ISSN: 2581 – 3633
PubMed - National Library of Medicine - ID: 101745081

International Journal of Medical Science and Advanced Clinical Research (IJMACR)

Available Online at:www.ijmacr.com

Volume – 9, Issue – 2, April – 2026, Page No.: 152 – 161

Comparison of Antimicrobial Efficacy Between Natural Herbal Extracts and Sodium Hypochlorite as Endodontic Irrigants

[1]Dr. Ravi Pratap, Reader, Department of Conservative Dentistry & Endodontics, Vananchal Dental College & Hospital, Garhwa, Jharkhand

[2]Dr. Sumit Sabharwal, Reader, Department of Conservative Dentistry & Endodontics, Seema Dental College & Hospital, Rishikesh

Corresponding Author: Dr. Ravi Pratap, Reader, Department of Conservative Dentistry & Endodontics, Vananchal Dental College & Hospital, Garhwa, Jharkhand.

How to citation this article: Dr. Ravi Pratap, Dr. Sumit Sabharwal, "Comparison of Antimicrobial Efficacy Between Natural Herbal Extracts and Sodium Hypochlorite as Endodontic Irrigants", IJMACR – April – 2026, Volume – 9, Issue – 2, P. No. 152 – 161.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: Interest in using herbal remedies as root canal irrigants in endodontic therapy has grown. Previous research has demonstrated the antibacterial efficacy of eucalyptus leaf extract. Both gram-positive (Streptococcus aureus) and gram-negative (Escherichia coli) bacteria have been demonstrated to be susceptible to the antibacterial effects of essential oil extracted from Eucalyptus globules leaves

Aim: Comparative Evaluation of Antimicrobial Efficacy of natural herbal extracts and Sodium Hypochlorite as endodontic irrigants

Methods: Five study groups (5.25% NaOCl, 10% Triphala, 1.25% Eucalyptus, 0.6% carvacrol, and negative control (saline) group) were randomly assigned to 150 mandibular premolar teeth. Paper points were used to collect samples from canal spaces, and Gates-Glidden (GG) drills were used to collect samples from dentinal tubules. Following sample culture, the colony forming unit (CFU) was counted.

Results: Microorganisms in the root canal space have decreased with all irrigants. Compared to triphala and carvacrol, the bacterial count in the canal and dentin samples was considerably lower following the application of NaOCl and eucalyptus. There was a significant difference ($p < 0.05$) in the antibacterial efficacy of all irrigants against E. faecalis.

Conclusion: Significant antibacterial activity was demonstrated by all irrigants against E. faecalis. The most effective irrigant was about 1.25% eucalyptus, compared to 5.25% NaOCl, triphala, and carvacrol.

Keywords: Herbal Extracts, Sodium Hypochlorite, Endodontic Irrigants

Introduction

The goal of endodontic treatment is to rid the dentinal tubules and root canals of bacteria, which are the primary cause of endodontic disorders. Fins, anastomoses, and lateral canals are just a few of the many portals in the complex root canal system that aid in the growth and harboring of bacteria. These canals are difficult to clean biomechanically because they are difficult to access with an irrigant solution. In these intricate anatomical processes, chronic root canal infections may develop.[1] The primary cause of persistent periapical disease is gram-positive, facultative, anaerobic cocci called E. faecalis. E. faecalis's physicochemical traits, such as its capacity to enter dentine, form biofilms, and have innate bacterial resistance, aid in its growth and survival under famine.[2-4]

The majority of microorganisms in pulp space can be eliminated with biomechanical preparation, but effective endodontic treatment requires the use of antibacterial solutions or irrigants.[5] Biomechanical pretreatments is combined with a variety of antibacterial irrigant treatments. With superior intracanal efficiency against E. faecalis, NaOCl is currently the most widely recognized and utilized root canal irrigant.[5] However, it has certain restrictions and disadvantages, such as corrosion to devices, a reduction in flexural strength, and dentine's elastic modulus. Newer intracanal irrigant solutions need to be investigated and taken into consideration because of the impact on surrounding tissues caused by cytotoxicity, unpleasant taste, chemical effects triggered by intracanal irrigants, and growing antibiotic resistance by microorganisms[5].

Interest in using herbal remedies as root canal irrigants in endodontic therapy has grown. Previous research has demonstrated the antibacterial efficacy of eucalyptus leaf extract.[7] Both gram-positive (Streptococcus aureus) and gram-negative (Escherichia coli) bacteria have been demonstrated to be susceptible to the antibacterial effects of essential oil extracted from Eucalyptus globules leaves.[8] The main ingredients of the herbal remedy triphala are "amulaki" (Emblica officinalis), "halituki" (Terminalia chebula), and "bibhitaki" (Terminalia bellirica). The fruits' citric acid functions as a chelating agent, aiding in the removal of the smear layer from the canal wall. Triphala's antibacterial effectiveness as an irrigant against E. faecalis was assessed by Prabhakar et al.[8-15]

One of the components of organic and essential oils is carvacrol, which is produced by combining caustic potash with cymol sulfonic acid. It promotes the nonselective permeability of bacterial cell membranes and has broad-spectrum antibacterial action. The quest for antimicrobial solutions as root canal irrigants with greater disinfection efficacy and improved biological and chemical properties is still necessary in light of the disadvantages or deficiencies of currently employed root canal irrigants. The purpose of this study is to find and assess root canal irrigants that are just as effective as NaOCl against a particular endodontic infection.

Therefore, *in vitro* study is proposed to compare the antimicrobial effect of these test irrigants against E. faecalis.

Materials and Methods

Five study groups (5.25% NaOCl, 10% Triphala, 1.25% Eucalyptus, 0.6% carvacrol, and negative control (saline) group) were randomly assigned to 150 mandibular

premolar teeth. Paper points were used to collect samples from canal spaces, and Gates-Glidden (GG) drills were used to collect samples from dentinal tubules. Following sample culture, the colony forming unit (CFU) was counted.

Preparations of Specimens

For the study, 150 human mandibular premolars free of cavities were selected. The single-rooted teeth that were free of canal obliteration, resorption, grooves, and cracks were chosen. After the outer tooth surface was cleaned using periodontal curettes, the teeth were decontaminated in a 2.5% NaOCl solution (Nimai Dento, India) and stored in the saline solution until needed. All premolars had their crown sections trimmed, and uniform root lengths of 15 mm were attained. K-files were used for the biomechanical preparation up to #20 with tap water watering. The smear layer was removed using an ultrasonic bath containing 17% ethylenediaminetetraacetic acid for ten minutes. The chemicals were then removed by irrigation with 5.25% NaOCl for ten minutes and an hour under tap water.

To stop microbiological leakage, the surface of the teeth samples and the root apices were covered with nail polish and glue, respectively. After being placed in glass tubes with brain heart infusion (BHI) broth medium (Merck, Darmstadt, Germany), the samples were autoclaved for 15 minutes at 121°C and then incubated for 48 hours at 37°C.

After being purchased from Central Scientific Instruments Organization in Chandigarh, India, E. faecalis (ATCC 29212) was fully grown in BHI for an entire night until the turbidity reached 0.5 McFarland standard (1.5 × 108 CFU/mL). After opening the glass tubes containing the samples, 2 mL of the bacterial inoculum was added in place of 2 mL of sterile BHI, and the tubes were then cultured for 21 days at 37°C. Every two days, the glass tubes were revived to confirm the bacterial development. Gram staining, colony morphology evaluation on BHI, E. faecalis broth, and bile esculin tests after 21 days were used to confirm the contamination. Following contamination, the teeth would be eliminated.

Preparation of Irrigants

Triphala

A pre-made Triphala churn (IMPCOPS Ltd., Chennai, India) was utilized. Triphala powder was dissolved in 10% dimethyl sulfoxide (DMSO) to create a 10% triphala irrigant (S.D. Fine Chem Pvt. Ltd., India).

Extract from Eucalyptus Leaves

Fresh eucalyptus plant leaves were gathered. After being cleaned with distilled water, the leaves were allowed to dry at room temperature before being ground into a powder. The Soxhlet device was then used to extract the powder using ethanol for a whole day. A rotary evaporator was used to concentrate the extract. To obtain a 1.25% concentration, the extracts were once more dissolved in DMSO.

Carvacrol

A carvacrol preparation that was readily available was utilized. Carvacrol was dissolved in DMSO to reach the necessary concentration, which was 0.6%.

Antimicrobial Assessment

After being cleaned with gauze and irrigated with sterile saline water, the study samples were divided into five groups (n = 30) based on the root canal irrigant solutions: group I received 5.25% NaOCl; group II received 10% Triphala; group III received 1.25% Eucalyptus extract; group IV received 0.6% carvacrol; and group V received saline (negative control). To ascertain and compare the antimicrobial impact of test

irrigants, the dental samples were divided into five groups. Before the test irrigant was used, each canal was sampled using sterile paper points, transferred to a tube containing one milliliter of BHI, and left for bacteriological analysis.

Root canals were then cleaned and shaped utilizing the crown-down approach with Protaper universal rotary files up to F2 using a one-length technique in accordance with the manufacturer. Next, a 29-gauge needle was used to irrigate the canal for five minutes with two milliliters of each irrigant (5.25% NaOCl, 1.25% Eucalyptus extract, 10% Triphala, 0.6% carvacrol, and saline) before switching to new equipment. After using new equipment, 4 mL of saline solution was used to irrigate the canals.

Bacterial Sampling

Root Canal Sample

Following instrumentation, samples were taken from each root canal using sterile paper points (Meta Dental Co., Seoul, Korea). After soaking the moisture within the canal, the paper points were put in tubes containing one milliliter of BHI broth. To ensure that the microorganisms on the paper points were evenly distributed, the glass tubes containing the paper points were placed on a vortex mixer. A microstreaker (inoculation loop) was then used for streaking. Following an overnight incubation period at 37°C, the plates were examined and the CFU was tallied.

Dentin Sample

Following canal sampling, #3, 4, and 5 sterile GG drills (Dentsply-Maillefer, Ballaigues, Switzerland) were used to retrieve dentin samples from canal walls. Dentine flakes are removed from the canal wall at depths of 200, 400, and 600 μm using GG drills #3, #4, and #5. With the use of a microbrush, the dentinal shavings were immediately collected in individual test tubes to create the spiral flutes on the GG drill, and the streaking was carried out on plates. Following an overnight incubation period at 37°C, the plates were counted for CFU. The total number of CFU per tooth is calculated by multiplying the total number of bacterial colonies that appeared by the dilution factor.All the experiment was performed in triplicates under strict aseptic condition. The purity of the infection was checked to confirm the purity of bacterial growth.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS 20.0; IBM, Armonk, New York, USA) program was used to analyze the colony forming unit data that was imported from Excel. Since the study's alpha error was set at 5% and its confidence interval was set at 95%, probability $p < 0.05$ is regarded as significant. Due to their inability to adhere to normalcy criteria, the data were determined to be nonparametric. Therefore, a nonparametric test was employed. The statistical significance of each research group's antibacterial efficacy against E. faecalis before and after irrigation was determined using the Wilcoxon signed-rank test. The five groups' antibacterial effectiveness was compared using the Kruskal-Wallis H test.

Results

Table 1 shows the total antibacterial efficacy of all test irrigants against E. faecalis both before to and following biomechanical preparation and irrigation. When compared to the negative control group, all test irrigants showed a substantial reduction in bacteria ($p < 0.05$). The CFU count varied significantly across all test groups ($p < 0.05$). Eucalyptus extract and NaOCl were more effective than triphala and carvacrol in reducing the number of bacterial CFUs. Our study's findings indicate

that the eucalyptus extract completely inhibits E. faecalis. After eucalyptus, NaOCl has demonstrated a notable decrease in microorganisms. When compared to other groups, the total decrease in microbes following the treatment of carvacrol and triphala was noticeably lower.

Table 1: Intragroup comparison of antimicrobial efficacy of all test irrigants against *E. faecalis* before and after irrigation in terms of change in CFU count

Groups	Mean CFU ± standard deviation (SD)		Wilcoxon signed-rank test	p-value, significance
	Before irrigation	After irrigation		
Group I (hypochlorite)	104.27 (19.23)	1.09 (3.26)*	W = −5.968	p < 0.001**
Group II (Triphala)	104.27 (19.23)	13.51 (14.85)*	W = −5.954	p < 0.001**
Group III (Eucalyptus)	104.27 (19.23)	0.0 (0.0)*	W = −5.978	p < 0.001**
Group IV (carvacrol)	104.27 (19.23)	6.25 (16.13)*	W = −5.557	p < 0.001**
Group V (negative control)	104.27 (19.23)	58.88 (15.78)	W = −5.690	p < 0.001**

*$p < 0.05$, significant difference; **$p < 0.001$, highly significant

In comparison to the negative control group (saline group), the mean CFU count from dentin samples for all research groups in all depths was considerably lower ($p < 0.05$) (Table 2). Eucalyptus, NaOCl, carvacrol, and triphala all showed antimicrobial effects at depths of 200, 400, and 600 µm. 10% Triphala was significantly more effective than 1.25% Eucalyptus, 5.25% NaOCl, and carvacrol. When it comes to E. faecalis, eucalyptus has demonstrated the strongest antibacterial action, followed by NaOCl, carvacrol, and triphala. Furthermore, the data shows that increasing dentin depth significantly raises log CFU counts.

Table 2: Comparison of CFU count obtained from dentin samples using #3, 4, and 5 GG drills among all test irrigants after irrigation

Groups	Mean CFU	SD	Kruskal–Wallis H test	p-value, significance
Group I (hypochlorite)	0.0752*	0.34	H = 1213.4	p < 0.001**
Group II (Triphala)	1.333*	4.24		
Group III (Eucalyptus)	0.048*	0.19		
Group IV (carvacrol)	0.392*	1.17		
Group V (negative control)	103.03	34.18		

*$p < 0.05$, significant difference; **$p < 0.001$, highly significant

Discussion

The thorough cleaning and disinfecting of the root canal system is the main goal of endodontic treatment. Complete disinfection is complicated by the ability of germs to enter the dentine wall, insufficient irrigant diffusion into dentinal tubules, and dentin's inactivation of these irrigants.[10] A standard strain of E. faecalis was used for this study since it has been shown to be a significant bacterium in the failure of teeth that have had endodontic treatment. The majority of the bacteria and debris can be removed by mechanical equipment during endodontic treatment, however antimicrobial irrigants

aid in the removal of the remaining germs, particularly in difficult-to-reach places where mechanical instrumentation is ineffective.[11]

An optimal irrigating agent or solution should have little or no harmful effects on surrounding tissue, maximum antibacterial efficacy, and tissue-dissolving qualities for endodontic treatment to be successful.[2] The most widely used and approved root canal irrigant is NaOCl, which has demonstrated superior tissue-dissolving and antibacterial properties during the endodontic process. Despite its widespread use, it cannot completely eradicate microbial colonies from canal space.[12] It also has some significant drawbacks, such as the risk for allergies and cytotoxic effects on nearby tissues.[13,14]

Using root canal irrigants made from natural extracts is advised given the prevalence of drug-resistant bacteria and related problems.[15]

Natural extract alternatives have demonstrated several significant benefits, including increased shelf life, reduced toxicity, accessibility, affordability, and, most importantly, the absence of microbial resistance.[16] Some of these derivatives have been included to oral hygiene products because plant-derived natural extracts are a rich source of antibacterial chemicals. Given these benefits, various herbal extracts, including carvacrol, eucalyptus, and triphala, were used in our research. These test irrigants are said to have natural antibacterial qualities. However, there are few research in the literature regarding these extracts' antimicrobial activity against endodontic pathogens, and their effects in a biofilm tooth model have not been thoroughly investigated.

The concentration of the herbal extract was taken from the previous studies.[17–19] These test agents have shown superior antimicrobial activities at certain concentrations in respective studies so that the herbal irrigants with the most potent antimicrobial activity at that concentration can be determined and used against E. faecalis, which was incorporated in the tooth model.

The CFU was counted under the electronic colony counter and statistically analyzed. The mean CFU count obtained from low to high with all irrigants tested was as follows: group III, 1.25% Eucalyptus (0.00 CFU); group I, 5.25% NaOCl (1.08 CFU); group IV, carvacrol (6.24 CFU); group II, Triphala (13.40 CFU); and group V, normal saline (58.77 CFU). The CFU count obtained before and after irrigation using root canal irrigants was analyzed, and it showed a significant difference ($p < 0.05$).

Herbal extracts, Triphala, Eucalyptus, and carvacrol, were found to be efficient against E. faecalis. Among them, Eucalyptus was more effective than Triphala and carvacrol. Nourzadeh et al. also studied the antimicrobial efficacy of Eucalyptus along with NaOCl, and in his study, he found that NaOCl has shown a greater antimicrobial effect against E. faecalis as compared to Eucalyptus,[20] but in the present study, Eucalyptus has shown greater antimicrobial efficacy against E. faecalis than NaOCl. This result could be attributed to the concentration of Eucalyptus used in our study, which has shown the highest antimicrobial activity. Also, in the previous studies of Paz et al.,[21] Kudi et al.,[22] and Vlietinck et al.,[23] it is found that Eucalyptus has shown its antimicrobial activity more on gram-positive bacteria like E. faecalis. Studies have shown the antimicrobial effect of various Eucalyptus species extracts on Streptococcus mutans, Lactobacillus, E. faecalis, and Candida albicans.[24,25] It is also found that components of Eucalyptus species cause an effect on E. faecalis by interfering with enzymes which helps in the fatty acid synthesis pathway.

Pujar et al.[8] stated after a comparison of the antimicrobial efficacy of Triphala, green tea polyphenols, and 3% of NaOCl on E. faecalis biofilms formed on tooth substrate. Triphala has shown significantly better antibacterial activity but was not effective as NaOCl. Nosrat et al.[19] studied the effect of carvacrol as a final endodontic irrigant against E. faecalis. They confirmed that 0.6% of carvacrol could effectively disinfect the root canals. Gill and Holley.[26] and Helander et al.[27] studied the adenosine triphosphate (ATP) changes at the cellular level in bacteria induced by carvacrol.

In this research, dentine flakes of depths 200, 400, and 600 μm from the dentine wall were evaluated and studied. As found earlier in the literature, the number of E. faecalis in the most superficial layer (200 μm) of dentin was very low as compared to the dentine layer of 400 and 600 μm depths, indicating effective antibacterial action of irrigant solutions on dentine wall.[11] Antimicrobial effect of all test irrigants in dentinal tubules was considerably more than a normal saline solution (negative control). The result obtained from dentin samples was analogous to the results of canal sampling. The test irrigants 1.25% Eucalyptus, 5.25% NaOCl, 0.6% carvacrol, and 10% Triphala have shown their antimicrobial effect in all depths, that is, 200, 400, and 600 μm with variable antimicrobial efficacy. The Eucalyptus had shown complete inhibition at 200 and 400 μm depth. The effectiveness of 10% Triphala was considerably <1.25% Eucalyptus and 5.25% NaOCl. The inhibitory effect of 10% Triphala was less in all depths. The efficacy is dependent on the penetration ability of antimicrobial agents into dentinal tubules. In our study, the intratubular effect of NaOCl, Eucalyptus, Triphala, and carvacrol had significant differences with the negative control group. Nourzadeh et al.[20] found that NaOCl has shown a significant difference in antimicrobial efficacy in comparison with Eucalyptus galbie, where NaOCl has shown deeper penetration into dentinal tubules.

However, literature shows that by increasing the concentration of irrigants and increasing the diffusion for antibacterial effect, complete bacterial elimination from the dentinal tubules can barely be achieved by irrigants, so dentinal tubules show the presence of microorganisms.[11] Multiple reasons should be considered for this incomplete bacterial elimination, like concentration of irrigants, time, and penetration into dentinal tubules. A 5-minute irrigation time was considered for test irrigants to show their antimicrobial effect on E. faecalis. Whereas literature shows no confirmation about the exact time needed for irrigants to have a complete antimicrobial effect. Buffering effect of dentine might reduce the antimicrobial efficacy of herbal extracts. Also, the inadequate diffusion of root canal irrigants and their inactivation by dentin and microbial biofilms are considered a reason for the incomplete elimination of bacteria.

Conclusion

Triphala and carvacrol guarantee a long and effective use in the endodontic profession given the issues related to the use of high NaOCl concentrations and the encouraging results of the current investigation with eucalyptus. In this trial, eucalyptus outperformed NaOCl. It is urgently necessary to do additional clinical and in vitro research to ascertain the effectiveness of these herbal extracts in dissolving tissue and to establish their use as endodontic irrigants.

References

1. Nourzadeh M, Amini A, Fakoor F, et al. Comparative antimicrobial efficacy of Eucalyptus galbie and Myrtus communis L. extracts, chlorhexidine and sodium hypochlorite against Enterococcus faecalis. Iran Endod J. 2017;12 (2):205–210. doi: 10.22037/iej.2017.40. [DOI] [PMC free article] [PubMed] [Google Scholar]
2. Paz EA, Cerdeiras MP, Fernandez J, et al. Screening of Uruguayan medicinal plants for antimicrobial activity. J Ethnopharmacol. 1995;45(2):67–70. doi: 10.1016/0378-8741(94)01192-3. [DOI] [PubMed] [Google Scholar]
3. Kudi AC, Umoh JU, Eduvie LO, et al. Screening of some Nigerian medicinal plants for antibacterial activity. J Ethnopharmacol. 1999;67(6):225–228. doi: 10.1016/s0378-8741(98)00214-1. [DOI] [PubMed] [Google Scholar]
4. Vlietinck AJ, Van Hoof L, Totté J, et al. Screening of hundred Rwandese medicinal plants for antimicrobial and antiviral properties. J Ethnopharmacol. 1995;46(1):31–47. doi: 10.1016/ 0378-8741(95)01226-4. [DOI] [PubMed] [Google Scholar]
5. Firas HQ, Al-Mizraqchi AS. The antimicrobial effect of aqueous & alcoholic extracts of eucalyptus leaves on oral Mutans streptococci, Lactobacilli & Candida albicans (an in vitro study). J Bagh Col Dent. 2009;21(4):109–112. [Google Scholar]
6. Cock IE. Antimicrobial activity of eucalyptus major and Eucalyptus baileyana methanolic extracts. Internet J Microbiol. 2015;6(1):1–14. [Google Scholar]
7. Gill AO, Holley RA. Disruption of Escherichia coli, Listeria monocytogenes and Lactobacillus sakei cellular membranes by plant oil aromatics. Int J Food Microbiol. 2006;108(1):1–9. doi: 10.1016/ j.ijfoodmicro.2005.10.009. [DOI] [PubMed] [Google Scholar]
8. Helander IM, Alakomi HL, Latva Kala K, et al. Characterization of the action of selected essential oil components on gram-negative bacteria. J Agric Food Chem. 1998;46(9):3590–3595. doi: 10.1021/ jf980154m. [DOI] [Google Scholar]
9. Narayanan LL, Vaishnavi C. Endodontic microbiology. J Conserv Dent. 2010;13(4):233–239. doi: 10.4103/0972-0707.73386. [DOI] [PMC free article] [PubMed] [Google Scholar]
10. Kayaoglu G, Qrstavik D. Virulence factors of Enterococcus faecalis: relationship to endodontic disease. Crit Rev Oral Biol Med. 2004;15(5):308–320. doi: 10.1177/154411130401500506. [DOI] [PubMed] [Google Scholar]
11. Afkhami F, Akbari S, Chiniforush N. Enterococcus faecalis elimination in root canals using silver nanoparticles, photodynamic therapy, diode laser, or laser- activated nanoparticles: an in vitro study. J Endod. 2017;43(2):279–282. doi: 10.1016/ j.joen.2016.08.029. [DOI] [PubMed] [Google Scholar]
12. Zand V, Lotfi M, Soroush MH, et al. Antibacterial efficacy of different concentrations of sodium hypochlorite gel and solution on Enterococcus faecalis biofilm. Iran Endod J. 2016;11(4):315–319. doi: 10.22037/iej.2016.11. [DOI] [PMC free article] [PubMed] [Google Scholar]
13. Zehnder M. Root canal irrigants. J Endod. 2006;32(5):389–398. doi: 10.1016/ j.joen.2005. 09.014. [DOI] [PubMed] [Google Scholar]

14. Sim T, Knowles J, Ng YL, et al. Effect of sodium hypochlorite on mechanical properties of dentin and tooth surface strain. Int Endod J. 2001;34(2):120–132. doi: 10.1046/j.1365-2591.2001.00357.x. [DOI] [PubMed] [Google Scholar]
15. Jaju S, Jaju PP. Newer root canal irrigants in horizon: a review. Int J Dent. 2009;8(5):1–6. doi: 10.1155/2011/851359. [DOI] [PMC free article] [PubMed] [Google Scholar]
16. Pujar M, Patil C, Kadam A. Comparison of antimicrobial efficacy of Triphala, green tea polyphenols and 3% sodium hypochlorite on Enterococcus faecalis biofilms formed on tooth substrate—in vitro. J Int Oral Health. 2011;3(2):23–29. [Google Scholar]
17. Ultee A, Kets EP, Smid EJ. Mechanisms of action of carvacrol on the food-borne pathogen Bacillus cereus. Appl Environ Microbiol. 1999;65(10):4606–4610. doi: 10.1128/AEM.65.10.4606-4610.1999. [DOI] [PMC free article] [PubMed] [Google Scholar]
18. Asgary S, Nourzadeh M, Eghbal MJ. Miniature pulpotomy of symptomatic mature permanent teeth: a report of two cases. Iran Endod J. 2016;11(1):75–78. doi: 10.7508/iej.2016.01.015. [DOI] [PMC free article] [PubMed] [Google Scholar]
19. Berber V, Gomes B, Sena N, et al. Efficacy of various concentrations of NaOCl and instrumentation techniques in reducing Enterococcus faecalis within root canals and dentinal tubules. Int Endod J. 2006;39(1):10–17. doi: 10.1111/j.1365-2591.2005.01038.x. [DOI] [PubMed] [Google Scholar]
20. Önçağ Ö, Hoşgör M, Hilmioğlu S, et al. Comparison of antibacterial and toxic effects of various root canal irrigants. Int Endod J. 2003;36(6):423–432. doi: 10.1046/j.1365-2591.2003.00673.x. [DOI] [PubMed] [Google Scholar]
21. Neelakantan P, Jagannathan N, Nazar N. Ethnopharmacological approach in endodontic treatment: a focused review. J Dr NTR Univ Health Sci. 2011;3(4):68–77. [Google Scholar]
22. Kleier DJ, Averbach RE, Mehdipour O. The sodium hypochlorite accident: experience of diplomates of the American Board of Endodontics. J Endod. 2008;34(11):1346–1350. doi: 10.1016/ j.joen. 2008. 07.021. [DOI] [PubMed] [Google Scholar]
23. Prabhakar J, Senthilkumar M, Priya M, et al. Evaluation of antimicrobial efficacy of herbal alternatives (Triphala and green tea polyphenols), MTAD, and 5% sodium hypochlorite against Enterococcus faecalis biofilm formed on tooth substrate: an in vitro study. J Endod. 2010;36(1):83–86. doi: 10.1016/j.joen.2009.09.040. [DOI] [PubMed] [Google Scholar]
24. Kamath U, Sheth H, Ramesh S, et al. Comparison of the antibacterial efficacy of tea tree oil with 3% sodium hypochlorite and 2% chlorhexidine against E. faecalis: an in vitro study. J Contemp Dent. 2013;3(3):117–120. doi: 10.5005/jp-journals-10031-1049. [DOI] [Google Scholar]
25. Jyothi KN, Gopal A. Comparison of antimicrobial efficacy of 0.3% propolis, 10% neem, 10% Triphala and 5% sodium hypochlorite on Candida albicans and E. faecalis biofilm formed on root dentin: an in-vitro study. J Dent Res. 2016;4(3):90–94. [Google Scholar]
26. Raoof M, Khaleghi M, Siasar N, et al. Antimicrobial activity of methanolic extracts of Myrtus communis L. and Eucalyptus galbie and their combination with

calcium hydroxide powder against Enterococcus faecalis. J Dent. 2019;20(3):195–202. doi: 10. 30476/DENTJODS.2019.44898. [DOI] [PMC free article] [PubMed] [Google Scholar]

27. Nosrat A, Bolhari B, Sharifian MR, et al. The effect of carvacrol on Enterococcus faecalis as a final irrigant. Iran Endod J. 2009;4(3):96–100. [PMC free article] [PubMed] [Google Scholar]