International Journal of Health Sciences and Research
Volume 14; Issue: 11; November 2024
Website: www.ijhsr.org
Review Article *ISSN: 2249-9571*

A Review on Endodontic Irrigants: Herbal versus Conventional

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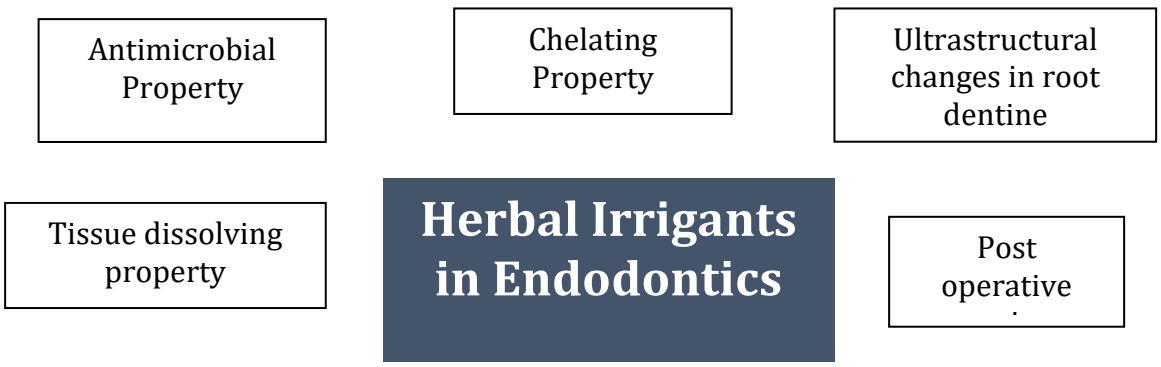
DOI: https://doi.org/10.52403/ijhsr.20241111

ABSTRACT

The intricate structure of the root canal system and the resistance mechanisms of multi-species microbial biofilms are the main challenges of root canal therapy, which provide substantial obstacles for irrigants. Herbal irrigants, derived from natural sources, have gained attention for their potential antimicrobial properties and reduced side effects compared to conventional irrigants. This article presents a comprehensive and comparative analysis of herbal irrigants over conventional irrigants in root canal therapy.

Keywords: Root canal, irrigation, herbal, Sodium hypochlorite, Ethylenediamine tetraacetic acid, M. citrifolia juice, Triphala, Green Tea, Proanthocyanidins, Chlorhexidine, Azadirachta Indica, Arnica montana, anti-oxidant, oregano extract, cyclooxygenase

Graphical Abstract:



INTRODUCTION

Endodontics is a specialty that primarily focuses on the study of structure and function of the tooth, the pulp and periradicular tissues, and its necessary treatment. Mechanical shaping of the root canal system is required for effective placement of intracanal medicaments and

subsequent obturation. However, irrigation performed before, during and post instrumentation, is crucial for thorough disinfection and elimination of contaminated necrotic tissue.

Over the past two decades, irrigation has become increasingly vital for successful root canal therapy. Challenges for effective root canal irrigation are multifaceted.

Aside from the flushing action, biologically effective irrigation solutions are necessary to thoroughly clean the main canal and its intricacies. These areas can harbor biofilm and dentin debris, protecting underlying biofilm from instruments and irrigants. The presence of multi-species microbial biofilms with the ability to adhere to dentin surfaces poses a significant challenge to conventional irrigation strategies.

Therefore, an ideal irrigant should possess antimicrobial properties, an ability to dissolve the remnant necrotic pulp tissue, and should pose minimal irritation to the periapical tissue.[1]

Currently used Irrigants:

Tissue dissolving agent

- Sodium Hypochlorite

Sodium hypochlorite (NaOCl) is primarily used as a root canal irrigant owing to tissue dissolving properties. It has an antibacterial effect, particularly against bacteria in biofilms. The principal ingredients of a concentrated hypochlorite solution are hypochlorite and sodium hydroxide which exhibits actions based on the pH and the concentration of available chlorine. Hypochlorous acid (HOCI) is a weak acid and dissociates to the hypochlorite ion (-OCI) and proton (H+) depending on the solution pH. Chlorine (Cl) atoms in HOCl and OCl- act on various biological molecules. It is generally believed that HOCI is the active species in the germicidal action, whereas the concentration of -OCI is a key factor determining the cleaning efficiency.[2]

Regarding concentration of the solution there is no consensus on the ideal concentration, with recommendations varying from 0.5 to 8.25%[3]. While higher concentrations may be beneficial, evidence supporting this is limited. It is well known that NaOCl is caustic, and its accidental extrusion into periapical tissues should be avoided. There is a lack of clinical evidence linking NaOCl concentration to the severity of such accidents.

Pre-heating to 50–60°C prior to irrigation has shown to enhance the effectiveness of low-concentration NaOCl solutions[4]. However, rapid cooling occurs after application in vivo, limiting any potential short-term benefits.[5]

Chelating Agents

- Ethylenediamine tetraacetic acid (EDTA)

NaOCl has limited action on the inorganic smear layer components and hard tissue debris thus necessitating the additional action of a demineralizing agent. Studies have shown that NaOCl acts on the organic content of the smear layer facilitating its removal. Most widely used chelating agent is ethylenediamine tetraacetic acid (EDTA [6,7]. After instrumentation, a 15–17% solution of its disodium salt, with a pH of 7-8, is a strong chelator that dissolves the inorganic content of smear layer and hard tissue fragments [8,9]

EDTA also appears to disturb the biofilm matrix, which encourages its separation[10]. This suggests that EDTA may also function in tandem with NaOCl's anti-biofilm activity & smear layer removal. Other chelators that have been used instead of EDTA are Maleic acid, citric acid and HEDP (1- hydroxy ethylidene 1,1-diphosphonate) also known as etidronic acid.

Antimicrobial agents

- Chlorhexidine (CHX)

Earlier studies have shown that CHX is as effective as or even more successful than NaOCl against bacteria[11]. These results were based on the overuse of Enterococcus faecalis as a test species in most of the studies. (Swimberghe et al., 2019)[12].

However current literature has shown that endodontic microbiology in root canal is polymicrobial and multispecies biofilm plays a major role. Therefore, it is concluded that CHX is not as effective as NaOCl as an antibacterial agent and has limited action against the EPS matrix[10,13]. The possibility of CHX binding to dentine and providing a long-lasting antibacterial action (substantivity) is one of the primary arguments in favor of the drug, since it may help to prevent bacterial recolonization following root canal therapy[14]

Combination Irrigants

No one irrigant exists that has optimal tissue dissolving, demineralizing and anti-bacterial action. In order to improve the characteristics, combination irrigants are available in the market. To improve wettability and decrease the surface tension, surfactants are occasionally added. Other formulations have combined irrigant with antibiotic, chelating agent, and one or more surfactants (Figure 1). One example is Bio Pure MTAD (Dentsply Sirona, Charlotte, NC, USA), QMix, Tetra clean.

Dioguardi, *et al*.: Methods for endodontic irrigation

Table 2: Advantages/disadvantages of irrigants mainly used in the clinical practice

	Parameters						
	Efficacy on organic residues	Efficacy on inorganic residues	Antibacterial activity	Damage to the surrounding periodontal tissues	Manageability (bad smell, clothes staining and others)	Cost	Enlargement of dentinal tubules
Irrigants							
NaOCl	Yes	No	Yes	Yes	Bad	Low	High
EDTA	No	Yes	No	Very low	Good	Low	High
Citric acid	Yes	Yes	Yes	Yes	N/A	Low	Low
Digluconate chlorhexidine	No	No	Yes	No	Good	Low	Not influenced
Tetraclean	Yes	Yes	Yes	No	Good	High	High
BioPure MTDA	Yes	Yes	Yes	No	Good	High	High
QMix	Yes	Yes	Yes	No	Good	High	High

EDTA: Ethylenediaminetetraacetic acid, MTDA:Mixture of Tetraciclyne Detergent Acid, N/A: Not reported

Figure 1. Methods for endodontic irrigation[15]

Disadvantages of Conventional Irrigants:

1. Owing to the caustic nature of NaOCl, its inadvertent extrusion of even 1% concentration into periapical tissue can have adverse reactions[16, 17]
2. EDTA has a weak antimicrobial effect. When used in combination with NaOCl, there is a loss of free available chlorine[18], reducing the efficacy of NaOCl. Furthermore, this combination adversely brings about erosion and decalcification of root dentin which has an overall negative effect on dentin flexural strength.
3. Maleic acid and Citric acid[19, 20]. in combination with NaOCl have shown to reduce the available chlorine [18]. The antimicrobial activity of citric acid is very limited[21].
4. CHX when used in similar concentration as NaOCl, is equally or more cytotoxic[22]. Additionally, it reacts with residual NaOCl in the root canal and forms para-chloroaniline which is a potentially toxic, carcinogenic orange-brown precipitate[23] that may also cause discoloration[24].

Herbal Endodontic Irrigants

Herbal and natural products have been used in dentistry and medicine for thousands of years. Renewed awareness and popularity in recent years may be owing to the advantages - affordability, ease of use, longer shelf life, biocompatibility, antioxidant and anti-inflammatory properties. There are a variety of herbal products available which have the potential to match the effect or to be used as adjuncts to conventional irrigants.

Kale and Raut have proposed classification based on the properties of the currently available herbal irrigants (Figure 2)

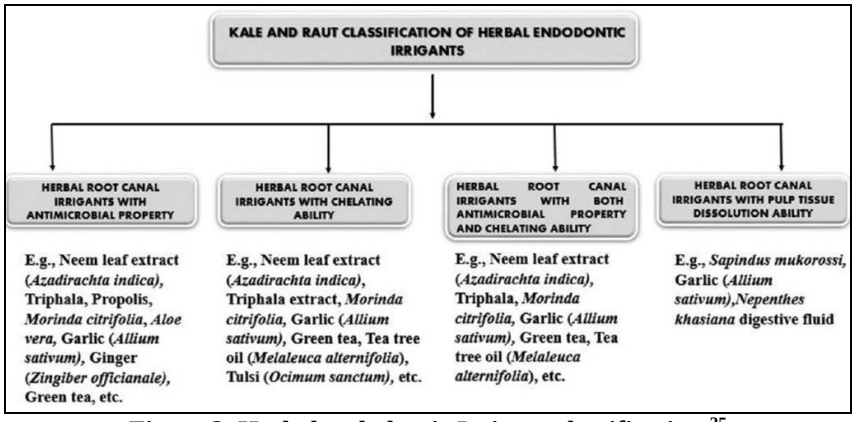


Figure 2. Herbal endodontic Irrigant classification [25]

Properties of Herbal Irrigants in Endodontics

1. Smear layer removal
2. Antimicrobial efficacy
3. Post operative pain
4. Ultrastructural changes in root dentine
5. Tissue dissolving property

1. Smear layer removal:

Elimination of the smear layer allows for deeper penetration of irrigants into the root canal intricacies and facilitates the proper contact of intracanal medication. [26]

Regarding smear layer removal efficiency, Murray et al., 2008 demonstrated that 6% M. citrifolia juice (MCJ) was equally effective as 6% NaOCl when 17% liquid EDTA was used as final flush. [27] Another study by Ok et al., 2015 oregano extract 1 or 2% had a similar smear layer eradication efficacy to 5.25% NaOCl followed by 17% EDTA.

In a recent systematic review [28] authors stated that additional factors also play a role such as volume of the irrigant used and the contact time. The smear layer removal efficiency of oregano extract was found to be similar to that of the conventional agent (NaOCl, EDTA). However, it was concluded that herbal agents show inferior smear layer removal when compared to EDTA.

2. Antimicrobial efficacy:

- M. citrifolia juice (MCJ) –

M. citrifolia juice (MCJ) is a biocompatible antioxidant and contains antibacterial compounds such as L-asperuloside and alizari. It has shown potential to be used as an endodontic irrigant. Unlike NaOCl, accidental extrusion does not bring about any adverse effects. It has been shown to be more effective than 2% CHX against E. faecalis. However, MCJ and CHX are not effective when used in combination because they neutralize each other's properties.

An in-vitro study on extracted teeth evaluated for the antimicrobial activity of 2% CHX gel, propolis, MCJ and Ca $(OH)_2$ in infected root canal dentin. It was concluded that propolis and M. citrifolia were more effective against E. faecalis.

- Triphala

Triphala is a popular ayurvedic herbal formulation consisting of dried and powdered fruits of three medicinal plants namely Terminalia bellerica, Terminalia chebula, and Emblica officinalis.[29] Triphala constitutes a number of compounds such as Tannin, Quinones, flavins, flavonoids, flavanols, gallic acid and Vitamin C. Tannins have the ability to inactivate microbial adhesins, enzymes, and cell envelope transport proteins whereas quinones target the microbial cell by acting on surface-exposed adhesins, cell wall polypeptides and membrane-bound enzymes.

A systematic review compared the antimicrobial action of herbal irrigants and NaOCl. Amongst the herbal agents used were triphala, green tea polyphenol, and Morinda citrifolia. Triphala was found to be

the most effective antimicrobial agent, followed by green tea polyphenol, and Morinda citrifolia. [27]

- Green Tea

Green tea polyphenols (GTPs) are prepared from the young shoots of the tea plant Camellia sinensis. The antimicrobial activity is due to inhibition of bacterial enzyme gyrase by binding to ATP B sub-unit.

Green tea has been shown to exhibit antibacterial activity on E. faecalis[30] but has shown reduced antibacterial effect in comparison to NaOCl.

The antibacterial properties have been associated with the polyphenol catechin fraction of green tea leaves which constitute up to 30%. There are four main types of catechins: Epigallocatechin-3-gallate (EGCG), epigallocatechin, epicatechin-3-gallate and epicatechin. EGCG has been shown to cause irreversible membrane disruption in both Gram-positive and Gram-negative bacteria and also to inhibit bacterial DNA gyrase, leading to bacterial cell death.[31]

- Azadirachta Indica

It is known as the Indian Neem or Margosa tree. It has antibacterial properties against E. faecalis and Candida albicans. It has strong antioxidant and antimicrobial properties, making it a potential agent for root canal irrigation.[32]

The antimicrobial efficacy of 2.5% sodium hypochlorite and 0.2% chlorhexidine gluconate were compared with an experimental irrigant formulated from A. indica and found that neem irrigant has potent antimicrobial efficacy and can be considered for endodontic use.[33]

3. Post operative pain

Postoperative discomfort immediately following the root canal therapy is an important concern for both patients and professionals (Kherlakian et al., 2016 and Farzaneh et al., 2018). 1.7 to 70% of patients experienced postoperative discomfort. Furthermore, within the first 24 hours, that percentage went up to 80% [34]

According to Hosny et al, an experimental study where Neem versus 2.5% NaOCl as irrigants were used to record the intensity of postoperative pain and number of endotoxins following root canal treatment of mandibular molars.

It was seen that the intensity of the pain gradually decreased over time, with no discernible difference between them at any of the follow-up times except for the first 24 hours where neem group recorded less pain than the control group. Also, Neem showed a positive correlation between high antibacterial effect with reduced endotoxin levels.

It is proposed that the potent antibacterial, anti-inflammatory, antipyretic, analgesic, and biocompatible properties of Neem play a vital role in reducing pain. Additionally, Neem inhibits bacterial adhesion and their capacity to colonize (Hannah et al. 2013)[35]

According to Khetarpal[36], the active components of neem such as nimbidin and nimbolide, can trigger bacterial cell wall lysis when present. By controlling pro-inflammatory enzymes including cyclooxygenase (COX) and lipoxygenase (LOX), neem also functions as an anti-inflammatory agent.

4. Ultrastructural changes in root dentine

Endodontic treatment aims to disinfect the root canal system and achieve 3D hermetic seal to prevent the entry of microorganisms[37]

Preservation of collagen present in root dentin has shown to have beneficial bonding at core material, sealer and root dentin. However, commonly used root canal irrigants such as NaOCl & EDTA have shown deleterious effect on the root dentin by causing degradation of collagen.[38]

According to Kumar PS et al, chloramines and protein-derived by-products dissociate when NaOCl reacts with organic portion of the root dentin. These by-products have adverse effects on the pyridinoline cross-links present within the type 1 collagen

leading to lower bond strength. Therefore, irrigation with NaOCl leads to structurally compromised collagen in the root dentin.[39]
Currently the focus is on stabilization of dentin collagen and neutralization of bacterial collagenase activity which would result in improved mechanical integrity of root filled teeth.
Research into increasing collagen cross-linking has been applied to improve the mechanical and biological stability of dentin collagen. Synthetic collagen cross-linking agents are available which can induce exogenous cross-links but have disadvantages such as high cytotoxicity and incompatible mechanical properties.[40]
Thus, an endodontic disinfectant that kills E. faecalis whilst not compromising the biomechanical properties of dentine would be beneficial for endodontic irrigation regimes. Herbal irrigants used during instrumentation have antioxidant properties in addition to being an anti-bacterial & anti-inflammatory agent. The antioxidant property can lead to scavenging of the oxidative by-products thereby increasing the adhesion of sealer to the root dentin (Houde V et al., 2006) [41]. Previous studies have shown that they may cause inhibition of collagen breakdown along with stiffening and cross-linking of the collagen.
A study was done to assess the effect of the pushout bond strength (PBS) of epoxy resin-based root canal sealer to root dentin following the use of two novel herbal irrigants, 10% proanthocyanidins (PAs) and 2% Azadirachta indica (neem extract) with 3% sodium hypochlorite. It was concluded that the PBS of 10% Proanthocyanidins was the highest, followed by 3% NaOCl and Azadirachta indica. Polyphenolic structures of proanthocyanidins that are capable of forming stable hydrogen bond structures and produce non-biodegradable collagen matrices.[42]
Another study conducted by Khanvilkar et al found that the binding between AH Plus and dentin was greatly increased by irrigation with Arnica montana. At a dosage of 5 mg/mL, Arnica montana demonstrates 63.68% total antioxidant activity and 71.52% DPPH scavenging capability using the phosphomolybdate method. It demonstrated the maximum binding capacity to resin sealer due to its anti-inflammatory and antioxidant properties, which mitigate the deleterious effects of free radicals.[43]

5. Tissue dissolving property

Sodium hypochlorite is a potent tissue solvent and antibacterial agent, however this chemical solution is harmful to periapical tissues only if it is extruded from the apical foramen[44] and its toxicity increases with the concentration. Numerous studies have shown clinically that sodium hypochlorite damages the periodontal and periapical tissues.
A study conducted by. Guçluer et al[45] showed extract solutions prepared from different solvents of S. mukorossi displayed a statistically significant effect as a tissue solvent. According to the study, the effective cause of the solvent ability might be linked to the structure of saponin in S. mukorossi, which reduces surface tension, thus increasing membrane permeability. Many studies revealed that the surfactant addition to NaOCl performed a synergistic action and affected the tissue dissolving specification positively.[46]

Properties	**Herbal Irrigants**
Herbal root canal irrigants with antimicrobial property – Extracts have demonstrated antimicrobial property against common endodontic pathogens (Kale and Raut et al., 2021) [25]	• Neem leaf extract (Azadirachta indica), • Triphala, Propolis, • Morinda citrifolia, • Aloe vera, • Garlic (Allium sativum), • Ginger (Zingiber officinal),

	• Green tea, Tea tree oil (Melaleuca alternifolia), • Carvacrol • Turmeric (Curcuma longa), • Arctium lappa, • Babool (Acacia nilotica), • Tulsi (Ocimum sanctum), • Cinnamon (Cinnamomum zeylanicum), • Miswak (Salvadora persica), • Passion fruit juice, Jeeryin, • Clove (Syzigium aromaticum), • Hybanthus enneaspermus • Guava (Psidium guajava), • Terminalia chebula seed extract, • Mangifera indica L. kernel (Mango kernel), • Zataria multiflora Essential oil, • Andrographis ukorossi, • Thymus vulgaris, • Calendula arvensis, • Mimusops elengi, • Syzygium cumini
Herbal root canal irrigants with chelating ability – These extracts possess the ability to remove the smear layer formed on the dentin surface after instrumentation (Kale and Raut, 2021) [25]	• Neem leaf extract (A. indica) • Triphala extract • M. citrifolia, garlic (A. sativum) • green tea, tea tree oil (M. alternifolia) • Tulsi leaf extract (O. sanctum) • Miswak (S. persica) • Grapefruit (Citrus paradisi) • Passion fruit juice, orange oil • German chamomile (Marticaria recutita) • T. chebula seed extract • Amla (Emblica officinalis) • Pomegranate peel (Punica granatum), • Citrus aurantifolia-Sapindus ukorossi extracts • Moringa oleifera • Lemon grass • Turmeric (C. longa)
Herbal root canal irrigants with both antimicrobial property and chelating ability – These extracts have demonstrated antimicrobial property as well	• Neem leaf extract (A. indica)

as the ability to remove the smear layer [25]	• Triphala • M. citrifolia • garlic (A. sativum) • green tea, tea tree oil (M. alternifolia) • Tulsi leaf extract (O. sanctum) • Miswak (S. persica) • passion fruit juice, • T. chebula seed extract • turmeric (C. longa)
Herbal root canal irrigants with pulp tissue dissolution ability – These extracts possess the ability to dissolve the pulp tissue [25]	• Sapindus mukorossi extract, • Garlic (A. sativum), • Nepenthes khasiana digestive fluid

Table 1. Classification of herbal irrigants based on their property

CONCLUSION

Herbal irrigants have shown potential to be used either as alternatives or as conjunctive agents in root canal disinfection. The advantages coupled with the lack of adverse reaction outweigh the disadvantages.

Herbal medicines performed less effectively in terms of the antibacterial property & smear layer removal than various sodium hypochlorite & EDTA concentrations except few which showed similar efficacy. Continued research into possible combinations for effective disinfection is the need of the hour.

Declaration by Author

Acknowledgement: None

Source of Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

1. Teja KV, Janani K, Srivastava KC, Shrivastava D, Jose J, Marya A, Karobari MI. Comparison of herbal agents with sodium hypochlorite as root canal irrigant: a systematic review of in vitro studies. Evidence-Based Complementary and Alternative Medicine. 2021;2021(1):8967219.
2. Fukuzaki SA. Mechanisms of actions of sodium hypochlorite in cleaning and disinfection processes. Biocontrol science. 2006 Dec 10;11(4):147-57.
3. Gazzaneo I, Vieira GC, Pérez AR, Alves FR, Gonçalves LS, Mdala I, Siqueira Jr JF, Rôças IN. Root canal disinfection by single-and multiple-instrument systems: effects of sodium hypochlorite volume, concentration, and retention time. Journal of endodontics. 2019 Jun 1;45(6):736-41.
4. Sirtes G, Waltimo T, Schaetzle M, Zehnder M. The effects of temperature on sodium hypochlorite short-term stability, pulp dissolution capacity, and antimicrobial efficacy. Journal of endodontics. 2005 Sep 1;31(9):669-71.
5. Dumitriu D, Dobre T. Effects of temperature and hypochlorite concentration on the rate of collagen dissolution. Journal of endodontics. 2015 Jun 1;41(6):903-6.
6. Dutner J, Mines P, Anderson A. Irrigation trends among American Association of Endodontists members: a web-based survey. Journal of endodontics. 2012 Jan 1;38(1):37-40.
7. Willershausen I, Wolf TG, Schmidtmann I, Berger C, Ehlers V, Willershausen B, Briseño B. Survey of root canal irrigating solutions used in dental practices within Germany. International Endodontic Journal. 2015 Jul;48(7):654-60.
8. Calt S, Serper A. Time-dependent effects of EDTA on dentin structures. Journal of endodontics. 2002 Jan 1;28(1):17-9.
9. De-Deus G, Reis C, Fidel S, Fidel R, Paciornik S. Dentine demineralization when subjected to EDTA with or without various wetting agents: a co-site digital optical microscopy study. International endodontic journal. 2008 Apr;41(4):279-87.
10. Busanello FH, Petridis X, So MV, Dijkstra RJ, Sharma PK, van der Sluis LW. Chemical

biofilm removal capacity of endodontic irrigants as a function of biofilm structure: optical coherence tomography, confocal microscopy and viscoelasticity determination as integrated assessment tools. International Endodontic Journal. 2019 Apr;52(4):461-74.
11. Menezes MM, Valera MC, Jorge AO, Koga-Ito CY, Camargo CH, Mancini MN. In vitro evaluation of the effectiveness of irrigants and intracanal medicaments on microorganisms within root canals. International Endodontic Journal. 2004 May;37(5):311-9.
12. Swimberghe RC, Coenye T, De Moor RJ, Meire MA. Biofilm model systems for root canal disinfection: a literature review. International Endodontic Journal. 2019 May;52(5):604-28.
13. Ruiz-Linares M, Aguado-Pérez B, Baca P, Arias-Moliz MT, Ferrer-Luque CM. Efficacy of antimicrobial solutions against polymicrobial root canal biofilm. International endodontic journal. 2017 Jan;50(1):77-83.
14. Rosenthal S, Spångberg L, Safavi K. Chlorhexidine substantivity in root canal dentin. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2004 Oct 1;98(4):488-92.
15. Dioguardi M, Di Gioia G, Illuzzi G, Laneve E, Cocco A, Troiano G. Endodontic irrigants: Different methods to improve efficacy and related problems. European journal of dentistry. 2018 Jul;12(03):459-66.
16. Boutsioukis C, Psimma Z, Van der Sluis LW. Factors affecting irrigant extrusion during root canal irrigation: a systematic review. International endodontic journal. 2013 Jul;46(7):599-618.
17. Guivarc'h M, Ordioni U, Ahmed HM, Cohen S, Catherine JH, Bukiet F. Sodium hypochlorite accident: a systematic review. Journal of endodontics. 2017 Jan 1;43(1):16-24.
18. Fukuzaki SA. Mechanisms of actions of sodium hypochlorite in cleaning and disinfection processes. Biocontrol science. 2006 Dec 10;11(4):147-57.
19. Ballal NV, Moorkoth S, Mala K, Bhat KS, Hussen SS, Pathak S. Evaluation of chemical interactions of maleic acid with sodium hypochlorite and chlorhexidine gluconate. Journal of endodontics. 2011 Oct 1;37(10):1402-5.
20. Zehnder M, Schmidlin P, Sener B, Waltimo T. Chelation in root canal therapy reconsidered. Journal of endodontics. 2005 Nov 1;31(11):817-20.
21. Arias-Moliz MT, Ferrer-Luque CM, Espigares-García M, Baca P. Enterococcus faecalis biofilms eradication by root canal irrigants. Journal of endodontics. 2009 May 1;35(5):711-4.
22. Scott II MB, Zilinski GS, Kirkpatrick TC, Himel VT, Sabey KA, Lallier TE. The effects of irrigants on the survival of human stem cells of the apical papilla, including endocyn. Journal of Endodontics. 2018 Feb 1;44(2):263-8.
23. Orhan EO, Irmak Ö, Hür D, Yaman BC, Karabucak B. Does para-chloroaniline really form after mixing sodium hypochlorite and chlorhexidine. Journal of endodontics. 2016 Mar 1;42(3):455-9.
24. Jeong JW, Sarmast ND, Terlier T, van der Hoeven R, Holland JN, Parikh N. Assessment of the cytotoxic effects and chemical composition of the insoluble precipitate formed from sodium hypochlorite and chlorhexidine gluconate. International Endodontic Journal. 2021 Oct;54(10):1892-901.
25. Kale PP, Raut AW. A proposed classification system for herbal endodontic irrigants. Journal of Conservative Dentistry and Endodontics. 2021 May 1;24(3):293-5.
26. Gomes BP, Aveiro E, Kishen A. Irrigants and irrigation activation systems in endodontics. Brazilian dental journal. 2023 Oct 27;34(4):1-33.
27. Murray PE, Farber RM, Namerow KN, Kuttler S, Garcia-Godoy F. Evaluation of Morinda citrifolia as an endodontic irrigant. Journal of endodontics. 2008 Jan 1;34(1):66-70.
28. Teja KV, Janani K, Srivastava KC, Shrivastava D, Jose J, Marya A, Karobari MI. Comparison of herbal agents with sodium hypochlorite as root canal irrigant: a systematic review of in vitro studies. Evidence-Based Complementary and Alternative Medicine. 2021;2021(1):8967219.
29. A. W. Asmita, B. K. Soumya, N. Gauri, and B. Rama, in Chemistry, Biological Activities and Therapeutic Applications of Medicinal Plants in Ayurveda, ed. A. Amalraj, S. Kuttappan, and K. Varma, The Royal Society of Chemistry, 2022, ch. 9, pp. 201-220.
30. Jadhav SK, Mookhtiar H, Hegde V, Shanmugsundaram S. Comparative evaluation of antimicrobial efficacy of sesame oil irrigants on Enterococcus faecalis–An in vitro study. Endodontology. 2020 Jul 1;32(3):148-53.

31. Khandelwal RS, Mantri SP, Paul B, Dube KA, Mishra G, Dhirawani VR. Antimicrobial efficacy of octenidine hydrochloride, green tea, sodium hypochlorite and chlorhexidine gluconate as retreatment endodontic irrigant against E. faecalis, Candida & Mixed culture–in-vitro study. J Evol Med Dent Sci. 2021 Aug 9;10(32):2629-33.
32. Wylie MR, Merrell DS. The antimicrobial potential of the neem tree Azadirachta indica. Frontiers in pharmacology. 2022 May 30; 13:891535.
33. Dutta A, Kundabala M. Comparative anti-microbial efficacy of Azadirachta indica irrigant with standard endodontic irrigants: A preliminary study. Journal of Conservative Dentistry. 2014 Mar 1;17(2):133-7.
34. Alamassi BY. Endodontic postoperative pain: etiology and related factors–an update. Int J Dent Sci Res. 2017 Mar 22;5(2):13-21.
35. Rosaline H, Kandaswamy D, Gogulnath D, Rubin MI. Influence of various herbal irrigants as a final rinse on the adherence of Enterococcus faecalis by fluorescence confocal laser scanning microscope. Journal of Conservative Dentistry. 2013 Jul 1;16(4):352-5.
36. Khetarpal S, Bansal A, Kukreja N. Comparison of anti-bacterial and anti-inflammatory properties of neem, curcumin and Aloe vera in conjunction with chlorhexidine as an intracanal medicament–An in vivo study. Dent J Adv Stud. 2014 Dec;2(3):130-7.
37. Gusiyska A, Dyulgerova E. Clinical approaches to the three-dimensional endodontic obturation protocol for teeth with periapical bone lesions. Applied Sciences. 2023 Aug 29;13(17):9755.
38. Baruwa AO, Martins JN, Maravic T, Mazzitelli C, Mazzoni A, Ginjeira A. Effect of endodontic irrigating solutions on radicular dentine structure and matrix metalloproteinases—a comprehensive Review. Dentistry Journal. 2022 Nov 23;10(12):219.
39. Kumar PS, Meganathan A, Shriram S, Sampath V, Sekar M. Effect of proanthocyanidin and bamboo salt on the push-out bond strength of an epoxy resin sealer to sodium hypochlorite-treated root dentin: An: in vitro: study. Journal of Conservative Dentistry and Endodontics. 2019 Mar 1;22(2):144-8.
40. Chen H, Sun G, Wang H, Yu S, Tian Z, Zhu S. Effect of collagen cross-linkers on dentin bond strength: A systematic review and network meta-analysis. Frontiers in Bioengineering and Biotechnology. 2023 Jan 24; 10:1100894.
41. Houde V, Grenier D, Chandad F. Protective effects of grape seed proanthocyanidins against oxidative stress induced by lipopolysaccharides of periodontopathogens. Journal of periodontology. 2006 Aug;77(8):1371-9.
42. Salkar SH, Bakare CH, Chacko DE, Doddwad PR, Joshi SO, Dhaded NE. Comparative Evaluation of the Effect of Herbal Irrigants on the Push-out Bond Strength of Epoxy Resin Based Sealer to Root Dentin: An In-vitro Study. Journal of Clinical and Diagnostic Research. 2022;16(3):38-41.
43. Khanvilkar U, Patil H, Bandekar S, Kshirsagar S, Pawar AM, Wahjuningrum DA, Pagnoni F, Reda R, Zanza A, Testarelli L. Pushout bond strength of root fillings after irrigation of root canals utilizing sodium hypochlorite, chlorhexidine, and Homeopathic Mother Tincture (arnica montana). Clinics and Practice. 2023 Feb 17;13(1):305-14.
44. Önçağ Ö, Hoşgör M, Hilmioğlu S, Zekioğlu O, Eronat C, Burhanoğlu D. Comparison of antibacterial and toxic effects of various root canal irrigants. International endodontic journal. 2003 Jun;36(6):423-32.
45. Güçlüer Ö, Akarsu E, Yavuz E, Er K, Kuştarcı A. Human pulp tissue dissolution ability of different extracts of Sapindus mukorossi: An in vitro study. Chinese Herbal Medicines. 2020 Apr 1;12(2):178-82.
46. Mansoorkhani H, Mahmoudi F. The importance of surface tension in endodontic irrigation: a review study. Arch Dent Res. 2023; 12:76-80.

How to cite this article: Minati Jain, Shruthi Nagaraja, Shwetha V, Deveswaran, Shruthika. A review on endodontic irrigants: herbal versus conventional. *Int J Health Sci Res.* 2024; 14(11):107-116. DOI: *10.52403/ijhsr.20241111*

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