and intertubular dentin for enhanced visualization of open dentinal tubules.[21] SEM evaluation of the root canal walls also provides ultrastructural assessment of the cleanliness of the dentin surfaces following different irrigation and cleaning methods, as employed in the previous studies.[22,23]

Our results showed that all the root canal specimens in the control group revealed almost complete removal of the smear layer at the coronal- and middle-thirds when compared to that of the apical root third samples. The moderate smear removal observed in the apical-third of the specimens may be attributed to incomplete penetration of EDTA in the apical area of the root canal. This could be attributed to the canal anatomy and inadequate penetration of the irrigants in the apical portion of the canals.[24]

In Groups II and III, the entire dentin surface was covered with a precipitate with very few patent dentinal tubules at all the three levels. Yet another interesting finding in this study was the presence of precipitate on the canal walls at all the root thirds in Group III as well, indicating that cleaning and shaping may not be very effective in the complete removal of the precipitate, though the amount of precipitate found was reduced. Thus, both the proposed null hypotheses were rejected.

As stated by Vidhya et al.,[14] there is an acid hydrolytic reaction between NaOCl and LA, thereby releasing hypochlorous acid which combines with carbon atoms present in lidocaine HCl molecule, leading to its disruption with subsequent cleavage of the double bond. On further hydrolysis, 2,6-xylidine (a known metabolite of lidocaine HCl) precipitate was formed. A major concern about this precipitate is that 2,6-xylidine was reported to be a toxic compound, as reported in the literature.[25]

This is a clinically significant study because the IPI technique is a routinely used procedure after establishing glide path in teeth where conventional anesthetic techniques have failed, with an added advantage of causing negligible systemic effects. In cases of hot tooth anesthetized with supplemental IPI followed by subsequent use of NaOCl, it may be of concern that this toxic precipitate will attach to the root canal surface and slowly leach into the periapical tissues. It may act as a potential concern for penetration of intracanal irrigants/medicaments and may significantly compromise the seal of the root canal. It may also hinder with the coronal seal of the post endodontic restoration if the resultant precipitate is not removed completely from the pulp chamber walls. Hence, it is advisable to avoid the immediate use of NaOCl following IPI with LA solution to avoid such detrimental effects. Since the anesthetic effect of the intrapulpal anesthesia is mainly due to the backpressure of the solution independent of the solution injected, as stated by Birchfield and Rosenberg,[12] it may be advisable to use 0.9% normal saline rather LA for IPI.

However, the study is not without its limitations. It can be argued that intrapulpal anesthesia is usually employed in the pulp chamber and probability of the LA solution entering into the root canal, following IPI is very minimal. In addition, all clinicians can neglect this significant interaction attributing to the reason that, only a small amount of LA (0.2–0.5 ml) is employed for supplemental IPI and the precipitate formed will be in negligible amounts that may be removed during the subsequent cleaning and shaping procedures.

Future investigations are warranted to determine the possible effects of the resultant precipitate on the mechanical properties of root dentin. The effect of this precipitate on the sealing ability of root canal obturation and postendodontic coronal restoration also has to be explored.

Conclusions

Within the limitations of this in vitro SEM study, it can be concluded that: (1) intrapulpal injection with LA into the pulpal space followed by subsequent irrigation with NaOCl forms a precipitate which occludes the dentinal tubules at the coronal-, middle-, and apical-thirds of the root canal;(2) conventional chemomechanical rotary instrumentation does not completely remove this precipitate; and (3) the combined use of LA and sterile water revealed patent dentinal tubules with no precipitate formation.

References

1. Oosterink FM, de Jongh A, Hoogstraten J. Prevalence of dental fear and phobia relative to other fear and phobia subtypes. Eur J Oral Sci 2009;117:135-43.
2. Troutman KC. Pharmacologic management of pain and anxiety for pediatric patients. In: Wei SH, editor. Pediatric Dentistry Total Patient Care. Philadelphia: Lea and Febiger; 1985. p. 156-62.
3. Potocnik I, Bajrović F. Failure of inferior alveolar nerve block in endodontics. Endod Dent Traumatol 1999;15:247-51.
4. Tortamano IP, Siviero M, Costa CG, Buscariolo IA, Armonia PL. A comparison of the anesthetic efficacy of articaine and lidocaine in patients with irreversible pulpitis. J Endod 2009;35:165-8.
5. Evans G, Nusstein J, Drum M, Reader A, Beck M. A prospective, randomized, double-blind comparison of articaine and lidocaine for maxillary infiltrations. J Endod 2008;34:389-93.
6. Hargreaves KM, Keiser K. Local anesthetic failures in endodontics: Mechanisms and management. Endod Top 2002;1:26-39.
7. Byers MR, Taylor PE, Khayat BG, Kimberly CL. Effects of injury and inflammation on pulpal and periapical nerves. J Endod 1990;16:78-84.
8. Walton RE, Torabinejad M. Managing local anesthesia problems in the endodontic patient. J Am Dent Assoc 1992;123:97-102.
9. Gross R, McCartney M, Reader A, Beck M. A prospective, randomized, double-blind comparison of bupivacaine and lidocaine for maxillary infiltrations. J Endod 2007;33:1021-4.
10. Boopathi T, Sebeena M, Sivakumar K, Harikaran J, Karthick K, Raj A, et al. Supplemental pulpal

anesthesia for mandibular teeth. J Pharm BioalliedSci 2013;5:S103-8.

11. Ingle JI, Beveridge EE. Endodontics. Philadelphia: Lea and Febiger; 1976.
12. Birchfield J, Rosenberg PA. Role of the anesthetic solution in intrapulpal anesthesia. J Endod 1975;1:26-7.
13. Zehnder M. Root canal irrigants. J Endod 2006;32:389-98.
14. Vidhya N, Karthikeyan BS, Velmurugan N, Abarajithan M, Nithyanandan S. Interaction between lidocaine hydrochloride (with and without adrenaline) and various irrigants: A nuclear magnetic resonance analysis. Dent Res J (Isfahan) 2014;11:395-9.
15. Byström A, Sundqvist G. Bacteriologic evaluation of the efficacy of mechanical root canal instrumentation in endodontic therapy. Scand J Dent Res 1981;89:321-8.
16. Peters OA. Current challenges and concepts in the preparation of root canal systems: A review. J Endod 2004;30:559-67.
17. Orstavik D, Haapasalo M. Disinfection by endodontic irrigants and dressings of experimentally infected dentinal tubules. Endod Dent Traumatol 1990;6:142-9.
18. Basrani BR, Manek S, Sodhi RN, Fillery E, Manzur A. Interaction between sodium hypochlorite and chlorhexidinegluconate. J Endod 2007;33:966-9.
19. Orhan EO, Irmak Ö, Hür D, Yaman BC, Karabucak B. Does para-chloroaniline really form after mixing sodium hypochlorite and chlorhexidine? J Endod 2016;42:455-9.
20. Rasimick BJ, Nekich M, Hladek MM, Musikant BL, Deutsch AS.Interaction between chlorhexidinedigluconate and EDTA. J Endod 2008;34:1521-3.
21. Teixeira CS, Felippe MC, Felippe WT. The effect of application time of EDTA and NaOCl on intracanal smear layer removal: An SEM analysis. IntEndod J 2005;38:285-90.
22. Akisue E, Tomita VS, Gavini G, Poli de Figueiredo JA. Effect of the combination of sodium hypochlorite and chlorhexidine on dentinal permeability and scanning electron microscopy precipitate observation. J Endod 2010;36:847-50.
23. Yang G, Wu H, Zheng Y, Zhang H, Li H, Zhou X. Scanning electron microscopic evaluation of debris and smear layer remaining following use of ProTaper and hero shaper instruments in combination with NaOCl and EDTA irrigation. Oral Surg Oral Med Oral Pathol Oral RadiolEndod 2008;106:e63-71.
24. Garberoglio R, Becce C. Smear layer removal by root canal irrigants. A comparative scanning electron microscopic study. Oral Surg Oral Med Oral Pathol 1994;78:359-67.
25. Kornreich M, Montgometry CA. Toxicology and carcinogenesis studies of 2, 6-xylidine (2,6-dimethylaniline) in Charles river cd rats (feed studies). In: Technical Report Series, editor. National Toxicology Program. Research Triangle Park, North Carolina, United States of America: National Institute of Environmental Health Sciences; 1990. p. 3-4.