Journal of Advances in Medicine and Medical Research

34(19): 68-76, 2022; Article no.JAMMR.87582
ISSN: 2456-8899
(Past name: British Journal of Medicine and Medical Research, Past ISSN: 2231-0614, NLM ID: 101570965)

Antibacterial Efficacy of Different Intracanal Irrigants on Root Canal Treatment: An *In-Vitro* Study

Sana Babar [a*#], Hina Ahmed [bφ], Abubakar Sheikh [c†], Saqib Rashid [d†], Tasleem Hosein [e‡] and Hasan Mehdi [f¥]

[a] Department of Operative Dentistry, Fatima Jinnah Dental College and Hospital, Building# 1, Street# 1, 100 Foot Road, Azam Town, Karachi, Pakistan.
[b] Department of Operative Dentistry, Ziauddin University Karachi, Pakistan.
[c] Department of Endodontics, Fatima Jinnah Dental College and Hospital, Karachi, Pakistan.
[d] Department of Operative Dentistry, Fatima Jinnah Dental College and Hospital, Karachi, Pakistan.
[e] Fatima Jinnah Dental College, and Hospital, Karachi, Pakistan.
[f] Department of Oral Surgery, Fatima Jinnah Dental College and Hospital, Karachi, Pakistan.

Authors' contributions

This work was carried out in collaboration among all authors. Author SB designed and wrote the final draft for the study, Author HA wrote the first draft. Author AS helped collect the sample and helped in writing the draft and author SR helped write the final draft. Author TH read and approved the final draft and author HM managed the analysis of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMMR/2022/v34i1931440

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/87582

Original Research Article

Received 27 March 2022
Accepted 06 June 2022
Published 13 June 2022

ABSTRACT

Aims: Out of many properties that an endodontic disinfecting agent should possess, the most important is that of having a wide range of antibacterial efficacy. This study has been performed to see the effect of different agents on the bacterial microflora and to see how efficient they are against them. Our study has used 3 different agents (Chlorohexidine, Sodium Hypochlorite, and Neem extract) and compared their efficacy against bacterial microflora.

[#] Registrar,
[φ] Professor,
[†] Professor, HOD,
[‡] Professor, Principal,
[¥] Associate Professor,
**Corresponding author: E-mail: sana.babar89@gmail.com;*

Study Design: Experimental study design
Place and Duration: The study was conducted in the Department of Endodontics at Fatima Jinnah Dental College and Hospital, Karachi, Pakistan from February 2020 to March 2020.
Methodology: Infected samples from individuals were collected through paper points and then allowed to be cultured and incubated on blood agar plates at 37 degrees in an incubator for 24 hours. The colonies were then identified through the gram staining procedure and grown on MHA agar to conduct the disk diffusion test for sensitivity. Individual zones of inhibition for irrigants were measured and compared against each other.
Results: A total of 36 infected samples were included in the study out of which 12 samples were irrigated with chlorohexidine, 12 with sodium hypochlorite, and 12 with neem extract. there was a statistically significant difference in mean diameters of the inhibition zone observed between the three groups for the mean inhibition zone (F=12.28, P=0.001).
Conclusion: Chlorohexidine showed greater efficacy against bacterial microflora, compared to both sodium hypochlorite and neem extract.

Keywords: Root canal treatment; chlorohexidine; sodium hypochlorite; neem; intracanal irrigants; neem extract; intracanal medicament.

1. INTRODUCTION

The goal of endodontic treatment is to cleanse the root canal system and periapical tissues completely and avoid reinfection. The current procedures, equipment, and irrigants for root canal sterilization are limited [1].

The main goals of endodontic treatment are to shape and clean a root canal system while also preserving the surrounding periodontal tissues. While the mechanical parts of a root canal treatment receive the most of the emphasis, irrigation is a critical component.as well [2].

Irrigants in endodontics have been associated for a long time now. Instrumentation, in combination with irrigation, helps to reduce microbial excess in the root canals. Irrigants can help with mechanical debridement by washing debris out of the root canal system, disintegrating tissue, and disinfecting it. Chemical debridement is especially important for teeth with intricate internal anatomy, such as fins or other anomalies that instrumentation may overlook [3].

Chemical irrigation's main goal is to destroy germs and disintegrate pulpal tissue. Sodium hypochlorite and chlorohexidine, for example, have been shown to be efficient antimicrobials in vitro and are commonly utilised during root canal therapy around the world. However, according to a systematic review, there is a paucity of high-quality evidence to support the use of one irrigant over another in terms of both short- and long-term therapeutic outcome [4].

An irrigant should be able to disinfect and penetrate dentin and tubules, provide a long-term antibacterial effect, remove the smear layer, and be non-antigenic, nontoxic, and non-carcinogenic in order to properly clean and disinfect the root canal system. It should also have no negative effects on dentin or the capacity of filling materials to seal [5-8]. Furthermore, it should be reasonably priced, simple to use, and free of tooth discolouration. The ability to disintegrate pulp tissue and inactivate endotoxins are two other desirable qualities of an ideal irrigant [9].

Sodium hypochlorite is the most commonly used irrigant with a broad spectrum of antibacterial action and a high potential for disintegrating pulpal tissue. However, because of the pH of 11-12, it has a toxic action that induces protein oxidation, resulting in hemolysis and necrosis. Sodium hypochlorite has a number of drawbacks, including clothing damage, injury to the patient's or operator's eye, and air emphysema while injecting in the canal [10]. Due to the following disadvantages, there is a need for a new biocompatible and effective root canal irrigant.

Chlorohexidine on the other is another intracanal irrigant, possessing a wide range of antimicrobial activity. It is effective against both gram-positive as well as gram-negative bacteria [11]. Chlorohexidine gluconate is used as the gold standard antimicrobial agent with the most potent chemotherapeutic activity against many microbes [12-14]. It is bacteriostatic in low concentration and bactericidal in high concentration [15].

Chlorohexidine produces staining of teeth, altered taste, and development of microbial resistance [16]. Sodium hypochlorite has unwanted side effects such as tissue toxicity,

allergy, and disagreeable smell and taste [17]. Side effects of non-herbal medicines, herbal medicines are gaining importance.

2. MATERIALS AND METHODS

The study was conducted in the Department of Endodontics at Fatima Jinnah Dental College and Hospital, Karachi, Pakistan from February 2020 to March 2020. Inclusion criteria were patients between 18 – 50 years both male and female, all teeth except those indicated for the extraction or had undergone previous endodontic treatment were included in the study.

Canals that were shaped till Rotary shaper files were used to collect the specimen. Once the canals had gone through initial filing and prepared till the last shaper file of rotary. A paper point of size 35 was introduced into the canal. The paper point was then carried into a sterile vial containing 1mm of saline. The paper point was then streaked onto blood agar plates and incubated at 37^0C for 24 hours in an incubator. After 24 hours bacterial growth was observed on the blood agar (Fig. 1) . The colonies were then inoculated onto slides for gram staining and identification. The slides were then viewed under a 100x magnification oil immersion lens of a compound microscope. Different bacteria were identified as either gram-positive or gram-negative rods and cocci (Fig. 2). The bacteria were then transferred using a sterile culture swab again onto the MHA agar to perform the disk/agar diffusion method to identify bacterial sensitivity against 2% Chlorohexidine, 3% NaOCl, and Neem extract. Three antibacterial sensitivity discs were then added at a specific distance from each other each of them containing the irritants. Once placed onto the MHA agar the sample was incubated again at 37^0 C for 24 hours. Zones of inhibition (Fig. 3) (the zone in which there is an antimicrobial activity seen as visible as a transparent area over the agar plate) were checked after incubation of each plate against the bacterial colonies identified. Zones were measured using a transparent scale and then entered onto the proforma later to be analyzed.

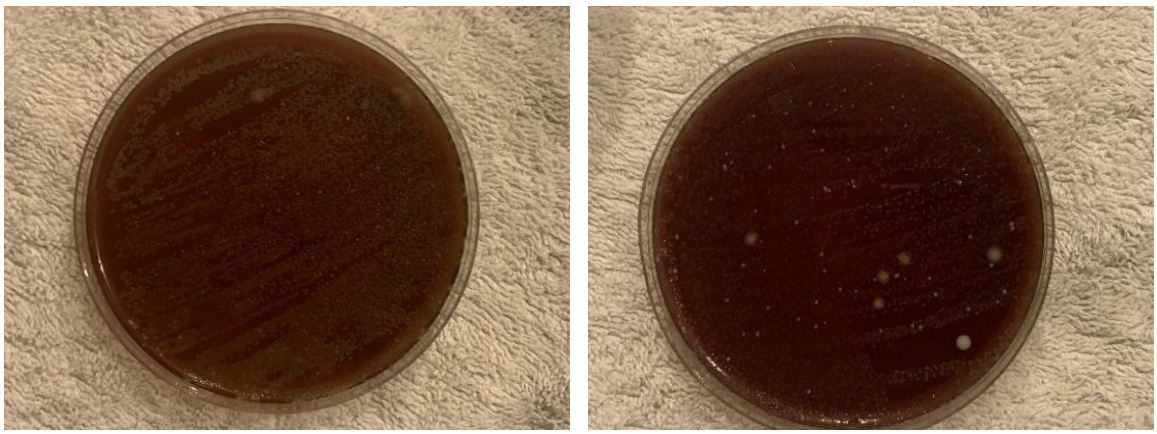
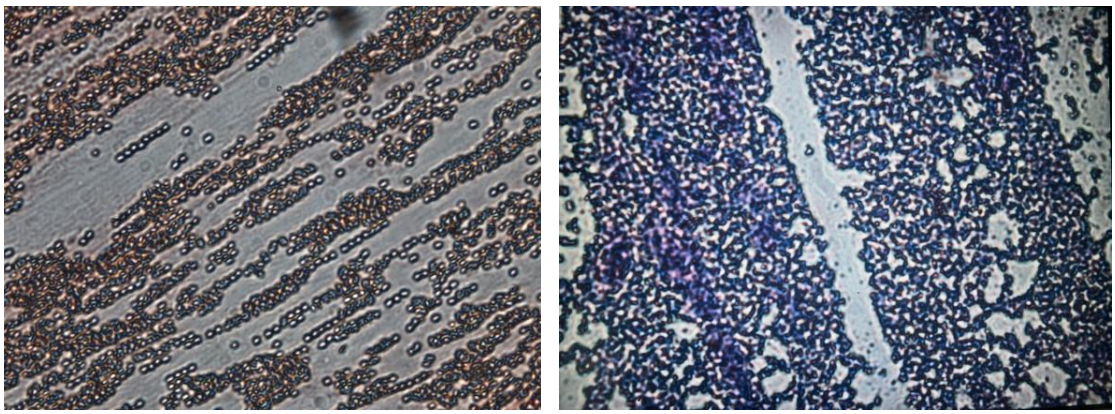


Fig. 1. Blood agar plates with bacterial colonies



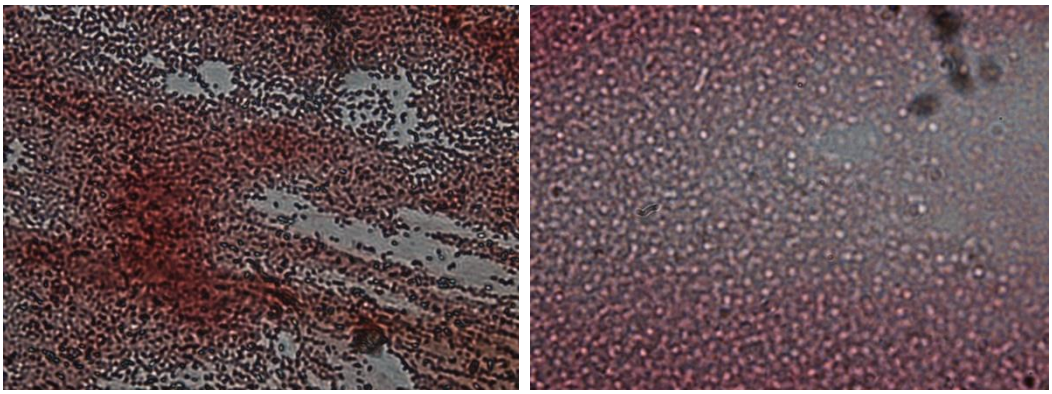


Fig. 2. Different gram stained bacterial colonies under 100x magnification

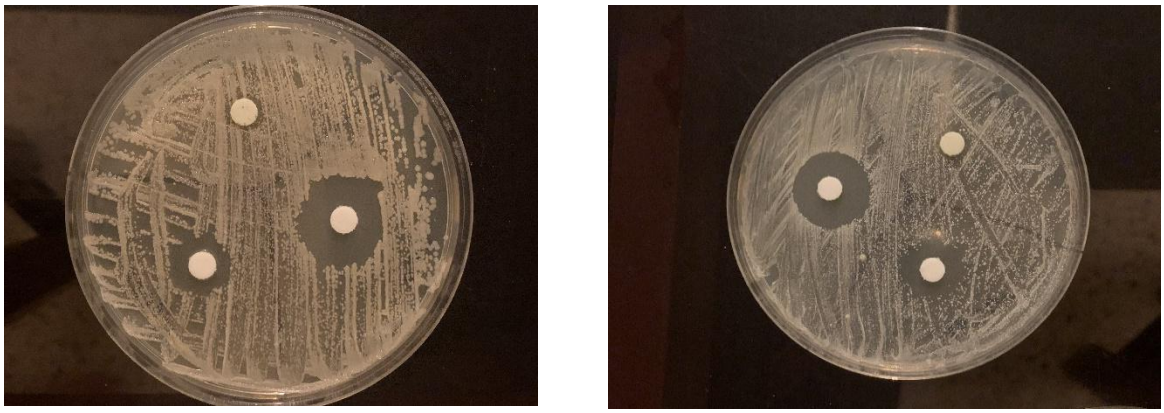


Fig. 3. Zones of inhibition on MHA plates

3. RESULTS AND DISCUSSION

A total of 36 infected samples were included in the study, wherein 12 samples were irrigated with 2% chlorhexidine, 12 with 3% sodium hypochlorite, and 12 with neem extract. Chlorohexidine had a significantly higher mean inhibition zone (1.49±0.25 mm) as compared to sodium hypochlorite (1.25±0.19 mm) and neem extract (1.10±0.11 mm) respectively. Hence, there was a statistically significant difference in mean diameters of the inhibition zone observed between the three groups for the mean inhibition zone (F=12.28, *P*=0.001). (Fig. 2)

For many years, herbal medicine has been associated with medical uses. Neem in particular, due to its vast variety of qualities, which include antibacterial, anti-inflammatory, and antifungal capabilities. Since it was utilised in medicine, it was felt that it would be wise to employ it in dentistry as well, combining its qualities into usage as an intracanal irrigant, to use not only as a pain reliever but also to eliminate a wide range of bacteria residing within the root canal system [18-21]. Previous research has revealed that neems have antibacterial as well as anti-adherent properties, affecting bacterial adherence and colonisation capacity [22].

Table 1. Comparison of mean between the irrigants

	Mean difference	p-value	Significance
1 vs 2	0.242	0.014*	Significant
2 vs 3	0.150	0.206	Insignificant
1 vs 3	0.392	0.001*	Significant
1=Chlorohexidine, 2= Sodium hypochlorite, 3=Neem extract			

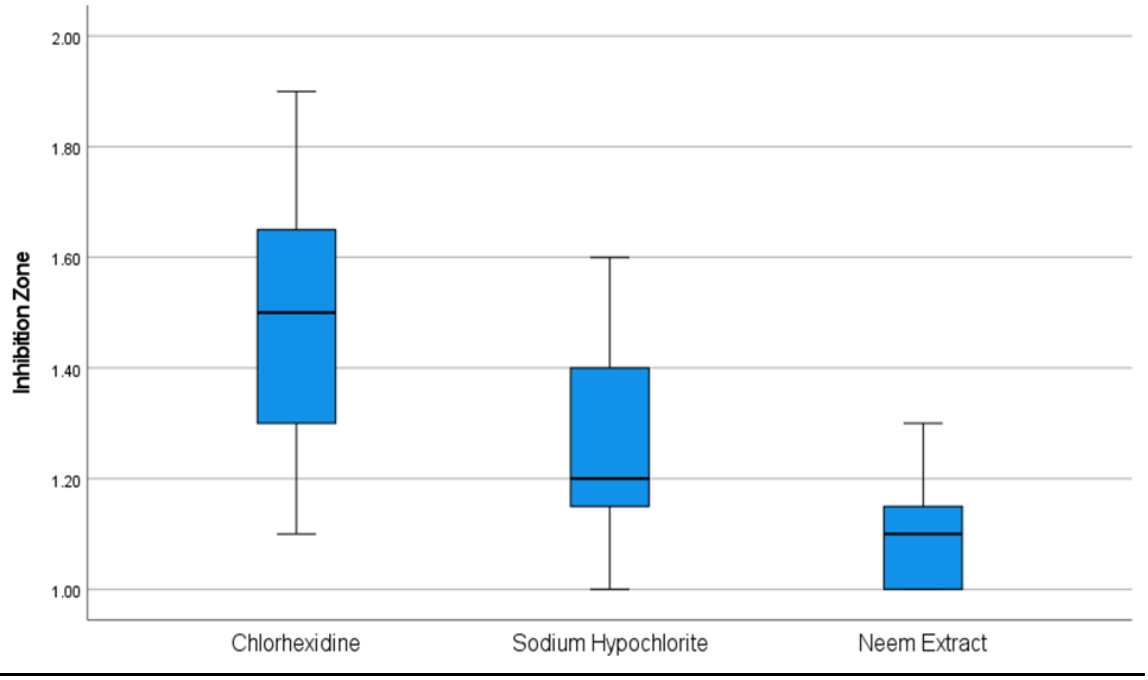


Fig. 2. Difference between mean diameters of zones of inhibition

About three different studies at a point (Prabhakar AR, Basavraj P, Basappa N 2013), [23,24] found a highest antimicrobial effect with 0.2% chlorhexidine compared to herbal medicament (*Morinda citrifolia*, garlic, and turmeric), whereas a different study showed that neem extract is more effective than sodium hypochlorite 5.25% against *E. faecalis* [17].

"In a recent study though no significant difference was found in antibacterial efficacy between Cholorohexidine and NaOCl treatments, which showed that intracanal endotoxin levels decreased compared with the initial levels after applying Cholorohexidine and NaOCl. However, they found that NaOCl was more effective in the reduction of gram-negative bacterial endotoxin than Cholorohexidine, but none of the gram-positive bacterial parameters were investigated" [25].

Bacteriologic samples were taken before, during, immediately after, and 24 hours after instrumentation, irrigation, and treatment with Chlorhexidine gluconate and NaOCl, respectively. Following the instrumentation and irrigation procedures, there was an extremely significant reduction in microorganisms in the Chlorhexidine-treated specimens. Another study [26] compared 2% Chlorhexidine to 5.25% NaOCl in vitro and found that Chlorhexidine was more successful in reducing the number of positive cultures, despite the fact that the difference was not statistically significant.

However, in another study conducted (Mustafa M 2016), "the antimicrobial efficacy of neem was compared with that of the chlorhexidine gluconate and NaOCl, and it was found that neem efficacy was comparable to that of other commonly used gold standard compounds. In this study, it was shown that the zone of inhibition in the agar diffusion test showing the antimicrobial efficiency of the neem extract was comparable to that of 2% chlorhexidine and 3% NaOCl".

"The antimicrobial efficacy of CHX and NaOCl irrigants was compared in root canal therapy of permanent teeth. No significant differences in their antimicrobial efficacy were found. In conclusion, the obtained evidence suggested that both CHX and NaOCl significantly, but not completely, reduced endodontic infections during root canal therapy. They were found to be equally effective despite their different molecular mechanisms". (Ruksakiet, K., Hanák, L., Farkas, N., Hegyi, P., Sadaeng, W., Czumbel, L.M., et al 2020)

"Antimicrobial drug resistance is a major problem in the medical and dental fields [27] which is why dental professionals are looking for alternatives, such as herbal products, which possess

significant antibacterial properties. Of all these natural medications, neem is drawing significant attention since the plant possesses excellent antibacterial and antifungal properties" (Raghavendra SS 2014)

"The isoprenoid group (Nimbin, nimbolide, and nimbidic acid) of constituents of neem has a broad range of therapeutic and antimicrobial effects suggesting its potential as an endodontic irrigant as suggested by these studie"s [28-30]. "The use of neem as an endodontic irrigant may be advantageous because neem is an excellent antioxidant with very high biocompatibility, and thus there is no risk of tissue toxicity with its use. Biocompatibility of neem to the human periodontal ligament fibroblasts has already been proved, and this is an important factor favoring its clinical application in endodontics" [31].

"Nimbina product of the seed kernel of *A. indica* demonstrates anti-inflammatory, antibacterial, antifungal, and antipyretic properties. Furthermore, neem exhibited substantial efficacy against periodontal pathogens and is biocompatible with PDL fibroblasts. Hence, its use as a biocompatible irrigant might be beneficial in endodontic therapy" [32]. Mistry et al. concluded in their study that neem extract showed significant activity against *S. aureus* [33].

Whereas, Bohora *et al*. and Tyagi *et al*. reported "neem to be an effective root canal medicament against E. faecalis and *C. Albican"* (Bohora A, Hegde V, Kokate S. 2010) [34]. However, the results of the study were not by them and neem exhibited less effectiveness against bacterial microflora. A present study [35] showed cinnamon extract irrigant to have better antibacterial effectiveness followed by sodium hypochlorite. Neem showed to have the least antibacterial effectiveness. This present study correlates to the result we see in our findings of the comparison of neem and sodium hypochlorite, showing less effectiveness [36-40].

"Another recent study published in 2021 showed that Neem was associated with lower pain intensity. Neem and 2.5% sodium hypocholorite significantly reduced endotoxin levels but were not effective in eliminating endotoxins from root canals of mandibular molars with necrotic pulps" [41].

"Based on the above given in the study, it can be concluded that neem leaf extract could be used as an alternative agent in root canal disinfection. However, further in vitro studies on its toxicological effects and optimal concentration against a wider spectrum of microorganisms have to be established" (Mustafa M 2016)

Keeping in mind the results of the present study that has been conducted Chlorohexdine is most effective against the bacterial microbes compared to both sodium hypochlorite and neem [42-47]. Despite its several disadvantages, its advantages outweigh and still bring it to the most efficient position as an intracanal irrigant, but further studies still need to be performed to come to a proper conclusion for the use of neem as an intracanal irrigant [48-52].

4. CONCLUSION

Within the constraints of this investigation, it was determined that chlorohexdine had the highest antibacterial activity as an intracanal irrigant against endodontic germs, whereas sodium hypochlorite and neem had equivalent antibacterial efficacy against the microbes, making them both equally beneficial. Having said that, the literature supports the idea that neem extract has antibacterial qualities and can be utilised as an alternative for intracanal irrigants, however in light of our findings.

DISCLAIMER

The products employed in this study are widely and often used in our field of study and in our country. There is no conflict of interest between the writers and makers of the products because we do not plan to use them as a means of pursuing legal action, but rather to further knowledge. Furthermore, the research was not supported by the production firm, but rather by the writers' own efforts.

CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ruksakiet K, Hanák, L, Farkas, N, Hegyi P, Sadaeng W, Czumbel LM, Sang-Ngoen T, Garami A, Mikó A, Varga G, Lohinai Z. Antimicrobial efficacy of chlorhexidine and sodium hypochlorite in root canal disinfection: a systematic review and meta-analysis of randomized controlled trials. *Journal of Endodontics.* 2020;*46*(8): 1032-1041.
2. Dioguardi, M., Di Gioia, G., Illuzzi, G., Arena, C., Caponio, V.C.A., Caloro, G.A., Zhurakivska, K., Adipietro, I., Troiano, G. and Lo Muzio, L., 2019. Inspection of the microbiota in endodontic lesions. *Dentistry Journal*, 2019;*7*(2):47.
3. Kandaswamy D, Venkateshbabu N. Root canal irrigants. J Conserv Dent. 2010;13(4):256–64.
4. Fedorowicz Z, Nasser M, Sequeira-Byron, P, de Souza RF, Carter B, Heft M. Irrigants for non-surgical root canal treatment in mature permanent teeth. *Cochrane database of systematic reviews*. 2012; (9).
5. Siswomihardjo W, Badawi SS, Nishimura M, Hamada T. The difference in the antibacterial effect of neem leaves and sticks extract. Int Chin J Dent. 2007;7:27–29.
6. Siqueira Jr JF, Rôças IN, Favieri A, Lima KC. Chemomechanical reduction of the bacterial population in the root canal after instrumentation and irrigation with 1%, 2.5% and 5.25% sodium hypochlorite. *Journal of Endodontics*. 2000;*26*(6):331-334.
7. Supriya R, Nagini S. Medicinal properties of neem leaves: a review. Curr Med Chem Anti Cancer Agents. 2005;5(2):149–56.
8. Sundaram D, Narayanan RK, Vadakkepurayil KA. Comparative evaluation on the antimicrobial effect of honey, neem leaf extract, and sodium hypochlorite as intracanal irrigant: an ex-vivo study. J Clin Diagn Res. 2016;10: ZC88-91.
9. Borzini L, Condò R, De Dominicis P, Casaglia A, Cerroni L. Root canal irrigation: Chemical agents and plant extracts against Enterococcus faecalis. *The Open Dentistry Journal*. 2016;*10*:692.
10. Zehnder M. Root canal irrigants. Journal of Endodontics. 2006;32(5):389–98.
11. Hulsmann M, Hahn W. Complications during root canal irrigation – literature review and case reports. Int Endod J. 2000;33:186–93
12. Bhardwaj A, Ballal S, Velmurugan N. Comparative evaluation of the antimicrobial activity of natural extracts of Morinda centifolia, papain, and aloe vera (all in gel formulation), 2% chlorhexidine gel and calcium hydroxide, against *Enterococcus fecal*: An *In vitro* study. J Conserv Dent. 2012;15:293–7.
13. Agarwal P, Nagesh L, Murlikrishnan Evaluation of the antimicrobial activity of various concentrations of Tulsi (*Ocimum sanctum*) extract against Streptococcus mutans: An *in vitro* study. Indian J Dent Res. 2010;21:357–9.
14. Prabhakar AR, Basavraj P, Basappa N. Comparative evaluation of Morinda citrifolia with chlorhexidine as antimicrobial endodontic irrigants and their effect on micro-hardness of root canal dentin: An *in vitro* study. Int J Oral Health Sci. 2013;3:5–9.
15. Bazvand L, Aminozarbian MG, Farhad A, Noormohmmadi H, Hasheminia SM, Mobasherizadeh S. Antibacterial effect of tri antibiotic mixture, chlorhexidine gel, and two natural materials Propolis and Aleo vera against *Enterococcus fecal*: An *ex vivo* study. Dent Res J (Isfahan) 2014;11: 469–74.
16. Vinothkumar TS, Rubin MI, Balaji L, Kandaswamy D. *In vitro* evaluation of five different herbal extracts as an antimicrobial endodontic irrigant using real-time quantitative polymerase chain reaction. J Conserv Dent. 2013;16:167–70.
17. Kishen A, Sum CP, Mathew S, Lim CT. Influence of irrigation regimens on the adherence of Enterococcus faecalis to root canal dentin. J Endod 2008 Jul;34(7):850-854.
18. Prasad SD, Goda PC, Reddy KS, Kumar CS, Hemadri M, Ranga Reddy DS. Evaluation of antimicrobial efficacy of neem and aloe vera leaf extracts in comparison with 3% sodium hypochlorite and 2% chlorhexidine against E. faecalis and C. Albicans. J NTR Univ Health Sci 2016;5:104-10.
19. Shahid M, Abdullah AY, Abdul Hamid, S, Khalid AH. Reasons for root canal treatment in students' and interns' clinics in the college of dentistry, King Saud University, Saudi Arabia.
20. Silva FB, Almeida JM, Sousa SMG. Natural medicaments in endodontics – a comparative study of the anti-inflammatory action. Braz Oral Res. 2004;18(2):174–79.

21. Sinha DJ, Nanda K.D.S, Jaiswal N, Vasudeva A, Tyagi SP, Singh UP; 2017.
22. Rosaline H, Kandaswamy D, Gogulnath D, Rubin Ml. Influence of various herbal irrigants as a final rinse on the adherence of Enterococcus faecalis by fluorescence confocal laser scanning microscope. J Cons Dent 2013 Jul-Aug;16(4):352-355.
23. Arora T, Kang RS, Mann JS, Khurana NS, Aggarwal R, Walia G. Antimicrobial activity of herbal extracts against recalcitrant endodontic pathogens: An original *in vitro* study. Saint Int Dent J. 2015;1:28–32.
24. Rani A, Thakur S, Gupta S, Gauniyal P, Bhandari M, Gupta H. Comparative evaluation of the antimicrobial activity of different herbal extracts and 2% chlorhexidine gluconate against E. Faecalis and C. Albicans-An *In vitro* study. Indian J Dent Sci. 2015;1:20–3.
25. Jeansonne M.J., White R.R. A comparison of 2.0% chlorhexidine gluconate and 5.25% sodium hypochlorite as antimicrobial endodontic irrigants. J. Endod. 1994;20(6):276–278. DOI: 10.1016/S0099-2399(06)80815-0
26. Reddy RR, Kumari K, Lokanatha O, Mamatha S, Reddy D. Antimicrobial activity of Azadirachta Indica (neem) leaf, bark, and seed extracts. Inter J Res Phtyochem Pharmacol 2013;3:1-4.
27. Raghavendra SS. Antifungal efficacy of Azadirachta Indica (neem) - an in vitro study. Braz J Oral Sci 2014;13:242-5.
28. Bohora A, Heghe V, Kokate S. Comparison of the antibacterial efficiency of neem leaf extract and 2% sodium hypochlorite against E. faecalis, C. Albicans and mixed culture - an in vitro study. Endodontology 2010;22:8-12.
29. Dutta A, Kundabala M. Comparative anti-microbial efficacy of Azadirachta indica irrigant with standard endodontic irrigants: a preliminary study. J Conserv Dent 2014;17:133-7. 16.
30. Ravishankar P, Lakshmi T, Aravind Kumar S. Ethnobotanical approach for root canal treatment –an update. J Pharm Sci & Res. 2011;3(10):1511–19.
31. Botelho MA, Santos RAD, Martins JG, Carvalho CO, Paz MC, Azenha CR, Ruela R, Queiroz DB, Ruela WS, Marinho G, Ruela FI. Efficacy of a mouth rinse based on leaves of neem in the treatment of patients with chronic gingivitis. J Med Plants Res. 2008;2:341-6.
32. Dedhia J, Mukharjee E, Luke AM, Mathew S, Pawar AM. Efficacy of Andrographis paniculata compared to Azadirachta indica, Curcuma longa, and sodium hypochlorite when used as root canal irrigants against Candida albicans and Staphylococcus aureus: An in vitro antimicrobial study. *Journal of Conservative Dentistry: JCD*. 2012;*21*(6):642.
33. Mistry KS, Shah S. Review on common root canal irrigants. J Dental Sciences. 2011;2(2):27–31.
34. Tyagi SP, Sinha DJ, Garg P, Singh UP, Mishra CC, Nagpal R, et al. Comparison of antimicrobial efficacy of propolis, Morinda citrifolia, *Azadirachta indica* (Neem) and 5% sodium hypochlorite on *Candida albicans* biofilm formed on tooth substrate: An in-vitro study. *J Conserv Dent.* study. *Indian Journal of Dental Research.* 2013;*31*(1):124.
35. Panchal, V., Gurunathan, D. and Muralidharan, N.P., 2020. Comparison of antibacterial efficacy of cinnamon extract, neem extract as an irritant, and sodium hypochlorite against Enterococcus fecal: an in vitro
36. Kale PP, Raut AW. A proposed classification system for herbal endodontic irrigants. *Journal of Conservative Dentistry: JCD*. 2021;*24*(3):293.
37. Khan M, Qasim M, Ashfaq UA, Idrees S, Shah M. Computer-aided screening of *Accacia nilotica* phytochemicals against HCV NS3/4a. Bioinformation. 2013;710.
38. Lakshmi T. Antibacterial activity of two herbal extracts and 2% sodium hypochlorite against Enterococcus faecalis An *in vitro* comparative study. J Chem Pharm Res. 2013;5:782–6.
39. Mohammed M Antibacterial Efficacy of Neem (Azadirachta indica) Extract against Enterococcus faecalis: An in vitro study, The Journal of Contemporary Dental Practice, October 2016;17(10):791-794
40. Neelakantan P, Jagannathan N, Nazar N. Ethnopharmacological approach in endodontic treatment: a focused review. Int J Drug Dev & Res. 2011;3(4):68–77.
41. NS. Hosny, SA. El Khodary, R. M. El Boghdadi, OG. Shaker.Effect of Neem (*Azadirachta indica*) versus 2.5% sodium hypochlorite as root canal irrigants on the intensity of postoperative pain and the number of endotoxins in mandibular molars with necrotic pulps: a randomized

controlled trial. International Endodontic Journal; 2021.
42. Akanksha, Srivastava AK, Maurya R. Antihyperglycemic activity of compounds isolated from Indian medicinal plants. Indian J Exp Biol. 2010;48(3):294–8
43. Asif M. Antimicrobial potential of Azadirachta indica against pathogenic bacteria and fungi. Journal of Pharmacognosy and Phytochemistry. 2012;1(4):78–83.
44. Bassan NJ, Tait CM Effectiveness of three root canal medicaments to eliminate *Actinomycess Israeli* from infected dentinal tubules *in vitro* 2001;SADJ;56:499 - 501
45. Berman LH, Hargreaves KM. *Cohen's Pathways of the Pulp-E-Book*. Elsevier Health Sciences.
46. Biswas K, Chattopadhyay I, Banerjee RK, Bandyopadhyay U. Biological activities and medicinal properties of neem (*Azadirachta indica*). Curr Sci (2002);82:1336-45.
47. Chandrabhatla SK, Rajasekar V, Nalam SG, Pandranki J. Natural medicaments in endodontics. Journal of Oral Research & Review. 2012;4(2):25–32.
48. Daga P, Asrani H, Farista S, Mishra P Comparative Evaluation of Antimicrobial Efficacy of Neem, Miswak, Propolis, and Sodium Hypochlorite against Enterococcus faecalis using EndoVac International Journal of Prosthodontics and Restorative Dentistry, April-June 2017;7(2):60-65
49. Delany GM, Patterson SS, Miller CH, Newton CW. The effect of chlorhexidine gluconate irrigation on the root canal flora of freshly extracted necrotic teeth. Oral Surg. Oral Med. Oral Pathol. 1982;53(5):518–523. DOI: 10.1016/0030-4220(82)90469-8.
50. Girish K, Bhat SS. Neem - A green treasure. Electron J Biol. 2008;4:102-11.
51. Hugar SM, Mistry LN, Hogade S, Badkar CM. An *in vitro* comparative evaluation of the efficacy of disinfection ability of garlic oil (Lasuna), Clove leaf oil (Lavang), and autoclaving on endodontic K files tested against *Enterococcus fecal*. IAMJ. 2015;3:2277–84.
52. Jalil A, Ashfaq UA, Shahzadi S, Javed MR, Rasul I, Rehman SU, et al. Screening and design of anti-diabetic compounds sourced from the leaves of neem (*Azadirachta indica*) Bioinformation. 2013; 9(20):1031.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/87582