



Advancements in Root Canal Irrigants-A Review

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ABSTRACT

Root canal irrigation is considered an important procedure of root canal treatment as it involves the healing of periapical tissues after treatment . In root canal irrigation , the motto is prevention of reinfection. Standard irrigation techniques are using common irrigants like NaOCl , chlorhexidine , EDTA etc but in this study , advanced root canal irrigants are reviewed . The newer irrigants like tetraclean , MTAD , ECA (Electronically activated solutions) , ozonated water , herbal induced irrigants can all serve as an adjunct to the commonly used root canal irrigants. Potential newer/advanced irrigants serve as a substitute for traditional endodontic irrigants. With the recent studies performed and available literature , even though none of the irrigants fully satisfy the requirements of an ideal root canal treatment they can all be used as an adjunct over the commonly used irrigants.

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INTRODUCTION

Root canal irrigation is an important procedure of root canal treatment as it involves the healing of periapical tissues [1]. Irrigants are used in the root canal space to dissolve pulp remnants [2]. Irrigant solutions are commonly used as a preparation that aids in the removal of pulp remnants and also to remove microorganisms from unreachable areas of the complex root canal system. Any root canal irrigants will have some ideal requirements[3]. Potential newer/advanced irrigants serve as a substitute for traditional endodontic irrigants. With the recent studies performed and available literature , even though no irrigants fully satisfy the requirements of an ideal root canal treatment, they can all be used as an adjunct over the commonly used irrigants [4].

The below mentioned are the following : [5]

- 1) Antimicrobial properties like removal of residual bacteria
- 2) Low toxicity
- 3) Debridement
- 4) Smear layer removal
- 5) Dissolving necrotic tissues
- 6) No discolouration of teeth
- 7) Availability and Convenience
- 8) Ease of use
- 9) Bleaching action

Therefore an ideal requirement should basically remove debris , be germicidal , lubricate , provide bleaching action etc. Previously we focused reviews on other aspects of dentistry [6–21] and this review we are focusing on irrigants used in endodontics.

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MATERIALS AND METHODS

All the articles collected have complete relevance to the topic, which are the recent advancements in root canal irrigation. They have been obtained from search engines such as PubMed, Google scholar, Elsevier, etc. All the articles collected had information regarding the recent advances of root canal irrigants, its side effects and efficacy. All the articles which were irrelevant to the topic were excluded from the list. The results for this review article are based on previous studies done by other esteemed and honoured authors and journals.

DISCUSSION

Commonly Used Root Canal Irrigants

- NaOCl (Sodium hypochlorite)
- CHX (Chlorhexidine)
- EDTA(Ethylenediamine tetra acetic acid)

NaOCl is a tissue dissolving agent , CHX is an antimicrobial agent and EDTA is a chelating agent [22][23].The tissue dissolving effect of NaOCl is directly related to its concentration . Broad spectrum of antimicrobial activity is shown by these commonly used irrigants . They have the ability to kill bacteria, fungi, viruses and even spores rapidly [24]. Bacterial cell walls are generally distributed and a chemical combination with protoplasm of bacterial cell wall is seen [24,25]. NaOCl is more advantageous against bacteria but less advantageous against endotoxins. After reacting with the calcium ions present in dentin, EDTA forms soluble calcium chelates. CHX completely lacks tissue dissolving capacity.

Recent Advances In Root Canal Irrigants

One of the very complicated tasks is the total removal of microorganisms from an infected root canal [2,26]. Mechanical enlargement of canals should be done along with the use of irrigants so that the prepared canal becomes as bacteria free as possible[27]. This was usually done with the commonly used irrigants but recent studies have advanced irrigants in the use [28].

Some of the newer root canal irrigants which we are going to discuss in this article mentioned below:

- 1) MTAD
- 2) Tetraclean
- 3) Electrochemically activated solutions
- 4) Ozonated water
- 5) Herbal Induced Root canal irrigants

[29]

Mtad

MTAD is basically a mixture of tetracycline, citric acid and detergent. It is commercially available as a powder liquid system. Depending upon the number of root canals, doses can be single or multiple.[30]. MTAD shows advantages over the commonly used root canal irrigants and solutions used in the root

canal treatment . It has the ability to eliminate the smear layer from the entire part and length of the root canal. It also helps in the removal of both the organic and inorganic debris without any erosion or physical damage to the dentin [31]. 17% EDTA and 5.25% of NaOCl do not show this efficacy. Tetracycline present in MTAD has many unique properties. It is said to be a calcium chelator and can cause enamel and root surface demineralisation. Certain studies also showed that the efficacy of MTAD was enhanced when NaOCl was used in low concentrations right before the use of MTAD as a final rinse [32]. Refer Table 1 for comparative studies between MTAD and other endodontic irrigants.

Tetraclean

Tetraclean is a contribution to root canal irrigation as it is proven by various other studies that it can eliminate biofilm in an hour [33,34]. This, like MTAD , is a mixture of an acid , an antibiotic and a detergent . But how it differs from MTAD is that the type of detergent and concentration of antibiotic varies [35]. Tetraclean is said to have low surface tension values when compared to EDTA, CHX and even MTAD [36]. Refer Table 2 for comparative studies between Tetraclean and other endodontic irrigants.

Electrochemically Activated Solutions

These solutions are obtained from tap water and salt solutions that has a low concentration [33,34,37].Electrochemically activated solutions have no toxicity when in contact with vital biological tissues [38].ECA solution leaves a very thin smear layer with an even and smooth surface. The dentures of the canal surfaces that were being treated with ECA were even and uniform in regions of the root canal [39]. It has given promising results due to ease of debris removal and the uniformity it gives to the surface canal [40,41]. It has the ability to be an effective root canal irrigant [33].

Ozonated Water

Ozone is a chemical compound and a very powerful bactericide that has the ability to kill microorganisms effectively . Ozone is a gas which is not stable and has the potential of oxidizing any biological form [42]. It can be generated by an ozone generator or obtained naturally from air [37].Ozonated water is generally a potent antimicrobial agent that can be used against bacteria, fungi, viruses and protozoans, but less attention has been paid to its antimicrobial action of ozonated water in biofilm and this in root canal infection [42,43].Studies show that ozonated water is active against Streptococcus mutans, but it's the case otherwise in other microbes [44].Ozone generates ozonised compounds once it enters the

body such as lipid oxidation products and reactive oxygen species [45]. This is a must need for further studies regarding ozonated water and its modification in root canal treatment [46].

Herbal Induced Root Canal Irrigants

Herbal alternatives can be used as root canal irrigants. Triphala, which is an Indian Ayurvedic formulation consisting of three medicinal plants can be widely in use [47]. Green tea polyphenols from the shoots of tea plant *Camellia Sinensis* can also be in use.

Studies show that Triphala and green tea polyphenols show promising antibacterial activity. Although, Triphala is seen to be more effective in dissolution of biofilms when compared to green tea polyphenols [48][49]. The quality of triphala can be contributed to its formulation that has three different medicinal plants in equal proportions [50]. In such formulations, the different compounds present in it helps to enhance the potency of the active compounds resulting in synergic positive effect [51].

Triphalas and green tea polyphenols have no chemicals and hence they are safe with active beneficial physiologic effect apart from its curative property such as antioxidant, anti inflammatory and radical scavenging activity and may also have an advantage over the traditionally used root canal irrigants [52][53]. Some of the common herbs used in dentistry for irrigation in the recent times are listed below:

- Triphala
- Propolis
- Turmeric
- Green Tea polyphenols
- Tea Tree Oil
- *Salvadora Persia*

Triphala

Triphala is an Indian Ayurvedic plant. This plant is said to contain abundance of citric acid and will help in the removal of the smear layer by acting as a chelating agent and as an alternative for NaOCl for endodontic infections [54]. Triphala is said to be showing anti inflammatory, anti oxidant, anti scavenging, anti carcinogenic and probiotic properties. It also comes with a set of advantages like its good availability, cost effectiveness, low toxicity, better shelf life and microbial resistance [54,55].

Propolis

Propolis is a herbal material which is brown in colour as it is prepared by bees by collecting it from some plant species and mixing it with wax and certain other substances. It has flavonoids and cinnamic acid derivatives which are biologically active components and thus shows multiple

pharmacological actions [56]. They exhibit antimicrobial, anti inflammatory, carostatic and immunomodulating properties. The presence of a rich component called CAPE (caffeic acid and phenethyl ester) contribute towards its anti-inflammatory property. The ethanol present in propolis plays a role in regeneration of bone and inducing hard tissue bridge formation in pulp capping [56,57]. This herb can be used as an alternative for intracanal medicament.

Turmeric

Turmeric is a popular Indian spice which is a part of the Zingiberene (ginger) family. Turmeric shows a wide range of anti-inflammatory properties and can also be used in the treatment of relieving pain and inflammation. It also shows antimicrobial property. Studies have proven that its antibacterial activity is significant enough to be used as an alternative for root canal irrigation and can also be used in root canal failure cases [58].

Green Tea Polyphenols

Green tea polyphenols are obtained from the leaves of the plant *Camellia Sinensis*. Recently, studies have been done to look at the possibility of green tea in antimicrobial therapy [59]. The particular properties found in the catechins have portrayed a promising antimicrobial effect [60,61]. The antimicrobial effects shown by green tea have proven that the ability for preventive, therapeutic and disinfecting purposes is present. The natural flavonoids present in them are beneficial for preventing dental caries. Clinical performance of green tea has been assessed and therefore it can be used as a root canal irrigant during treatment [60].

Tea Tree Oil

Tea tree oil, also known as *Melaleuca Alternifolia* scientifically, is a native Australian plant with antiseptic, anti-inflammatory and antifungal properties [62]. It has the efficacy to remove smear layers much better than NaOCl but no efficacy when compared to EDTA. Removal of the smear layer is a very important property of any kind of root canal irrigant and tea tree oil has this property to its advantage [63].

Salvadora Persia

This plant shows antimicrobial property on both aerobic and anaerobic bacteria recovered from the necrotic pulp within the teeth. The other name for *Salvadora Persia* is Miswak. Water irrigant of Miswak could be used as an effective antibacterial agent and therefore can be used as a root canal irrigant for teeth with necrotic pulp [64].

Refer Table 3 for comparative studies between herbal and other endodontic irrigants.

Need for Newer Root Canal Irrigants

The traditionally used root canal irrigants like CHX, EDTA and NaOCl have their fair share of disadvantages and thus the hunt for an ideal root canal irrigant continues with development of newer materials and methods [65]. The need for newer irrigants is to achieve complete disinfection of the complex root canal system [66]. With the immense number of products available to us in today's era we need to use a combination of two or more irrigants to get acceptable results. This will require careful understanding of the mechanism of action of various irrigants. Some new formulations which seem promising need further research to establish its full potential [67][68].

CONCLUSION

This article reviews the potential of newer irrigants that can substitute the traditional endodontic irrigants. Studies conducted so far show both the advantages and disadvantages of each advanced irrigant [40]. But none of the above discussed irrigants completely satisfy the requirements of an ideal root canal irrigant [69]. Presently, the newer root canal irrigants can be used as an adjunct to NaOCl, EDTA or CHX [70].

AUTHORS CONTRIBUTIONS

All authors have equal contribution in bringing out this research work.

CONFLICT OF INTEREST

Nil

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Table 1. Studies comparing MTAD with other irrigants.

AUTHOR	MTAD	OTHER IRRIGANTS	PROPERTIES	RESULTS
[71]	Biopure MTAD	NaOCl, EDTA	Disinfection of root canal.	NaOCl and EDTA showed consistent disinfection of the canal. Combination of MTAD and NaOCl left 50% of the canal contaminated.
[72,73]	MTAD	6% NaOCl, 2% CHX	Antifungal activity.	Antifungal activity of 6% NaOCl and 2% CHX is significantly greater than MTAD.
[72]	MTAD	5.25% NaOCl	Antimicrobial Efficacy against E. Faecalis biofilm.	NaOCl can disintegrate and remove the biofilm at every time, however disintegration of biofilm by MTAD is complained less.
[74]	MTAD	2.5% NaOCl, 2% CHX	Antibacterial efficacy	The antibacterial efficacy was shown to be high when MTAD was used as an initial rinse followed by 2.5% NaOCl as a final rinse when compared to using 2.5% NaOCl as an initial rinse and MTAD as a final rinse.

Table 2: Studies comparing Tetraclean with other irrigants.

AUTHOR	TETRACLEAN	OTHER IRRIGANTS	PROPERTIES	RESULTS
[75]	Tetraclean	MTAD	Antibacterial action against E. Faecalis	Tetraclean is more effective against E. Faecalis when compared to MTAD.
[76]	Tetraclean	6%NaOCl, 2% CHX , MTAD	Antifungal activity.	Antifungal activity of 6% NaOCl and 2% CHX is significantly greater than MTAD and Tetraclean.
[72]	Tetraclean	5.25% NaOCl	Antimicrobial Efficacy against E. Faecalis biofilm.	NaOCl can disintegrate and remove the biofilm at every time, however even treatment with Tetraclean showed a high degree of biofilm disintegration.
[77]	Tetraclean	MTAD, CHX+ Cetrimide and NaOCl	Antimicrobial effect on three common endodontic pathogens.	In this study, 5.25% NaOCl showed a high antimicrobial activity against anaerobic bacteria responsible for primary endodontic infection, but its action seems to be much lower against Enterococcus faecalis. MTAD and Tetraclean showed a high action against both, strictly anaerobic and facultative anaerobic bacteria. Chlorexidine + Cetrimide showed the lowest antibacterial activity against both, facultative and strictly anaerobic bacteria tested. ³

Table 3: Studies comparing Herbal irrigants with other irrigants.

AUTHOR	HERBAL IRRIGANTS	OTHER IRRIGANTS	PROPERTIES	RESULTS
[78]	Aloe vera, Green tea polyphenols	Sodium Hypochlorite	Antimicrobial Effect against Enterococcus Faecalis.	Both herbal and commonly used irrigants show antimicrobial effect. In the study, highest inhibitory zone against E. Faecalis was shown by NaOCl and least was shown by Aloe Vera.
[79]	Triphala, Green tea polyphenols	Sodium Hypochlorite	Disintegration of biofilm.	NaOCl showed maximum efficacy against biofilm formed.
[80]	Turmeric Extract	Sodium Hypochlorite	Antibacterial effect.	Most efficient- NaOCl. Turmeric shows significant antibacterial activity but comparatively less than NaOCl.
[81]	Tea Tree Oil	Chlorhexidine, Sodium hypochlorite	Antibacterial Effect.	Tea tree oil showed significant antibacterial activity, which is very much similar to NaOCl and CHX.
[82]	Salvadora Persica	CHX	Antibiotic and antibiofilm activities against S. Mutans.	Oils of Salvadora Persica can be as effective as CHX.