



IJCRR

Section: Healthcare

ISI Impact Factor
(2019-20): 1.628

IC Value (2019): 90.81
SJIF (2020) = 7.893



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Antifungal Efficacy of Commonly Used Endodontic Irrigating Solutions on *C Albicans* – A Systematic Review

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ABSTRACT

Introduction: Microorganisms have a pivotal role in the induction and continuing of pulp and periapical pathosis.

Objectives: To evaluate antifungal efficacy of commonly used endodontic irrigating solutions on reducing the CFU count of *C Albicans* in extracted human permanent teeth.

Methods: The research question was formulated using the PICO strategy. A planned literature search was conducted by two personnel independently using MEDLINE, PubMed, EBSCO, Scopus, Google Scholar and manual search using College library. Resources were searched from 1st Sept 2009 to 31st August 2019 to identify appropriate studies. Inclusion and exclusion criteria were implicated to select articles. All cross-references lists were also selected. A systematic data extraction sheet was formulated.

Results: A total of 101 articles were identified through the data base. 13 articles were selected after thoroughly reading full texts and were assessed for eligibility. After going through these 13 articles, it came to notice that no endodontic irrigant has 100% antifungal properties. In many studies, it is evident that out of different concentrations of Sodium hypochlorite, 5.25% concentrated solution showed the best results.

Conclusion: From this systematic review it can be concluded that although the antifungal activity of various endodontic irrigating solutions is checked by various authors, no single irrigant proves to be completely successful in reducing the count of candida.

Key Words: Antifungal, Colony-forming units, Disinfecting agent, Extracted human teeth, Irritants, Microorganisms

INTRODUCTION

Microorganisms have a pivotal role in the induction and continuing of pulp and periapical pathosis. Among the predominant root canal microbiota, fungi play an important role in the failure of root canal treatment. Kakehashietal¹ in a classic study proved that bacteria caused pulpal disease; however, numerous studies have revealed a possible role of fungi and more recently viruses in the incidence of endodontic infections. Literature has mentioned that *Enterococcusfaecalis*, *Actinomyces*, and *Candida albicans* were the most prevalent microorganisms associated with failed endodontic treatment. Their presence has been confirmed in dental plaque, dental caries, dentinal tubules, subgingival flora, and infected root canals.²The genus *Candida albicans* (*C. Albicans*) is the most important and influential

one. Sen et al found heavy fungal infections in 4 out of 10 teeth and suggested that *Candida* be considered a dentinophilic microorganism.³

C. Albicans is a versatile microorganism. It exhibits a variety of virulence factors and degrades dentinal collagen. *Candida* can grow on the dentinal surfaces in the absence of oral tissue fluids and penetrates the dentinal tubules by its various growth patterns. Despite *C. Albicans* being an aerobic microorganism, it can survive in the harsh environment of the root canal, which primarily favours the growth of anaerobes is because of these unique qualities. *C. Albicans* has also been isolated in culture samples taken from mixed endodontic infections.⁴

Waltimo et al⁵ showed that *Candida* species was resistant to calcium hydroxide; however, when combined with sodium

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ISSN: 2231-2196 (Print)

ISSN: 0975-5241 (Online)

Received: 03.10.2020

Revised: 12.12.2020

Accepted: 08.02.2021

Published: 04.06.2021

hypochlorite or CHX it could provide a wide spectrum antimicrobial action with a long-lasting effect. The resistance of *Candida* to calcium hydroxide and its ability to penetrate dentinal tubules are possible reasons for its occurrence in cases of apical periodontitis.⁶ This raised the curiosity of researchers to look for the antifungal potency of endodontic irrigants.

Sodium hypochlorite is one of the most commonly used irrigating solutions and is considered a gold standard. It has good antibacterial effects and tissue dissolving properties. But one of the biggest drawbacks of NaOCl is that it has low surface tension and hence it does not penetrate deep into dentinal tubules. This has led to the development of new irrigants which overcome this drawback. Chlorhexidine (CHX) is a biguanide with a wide antimicrobial spectrum that is effective against Gram-positive and Gram-negative bacteria as well as fungi.^{7,8}

There are some antibiotic-based root canal irrigation solutions in endodontics, as well. Adjunctive methods of disinfection like lasers, PDT are also used vividly. Attempts have been made to check the antifungal properties of irrigating solutions. But there is no one particular irrigant aiming at eliminating all micro-organism and resulting in successful endodontic treatment. Hence, the search for an ideal root canal irrigant to achieve the goal of disinfection of the canals from all microorganisms continues.^{9,10} This systematic review aims to evaluate the antifungal efficacy of various endodontic irrigants on the basis of reduction of the CFU count of *C. Albicans* on extracted human teeth.

MATERIALS AND METHDOS

This systematic review was done according to PRISMA guidelines.

Eligibility Criteria

Articles in the English language or those having a summary in English were selected. Studies published from 1st Sept 2009 to 31st August 2019 were chosen. In vitro studies done on Human extracted teeth evaluated by Colony Forming Unit were the main criteria while selecting the study. This systematic review included the articles in which methodology showed the use of endodontic irritants only and not a combination of these irrigants with any other material. Review, abstract, letter to the editor was excluded. In vivo studies were also excluded.

Information source

The internet source used to search papers for this study were: The National Library of Medicine (MEDLINE PubMed) and EBSCO HOST, Google Scholar, Google and manual search using DPU college library resources. All cross-references lists of the selected studies were screened for additional papers that could meet up the eligibility criteria. The databases were searched up to and including September 2019 using the search strategy.

Study selection and strategy

The databases were searched for relevant articles with title, abstract, keywords and their combination as follows:

Antifungal OR Antibacterial AND *Candida Albicans* OR endodontic fungi AND irrigating solutions OR Endodontic irrigating solutions OR root canal irrigants OR dental irrigants OR Sodium hypochlorite OR Chlorhexidine AND Extracted Human Teeth OR Invitro study AND Colony Focal count OR CFU. The yielded articles were assessed further after securing full-text and eliminating duplicates. The titles and abstracts were thoroughly screened and they were either included or excluded based on the inclusion criteria. Articles wherein the antifungal efficacy of one or more endodontic irrigating solution/s was checked against *candida Albicans* on extracted human teeth and were evaluated by Colony Forming Unit were chosen.

Data collection process

A standard pilot form in the excel sheet was initially used and then those headings not applicable for the review were removed. A pattern of data extraction was done for an article and this was reviewed by an expert and finalized. This was followed for data extraction of all articles. The data extracted from the included studies were as follows:

1. Title- Title of the article.
2. Author – the name of the author.
3. Year of publication- the year in which the study was published.
4. Sample size- the number of extracted human teeth included in the study.
5. Intervention- names and quantity of irrigating solution used.
6. Technique – materials and method used.
7. Results- results of the study.
8. Conclusion – conclusion made from the study.

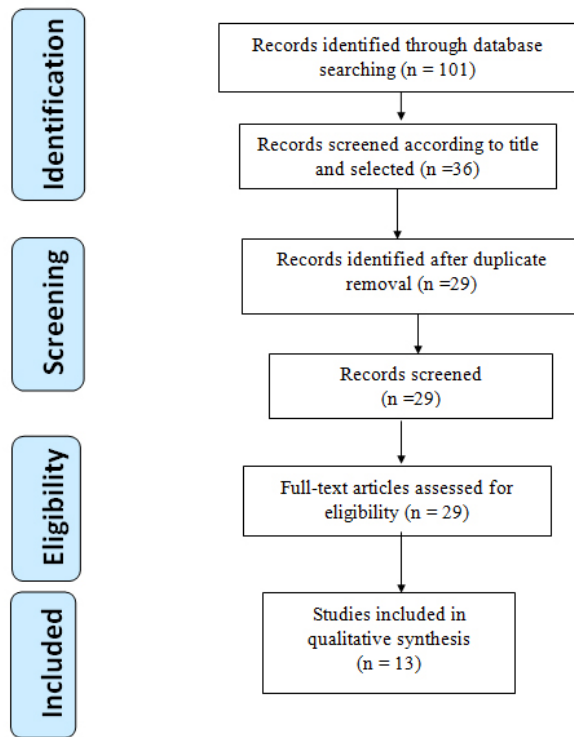


Figure 1: Flowchart for selection of studies and review.

RESULTS

Study selection

A total of 101 articles was identified through database searching. After reading titles, 64 articles were excluded as they did not match the inclusion criteria. Further 36 articles were assessed for any duplicate and seven articles were removed. The remaining 29 articles were then screened for abstract. After reading the full text of remaining 13 articles were selected and assessed for eligibility. These 13 articles were included in the study (Figure 1). The variables used to extract data i.e. study size, PICOS, methodology, irrigating solution, sample size, the method of preparation of the tooth, colony-forming unit, control used and others are mentioned.

DISCUSSION

The major goal of root canal treatment is to prepare the canals free of any pathogenic organism to provide a long-lasting treatment of the tooth. Along with bacteria, fungi are also been found in canals of infected teeth or endodontically failed teeth.⁹ Very few have been evaluated for their antifungal efficacy. Hence the main aim of this systematic review was to discuss the antifungal activity of all the commonly used endodontic irrigants. Thirteen articles were extracted for this systematic review. Routinely used irrigants like

NaOCl, CHX, saline, etc. were commonly used for comparison with other materials in the referred articles. Some herbal products like *Morinda Citrifolia (MC)*, *Triphala* juice, Aloe vera extract, etc. were also tested for their antifungal effectiveness. Some supplementary techniques like laser, photodynamic therapy(PDT) and light-activated disinfection were also studied for their antifungal effectiveness. The studies that used extracted human teeth for the growth of candida and Colony Forming Unit to assess the reduction in the number of Candida were the only ones chosen for this systematic review.

Sodium hypochlorite is one of the most commonly used irrigant in endodontics because of its cheap cost, ease of availability and majorly its tissue dissolving property. It is available in various concentrations of 0.2%, 0.5%, 2.5%, 3%, 5.25% and 6%. The efficacy of NaOCl also depends on its contact time, temperature and concentration. It has been demonstrated that *C. Albicans* is very susceptible to its action in 0.5% concentration within 10 s of contact time.² Mohamadi et al² in 2015 conducted a study to check the antifungal efficacy of sodium hypochlorite in three different concentrations (0.5%, 2.6%, 6%) with CHX (0.2%, 2%), MTAD, Chlor- Xtra, Hypoclean and Tetraclean. Antifungal activity of 6% NaOCl, Chlor-Xtra and 2% CHX was significantly greater than the rest of the irrigants. MTAD was introduced by Mahmoud Torabinejad and associated in the year 2003. It is a combination of 3% doxycycline, 4.25% citric acid and a surfactant. Mohamadi et al³ in 2010 conducted the first study comparing the effect of 1.3% NaOCl, 2% CHX, MTAD and Tetraclean as a final rinse against *C.albicans*. Similar to the study mentioned above, NaOCl and CHX had the highest Colony Forming Unit reduction with similar results. Tetraclean was found superior to MTAD. MTAD and Tetraclean both are Doxycycline based irrigants. But Tetraclean was significantly more effective than MTAD because it has deeper penetrating ability due to low surface tension. There is only one study using Hypoclean and it has very low results compared to Tetraclean.⁹

Propolis is also new biocompatible material in the market with good antibacterial properties. Awawdeh et al.¹¹ checked its antifungal properties of MTAD, 3% NaOCl and 2% CHX and 30% Propolis in the presence and absence of smear layer. The results showed that Propolis was having 70% efficacy, NaOCl up to 90% while CHX upto 95%. So, according to this study CHX was a more efficient antifungal agent than NaOCl, which is contrary to many studies considered in this systematic review. Also, no significant difference was seen in the reduction of colony count due to the presence or absence of smear layer according to this study.

Clonidine hydrochloride (OCT) is a bipyridine derivative. OCT has been suggested as an alternative endodontic irrigant based on its antimicrobial effects and lower cytotoxicity. Tirali

et al¹¹ in 2011 evaluated the effectiveness of 5.25% NaOCl, 0.1% OCT and 2% CHX at different time intervals of 30 sec, one minute and five minutes as per the groups. It was noticed that 1 ml of 2% CHX for Five minute showed the highest antifungal activity followed by 5.25% NaOCl. 0.1% OCT showed the least antifungal activity. This proved that the more the exposure time of the irrigant, the more potent was the antifungal action.

Zargar et al.¹³ conducted a study to evaluate the presence or absence of smear layer on the antifungal effect of irrigants at the time intervals of 5 minutes, 30 minutes and 60 minutes. Teeth were prepared. The smear layer was created in 50% (half) of the samples and its removal was done in half of the samples. They were infected with *C. albicans*. Irrigation with 2.61 % NaOCl, 0.2% CHX and 1% Povidone-iodine (PI) was done for five, 30 and 60 min. They concluded that removal of smear layer proved to be more effective in removing the fungi and 2.6% NaOCl was most potent followed by 2% CHX compared with 1% PI.

There is also a study where photodynamic therapy was used in adjunct to sodium hypochlorite by Bruna Paloma de Oliveria et al.¹⁴ In this study disinfection protocol used was as follows 1% NaOCl, 5.25% NaOCl, 1% NaOCl+ PDT, 5.25% NaOCl+ PDT, saline + PDT. For PDT, methylene blue (15µg/ml) remained in the root canal for two minutes, followed by irradiation with the diode laser. 5.25% NaOCl+ PDT resulted in the highest number of antifungal efficacies. Same antimicrobial effects were seen with 1% NaOCl and 1% NaOCl + PDT. Saline + PDT did not eliminate all microorganisms. This proves that PDT is an additional method for disinfection of canals followed by irrigation, but independently it cannot be much useful for disinfection. The above results coincided with a study conducted by Eldeniz et al.¹⁵ They evaluated the antifungal efficacy of light-activated disinfection (LAD/ PDT) in comparison with 2.5% NaOCl and 2% CHX and a new wound antiseptic, OCT. The result showed that the PDT group showed the least antifungal effect. 2.5% NaOCl showed the most antifungal effect followed by 2% CHX and OCT having a similar effect.

Another adjunct for disinfection is lasers. Emelonay et al.¹⁶ conducted a study to check the antifungal effect of Er, Cr: YSGG laser irradiation at different energy settings to eliminate *C. Albicans*, with or without 5.25% NaOCl. The specimens were divided into six treatment groups of NaOCl-I-W laser; 1-W laser, NaOCl 0.75-W laser, 0.75-W laser, NaOCl only and a group with no treatment. Although all the groups showed more or less reduction in the Colony Forming Unit count, there was no group showing complete eradication. Lasers when used alone were less effective. But when used in adjunct with NaOCl showed most antifungal action.

Some authors use herbal preparation to check their effect on *C. albicans*. Choudhary et al.¹⁷ check the antifungal proper-

ties of *Morinda Citrifolia*(MCJ) and *Triphala* juice as endodontic irrigants. Out of the two, MCJ showed higher antifungal efficacy. The disadvantage of these two herbal products was they cause discolouration of teeth. A study by Valera M et al.¹⁰ evaluated the antifungal properties of Aloe vera, Castor oil and Glycolic Ginger extract and compared them with 2.5% NaOCl and 2% CHX. Although Aloe vera has medicinal value and used as an antimicrobial and anti-inflammatory agent it was not able to reduce all the microorganisms. Despite the antimicrobial effects of Ginger, it didn't show an effective antifungal effect in the present study. The reason for poor results is attributed to lower concentrations used in the study. Castor oil has a literature background supporting its antimicrobial properties, biocompatibility etc. Castor oil is capable of removing debris similar to 1% NaOCl. This study completely removed the *C Albicans*.

Juneja et al¹⁷ combined 1.3% NaOCl and MTAD and checked its antifungal efficacy comparing with 2.5% NaOCl, 2% CHX and Iodine potassium iodide (IKI). After comparing the above irrigants, it was found that there was a significant reduction in growth but there was no significant difference in the antifungal effect. Also, the CFU counts in the study showed that the antifungal substantivity of IKI was less. 2.5% NaOCl, 2% CHX showed the highest antifungal effect followed by 1.3% NaOCl/MTAD. The substantivity nature of CHX is because it absorbs the acidic proteins of hydroxyapatite and gradually releases them in inactive cation form.¹⁸ Sedigh-Shams et al.¹⁹ compared the antifungal effect of *Zataria multiflora* EO with that of NaOCl as an irritant for root canals infected with *C Albicans*. NaOCl was effective than *Z multiflora* EO with minimum fungicidal concentration.

The study conducted by Chandra et al³ evaluated the antifungal efficacy of 5.25% NaOCl, 2% CHX and 17% EDTA as one subgroup. They compared the antifungal efficacy by adding Clotrimazole as an antifungal agent in another subgroup after irrigation. In the subgroup where irrigants were used without an antifungal agent, 5.25% NaOCl proved to be more potent than 2% CHX and 17% EDTA. When Clotrimazole was flushed in the canals after the irrigation, no difference was observed between NaOCl and CHX group and was more effective than 17% EDTA.

CONCLUSION

C. Albicans is proven to be responsible for pulpal and periapical infection. There have been attempts on the complete elimination of *C. Albicans* in-vitro. Various researchers have tried various irrigants to check their antifungal activity against *C. Albicans*. All irrigants were able to reduce the Colony Forming Unit count up to some extent. But no specific irrigant showed potent antifungal efficacy equal to NaOCl

and CXH. NaOCl is a gold standard endodontic irrigant and is routinely used by the clinician. CHX also has potential antifungal efficacy. Its use as a final rinse will have potential antifungal results. Smear layer removal may aid in increasing the potency of irrigating solutions. The use of adjunctive techniques such as Lasers, PDT, etc. can lead to effective disinfection of root canals from *C.Albicans*. Although there are various improved irrigating solutions in the market, the search for an ideal root canal irrigating solution to eliminate all the micro-organism continues.

Conflict of interest: None

ACKNOWLEDGEMENT

I would like to thank my Guide Dr Anita B. Tandale for her guidance and help throughout the course. I would also like to thank my colleagues Dr Sayali Maral and Dr. Karishma Krishnakumar for their help and support.

Source of Funding: None.

Authors' Contribution: All the authors contributed equally.

REFERENCES

1. Kakehashi S, Stanley HR, Fitzgerald RJ. The effects of surgical exposures of dental pulps in germ-free and conventional laboratory rats. *Oral Surg Oral Med Oral Path.* 1965;20(3):34–35.
2. Mohammadi Z, Giordano L, Pallazi F. Evaluation of the antifungal activity of four solutions used as a final rinse in vitro. *Aust Endod J.* 2013;39:31–34.
3. Chandra S, Miglani R, M.R. Srinivasan, Indira R. Antifungal Efficacy of 5.25% Sodium Hypochlorite, 2% Chlorhexidine Gluconate, and 17% EDTA With and Without an Antifungal Agent. *J Endod.* 2010;36(4):675-678.
4. Siqueira JF, Sen BH. Fungi in endodontic infections. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2004;97:632–41.
5. Waitomo TMT, Orstavik D, Siren EK, et al. In vitro susceptibility of *Candida albicans* to four disinfectants and their combinations. *Int Endod J.* 1999; 32:421–9.
6. Waltimo T, Siren E, TorkkoH, Olsen I, Haapasalo M. Fungi in therapy-resistant apical periodontitis. *Int Endod J.* 1997; 30, 96–101.
7. Palazzi F, Morra M, Mohammadi Z, Grandini S, Giardino L. Comparison of the surface tension of 5.25% sodium hypochlorite solution with three new sodium hypochlorite-based endodontic irrigants. *Int Endod J.* 2012;45(2):129-35.
8. Mohammadi Z, Abbott PV. The properties and applications of chlorhexidine in endodontics. *Int Endod J.* 2009;42(4):288-302.
9. Mohammadi Z, Asgary S. Antifungal Activity of Endodontic Irrigants. *Iran Endod J* 2015;10(2):144-147.
10. Valera M, Maekawa L, Oleviera L, Jorge A, Carvalho C. In vitro antimicrobial activity of auxiliary chemical substances and natural extracts on *Candida albicans* and *Enterococcus faecalis* in root canals. *J Appl Oral Sci.* 2013; 21(2):118-23.
11. Awawdeh L, Jamleh A, Beitawi M. The Antifungal Effect of Propolis Endodontic Irrigant with Three Other Irrigation Solutions in Presence and Absence of Smear Layer: An In Vitro Study. *Iran Endod J.* 2018;13(2):234-239.
12. Tiralı R, Bodur H, Sipahi B, Sungurtekin E. In vitro antimicrobial activity of Sodium hypochlorite, Chlorhexidinegluconate and OctenidineDihydrochloride in the elimination of microorganisms within dentinal tubules of primary and permanent teeth. *Med Oral Patol Oral Cir Bucal.* 2012;17(3):517-22.
13. Zargar N, Dianat O, Asnaashari M, Ganjali M, ZadsirjaS. The Effect of Smear Layer on Antimicrobial Efficacy of Three Root Canal Irrigants. *Iran Endod J.* 2015; 10 (3): 179-183.
14. Oliveira BP, AguiarC, Albuquerque M, Barros Correia A, Roca Soares M. The efficacy of photodynamic therapy and sodium hypochlorite in root canal disinfection by a single-file instrumentation technique. *Photodiagn Photodyn Ther.* 2015;05:004.
15. Eldeniz A, Gunecer M, Akbulut M. Comparative antifungal efficacy of light-activated disinfection and octenidine hydrochloride with contemporary endodontic irrigants. *Lasers Med Sci.* 2015;30(2):669-75.
16. Onay E, AlikayaV, Seker E. Evaluation of Antifungal Efficacy of Erbium, Chromium: Yttrium-Scandium-Gallium-Garnet Laser Against *Candida albicans*. *Photomed Laser Surg.* 2010;28(1):S73-78.
17. Choudhary E, Indushekar K, Saraf B, Sheoram N, Sardana D, Shekhar A et al. Exploring the role of *Morindacitrifolia* and *Triphala* juice in root canal irrigation: An ex vivo study. *J Conserv Dent.* 2018; 21(4): 443-449.
18. Juneja N, Hegde M. Comparison of the Antifungal Efficacy of 1.3% NaOCl/MTAD with Other Routine Irrigants: An Ex-Vivo Study. *Intech Res Notices.* 2014; 575748.
19. Sedigh-Shams M, Badiiee P. In vitro comparison of antimicrobial effect of sodium hypochlorite solution and *Zatariamultiflora* essential oil as irrigants in root canals contaminated with *Candida albicans*. *J Cons Dent.* 2016;19(1):101-105.