Comparative Evaluation of the Antimicrobial Efficacy of Octenidine Dihydrochloride with Contemporary Root Canal Disinfectants: A Systematic Review

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Authors’ contributions

This work was carried out in collaboration among all authors. Author RAG designed and managed the literature searches and also wrote the first draft of the manuscript. Authors PA and HS analysed the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Octenidine is a cationic disinfectant that has been tested for its wide range of antibacterial efficacy and biocompatibility. It finds its application in the medical field as an antiseptic for wounds and mucous membranes. The present systematic review aims to compare the antimicrobial efficacy of Octenidine Dihydrochloride with various root canal irrigants and medicaments. An electronic search strategy was planned to search the database of PUBMED CENTRAL and MEDLINE using the search terms alone and in combination using PUBMED search builder till September 2019 for related studies. In Vitro studies that compared the antibacterial efficacy of Octenidine Dihydrochloride to other irrigants and medicaments against Enterococcus faecalis and Candida albicans using extracted human teeth were included in the review. The primary outcome measure was the reduction in the microbial load which was assessed through either CFU or the percentage of viable and dead bacteria. A total of 7 studies that matched the inclusion criteria were included in

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the systematic review. The studies indicated that Octenidine Dihydrochloride was highly effective in eliminating *E. faecalis* and *C. albicans* and could be a more biocompatible potential alternative or an adjunct to the existing irrigants and medicaments.

**Keywords:** Antimicrobial; calcium hydroxide; octenidine; root canal irrigants; sodium hypochlorite.

## 1. INTRODUCTION

The role of microorganisms in the development of pulp and periradicular diseases has been well documented in scientific literature [1]. The primary endodontic infections are associated with a mixed array of microorganisms [2] whereas *Enterococcus faecalis* is one of the predominant species associated with secondary infections [3]. In addition, yeast like microorganisms, particularly *Candida albicans* has also been found to be associated with secondary endodontic infections [4]. The goal of endodontic treatment is the successful eradication of the causative microorganism thereby increasing the chances of a favorable outcome. Therefore, the use of chemical disinfectants such as root canal irrigants and intracanal medications between appointments for the elimination of these bacteria and for disinfection of the root canal system is highly imperative [1,5]. These disinfectants along with having a broad antibacterial spectrum, should not be cytotoxic and should have sufficient time of action to eliminate bacteria.

Root canal irrigants play a vital role in removal of smear layer and elimination of microorganisms located in isthmuses, ramifications, deltas, irregularities, and dentinal tubules where mechanical means alone will not suffice [6]. Antibacterial effectiveness of mechanical instrumentation and irrigation was evaluated by Bystrom and Sundqvist [7]. They found that all the teeth had a positive culture after the first appointment despite a considerable reduction in bacterial counts after instrumentation and irrigation with saline. There was a significant improvement in the elimination of bacteria after they used sodium hypochlorite (NaOCl) separately or combined with ethylene diamine tetraacetic acid (EDTA) [7]. However, sodium hypochlorite is highly toxic and can cause a reaction when it comes in contact with soft tissues [8].

Intracanal medicaments are used for eliminating microorganisms that persist even after mechanical instrumentation, for teeth with chronic periapical lesions and for treating weeping canals [9]. Calcium hydroxide has been widely recommended as the gold standard medicament owing to its proven antibacterial properties, biocompatibility, periapical tissue healing stimulation and anti-exudate activity [10,11]. However, it fails to eliminate *E. faecalis* which is the most commonly observed pathogen in a retreatment endodontic case [12].

Octenidine Dihydrochloride is a cationic surfactant and has been in use as an antiseptic, in concentrations of 0.1 to 2.0% owing to its antibacterial activity against gram-positive and gram-negative bacterial strains. Octenidine is not absorbed through the mucous membrane, nor the skin and wounds [13]. Octenidine has been tested against *E. faecalis* and is a well-known disinfectant in medical facilities [14,15]. In addition, it is also highly biocompatible and is a substitute for chlorhexidine which has concerns about the carcinogenic impurity 4-chloroaniline [16].

Previously our team had conducted numerous clinical studies [17,18], case reports [19], in vitro studies [20–25], surveys [26,27] reviews [28–31] in various aspects of endodontics and conservative dentistry over the past five years [32] from which the idea of the present study has stemmed. This systematic review aimed to compare the antimicrobial effectiveness of Octenidine dihydrochloride with conventional root canal disinfectants used in routine practice. This review shall aid in understanding the efficacy of Octenidine dihydrochloride as a root canal disinfectant and its future prospects.

## 2. MATERIALS AND METHODS

### 2.1 Sources Used

To identify the studies to be included or considered for the present review a detailed search was carried out on the following databases:

- PubMed central (until September 2019)
- Pubmed Advanced Search (until September 2019)
- Cochrane Database of Systematic Reviews
2.2 Language

Only those articles that were in the English language were considered for inclusion during the electronic search.

2.3 Hand Searching

The following journals were hand-searched:

- International Endodontic Journal
- Journal of Endodontics
- Journal of Conservative Dentistry
- Australian Dental Journal

2.4 Inclusion Criteria

In vitro studies that tested antimicrobial efficacy of irrigants against *E. faecalis* or *C. albicans* or both.

2.5 Exclusion Criteria

1. Animal studies
2. Review articles
3. Studies not meeting the inclusion criteria

2.6 Type of Intervention

Use of Octenidine Dihydrochloride as a root canal irrigant to eliminate the microorganism.

2.7 Type of Control

Use of various other root canal irrigants or medicaments for the disinfection to eliminate the microorganism.

2.8 Type of Outcome Measure

Evaluation of the antimicrobial efficacy in terms of colony forming units, percentage viable bacteria or number of dead cells.

3. RESULTS AND DISCUSSION

The electronic search identified 105 publications of which 89 were excluded after reviewing the title and the abstract. For further evaluation 16 full articles were obtained of which 9 were excluded. Therefore 7 publications fulfilled all the inclusion criteria and were included in the review (Fig. 1). Table 1 enlists the general information of the included studies. The results and interpretation of the studies are listed in Table 2. The seven studies that were included in the review were all in vitro studies that have a level of evidence 5. The present systematic review aimed to evaluate the antimicrobial effectiveness of octenidine dihydrochloride in comparison to the various other root canal irrigants and medicaments.
Table 1. Characteristics of included studies

| S No | Author and year | Study Design | Sample Size | Study groups | Variable evaluated | Method of Evaluation | Statistical Analysis |
|------|-----------------|--------------|-------------|--------------|--------------------|---------------------|---------------------|
| 1.   | Tirali RE et al 2012 | In Vitro Study | N=80 permanent teeth and 80 primary teeth | Group 1: 5.25% NaOCl for 30 sec Group 2: 5.25% NaOCl for 1 min Group 3: 5.25% NaOCl for 5 min Group 4: 0.1% Oct for 30 sec Group 5: 0.1% Oct for 1 min Group 6: 0.1% Oct for 5 min Group 7: 2% CHX for 30 sec Group 8: 2% CHX for 1 min Group 9: 2% CHX for 5 min Group 10: Saline for 5 min | Antimicrobial activity against *E. faecalis* and *C. albicans* | Colony Forming Units | Kruskal-Wallis Test, Mann Whitney U Test |
| 2.   | De Lucena JM et al 2013 | In Vitro Study | N=40 | Group 1: Calcium hydroxide paste Group 2: Chlorhexidine gel 5.0% Group 3: Chlorhexidine gutta percha points Group 4: Octenidine gel 5.0% | Antimicrobial effectiveness against *E. faecalis* | Percentage of viable bacteria | Colony Forming Units |
| 3.   | Eldeniz AU et al 2013 | In Vitro Study | N=70 | Group 1: Light | Antifungal efficacy against *C. albicans* | Colony Forming Units | Independent two |

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| S No | Author and year | Study Design | Sample Size | Study groups | Variable evaluated | Method of Evaluation | Statistical Analysis |
|------|-----------------|--------------|-------------|--------------|--------------------|----------------------|----------------------|
| 1.   | Gulzar et al 2013 | Study        |             | activated disinfection with toluidine blue<br>Group 2: Octenidine hydrochloride<br>Group 3: 2.5% Sodium Hypochlorite<br>Group 4: 5.25% Sodium Hypochlorite<br>Group 5: 2% Chlorhexidine<br>Positive control group<br>Negative control group | albicans | Units | sample t test |
| 2.   | Guneser MB.et al 2016 | In Vitro Study | N=70 | Group 1: 2.5% NaOCl<br>Group 2: 5.25% NaOCl<br>Group 3: 2% CHX<br>Group 4: Chlorhexidine and Cetrimide<br>Group 5: Methanol extract of S officinalis<br>Group 6: Octenidine<br>Positive control group: infected samples with no irrigant (n=5)<br>Negative control group: sterile root canals (n=5) | Antimicrobial effect against *E faecalis* | Colony Forming Units | Kruskal Wallis test<br>Mann Whitney U test |
| S No | Author and year | Study Design | Sample Size | Study groups | Variable evaluated | Method of Evaluation | Statistical Analysis |
|------|-----------------|--------------|-------------|--------------|---------------------|----------------------|----------------------|
| 5.   | Cherian B.et al 2016 | In Vitro Study | N=48 | Group 1: Conventional syringe irrigation (CSI) with 2% CHX<br>Group 2: CSI with 0.1% OCT<br>Group 3: Passive Ultra Sonic Irrigation (PUI) with 2% CHX<br>Group 4: PUI with 0.1% OCT | Antimicrobial efficacy against *E faecalis* | Colony Forming Units | One-way analysis of variance (ANOVA)<br>Scheffes multiple comparisons means<br>Paired t test |
| 6.   | Bukhary S.et al 2017 | In Vitro Study | N=90 | Group 1: OCT (n=20)<br>Group 2: 1% Alexidine (n=20)<br>Group 3: 2% CHX (n=20)<br>Positive control group: 5.25% NaOCL (n=15)<br>Negative control group: saline (n=15) | Antibacterial Efficacy against *E faecalis* | Proportion of dead cells in biofilm using confocal laser scanning | Kruskal Wallis test<br>Mann Whitney U test |
| 7.   | Varghese VS.et al 2018 | In Vitro Study | N=160 | Group 1: Octenidine<br>Group 2: Octenidine with chitosan carrier<br>Group 3: Calcium Hydroxide with chitosan carrier<br>Group 4: Calcium Hydroxide | Antibacterial efficacy against *E faecalis* and *C albicans* | Colony Forming Units | One way ANOVA and Tuckey's multiple post hoc test |
### Table 2. Results of the included study

| S No | Author and Year | Study Groups | Interpretation |
|------|-----------------|--------------|----------------|
| 1    | Tirali RE et al 2012 | Group 1: 5.25% NaOCl for 30 sec  <br> Group 2: 5.25% NaOCl for 1 min  <br> Group 3: 5.25% NaOCl for 5 min  <br> Group 4: 0.1% Oct for 30 sec  <br> Group 5: 0.1% Oct for 1 min  <br> Group 6: 0.1% Oct for 5 min  <br> Group 7: 2% CHX for 30 sec  <br> Group 8: 2% CHX for 1 min  <br> Group 9: 2% CHX for 5 min  <br> Group 10: Saline for 5 min | The study showed that application of 0.1% Octenidine for 5 mins was most effective in eliminating *E faecalis* that penetrated into the dentinal tubules of both primary and permanent teeth whereas all irrigating solutions except saline were equally effective in eliminating *C Albicans*. |
| 2    | De Lucena JM et al 2013 | Group 1: Calcium hydroxide paste  <br> Group 2: Chlorhexidine gel 5.0%  <br> Group 3: Chlorhexidine gutta percha points  <br> Group 4: Octenidine gel 5.0% | There was a significant reduction in the percentage of viable bacteria in test groups 2, 3 and 4 but Octenidine yielded the maximum reduction with no cells being alive at 12 weeks. |
| 3    | Eldeniz AU et al 2013 | Group 1: Light activated disinfection with toluidine blue  <br> Group 2: Octenidine hydrochloride  <br> Group 3: 2.5% Sodium Hypochlorite  <br> Group 4: 5.25% Sodium Hypochlorite  <br> Group 5: 2% Chlorhexidine  <br> Positive control group  <br> Negative control group | Octenidine hydrochloride, 5.25% and 2.5% sodium hypochlorite and 2% chlorhexidine were all equally effective in eliminating *C albicans* and were more effective than light activated disinfection. |
| 4    | Guneser MB et al 2016 | Group 1: 2.5% NaOCl  <br> Group 2: 5.25% NaOCl  <br> Group 3: 2% CHX  <br> Group 4: Chlorhexidine and Cetrimide  <br> Group 5: Methanol extract of *S officinalis*  <br> Group 6: Octenidine  <br> Positive control group: infected samples with no irrigant (n=5)  <br> Negative control group: sterile root canals (n=5) | Sodium Hypochlorite 5.25% and 2.5%, 2% chlorhexidine and Octenidine were equally effective in eliminating *E faecalis* whereas methanol extract of *S officinalis* and the combination of chlorhexidine and cetrimide could not achieve total elimination of the strains. |
| 5    | Cherian B et al 2016 | Group 1: Conventional syringe irrigation (CSI) with 2% CHX  <br> Group 2: CSI with 0.1% OCT | Octenidine 0.1% was more effective than chlorhexidine 2% both at 200 and 400 micrometer |
| S No | Author and Year | Study Groups                                                                 | Interpretation                                                                 |
|------|-----------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
|      |                 | Group 3: Passive UltraSonic Irrigation (PUI) with 2% CHX                      | and passive ultrasonic irrigation enhanced the antimicrobial action of both the irrigants. |
|      |                 | Group 4: PUI with 0.1% OCT                                                    |                                                                                |
| 6.   | Bukhary et al 2017 | Group 1: OCT (n=20)                                                           | Octenidine was more effective than Alexidine and Chlorhexidine but Sodium Hypochlorite had significantly greater antimicrobial activity against *E faecalis*. |
|      |                 | Group 2: 1% Alexidine (n=20)                                                  |                                                                                |
|      |                 | Group 3: 2% CHX (n=20)                                                       |                                                                                |
|      |                 | Positive control group: 5.25% NaOCL (n=15)                                   |                                                                                |
|      |                 | Negative control group: saline (n=15)                                        |                                                                                |
| 7.   | Varghese VS. et al 2018 | Group 1: Octenidine                                                           | Octenidine showed significantly better antimicrobial activity than other groups |
|      |                 | Group 2: Octenidine with chitosan carrier                                      |                                                                                |
|      |                 | Group 3: Calcium Hydroxide with chitosan carrier                              |                                                                                |
|      |                 | Group 4: Calcium Hydroxide                                                    |                                                                                |
Tirali RE. et al conducted an in vitro study to compare the antimicrobial effectiveness of Sodium Hypochlorite, Chlorhexidine and Octenidine Dihydrochloride as root canal irrigants at different time intervals. The study was performed on sections of primary and permanent teeth. The total sample size was 80 and each group had 10 samples. The teeth were sectioned into 4mm, sterilized and then contaminated with E faecalis and C albicans strains. The sections were subjected to different irrigating solutions followed by neutralisers for inactivation. Dental shavings were placed in TSB and 10 microliter from each tube was then inoculated on agar plates and the colonies were counted microscopically. Kruskal-Wallis and Mann Whitney U tests were used for statistical analysis. Amongst all the solutions, application of 0.1% Octenidine was found to be the most effective in eliminating the strains of E faecalis from both primary and permanent teeth. But there was no statistical difference when comparing the effectiveness of the solutions in eliminating C albicans [33].

De Lucena JM. et al conducted a study to evaluate the effectiveness of calcium hydroxide, chlorhexidine gel, chlorhexidine active gutta-percha points and Octenidine as intracanal medicaments in eliminating E faecalis strains. A total of 40 root segments were included in the sample size with 10 samples per group. They were infected with E faecalis and the root dentin samples collected at 4 weeks were considered as baseline values. At week 8, the samples were randomly divided into four groups and were subjected to the various medicaments followed by incubation for 4 weeks. The outcome measure was expressed in the percentage of viable bacteria and colony forming units. In comparison to calcium hydroxide, chlorhexidine and octenidine were more effective in decreasing the viability of E faecalis, of which octenidine showed the most favourable results [34].

Eideniz AU. et al conducted a study to compare the antifungal efficacy of light-activated disinfection and Octenidine Dihydrochloride with contemporary endodontic irrigants being 5.25% and 2.5% sodium hypochlorite and 2% chlorhexidine. Hence a total of 5 groups were present in the study along with a positive and negative control with the sample size being 10 per group. The samples were subjected to the test solutions for 3 mins and the irradiation time for light activated disinfection was 30 seconds. The dentin chips were collected from the inner walls of the canals after disinfection and transferred into vials containing phosphate buffered saline. The outcome measure was expressed in terms of colony forming units. All Candida cells were found to be totally eliminated in root canals that were treated with Octenidine, 2% chlorhexidine, 5.25% and 2.5% sodium hypochlorite suggesting Octenidine as a promising alternative to sodium hypochlorite and chlorhexidine [35].

Guneser MB. et al conducted a study where the antibacterial effects of Octenidine were compared with chlorhexidine-cetrimide combination, methanol extracts of S officinalis plant, 5.25% and 2.5% sodium hypochlorite and 2% chlorhexidine. For his study, seventy decoronated single rooted teeth were divided into 6 test groups (n=10) and two control groups (n=5) and were infected with E faecalis. They were subjected to the different irrigating solutions and the dentin chips obtained from the inner walls of the canals were subjected to analysis to determine the number of Colony Forming Units. They found out that Sodium Hypochlorite, Chlorhexidine and Octenidine could eliminate E faecalis cells thus suggesting Octenidine as a potential root canal disinfectant [36].

Cherian B. et al conducted a study to compare the antibacterial efficacy of Octenidine Dihydrochloride and Chlorhexidine with and without a Passive Ultrasonic Irrigation. Freshly extracted 48 teeth were allocated into four groups after growing a biofilm of E faecalis for seven days. They were subjected to the two irrigants with and without passive ultrasound post which the dental shavings at a depth of 200 and 400 micrometer were obtained and subjected to analysis for determining the colony forming units. The data was statistically analyzed using the ANOVA and paired t test. Their study concluded that 0.1% Octenidine was more effective than 2% Chlorhexidine at both the depths 200 and 400 micrometer and that passive ultrasonic activation increased their efficacy [37].

Bukhary S et al. conducted a study to determine the antibacterial efficacy of Octenisept, Alexidine, chlorhexidine and Sodium Hypochlorite against E faecalis biofilms. Octenisept, Alexidine, chlorhexidine groups had 20 samples whereas, the positive control, 5.25% sodium hypochlorite and negative control, saline had 15 samples per group. The root dentin discs were first infected with the strains of E faecalis and then subjected to the various irrigating solutions. The proportion
of dead cells in the biofilm were determined and it was observed that sodium hypochlorite has the highest antibacterial activity followed by Octenidine thus suggesting it as a potential alternative to chlorhexidine [14].

Varghese V S et al conducted a study to evaluate the antimicrobial efficacy of Octenidine Dihydrochloride and Calcium Hydroxide with and without chitosan carrier. The study consisted of a sample size of 160 extracted teeth which were divided into four groups. The samples were infected with strains of *E faecalis* and *C albicans* and were subjected to different medicaments. The antibacterial efficacy was evaluated based on the number of colony forming units at day 2 and day 7. The antibacterial and antifungal activity of all the four groups diminished from day 2 to day 7. Octenidine showed significantly better antibacterial efficacy as compared to Calcium hydroxide. The addition of chitosan carriers reduced their antibacterial and antifungal efficacy [38].

The results of this Systematic Review indicate that Octenidine Dihydrochloride is a more potent disinfectant for root canal systems than the existing contemporary disinfectants.

Octenidine dihydrochloride (octenidine) was introduced more than 20 years ago for skin, mucous membrane and wound antisepsis. Several *in vitro*, animal studies, prospective clinical trials have provided evidence for its efficacy, tolerance and safety. Octenidine represents an alternative to older substances such as chlorhexidine, povidone-iodine or triclosan and is nowadays an established antiseptic in a large field of applications [39]. In studies testing Octenidine for the oral cavity, it was found to be effective in efficiently controlling gingivitis and bleeding and plaque [40]. In another study comparing the effects of Octenidol, Glandomed and Chlorhexidine mouthwash, Octenidol was found to be the most effective in reducing the oropharyngeal flora [41]. Octenidine could also inhibit the adhesion of *C albicans* to human buccal epithelium [42].

The importance of disinfection in endodontics cannot be undermined. [27,28] Octenidine has shown promising antibacterial efficacy owing to its broad-spectrum antibacterial effect which include gram-positive as well as gram negative-organisms and yeast.

### 3.1 Limitation

A meta-analysis is performed for systematic reviews for the statistical pooling of data from individual studies when the studies are similar. A meta-analysis will help in yielding a more accurate estimate of the treatment effect. However, due to the heterogeneity of the groups in the studies included for the systematic review, a meta-analysis could not be performed. Hence only a descriptive evaluation of the data has been provided in the review.

### 3.2 Implications for Practice and Research

Opting for a medicament that is biocompatible and at the same time has a broad range of antibacterial effects will help in achieving the goal of endodontic treatment by efficiently eliminating the causative microorganisms without being toxic to the surrounding periapical tissue. This systematic review is a comparative analysis of the antimicrobial efficacy of Octenidine Dihydrochloride with the contemporary root canal irrigants and medicaments. There is scientific evidence to support the promising results of Octenidine Dihydrochloride as a potent root canal disinfectant. It could be a possible alternative or an adjunct to the contemporary disinfectants. Based on the results obtained from in vitro studies, further clinical studies can be carried out to prove its efficacy.

### 4. CONCLUSION

The systematic review concludes that Octenidine Dihydrochloride is a more potent antimicrobial agent against *E faecalis* and *C albicans* than the contemporary root canal disinfectants. The studies included in the review were *in vitro* studies which bring about the necessity of performing well designed randomized control trials so as to give concrete evidence on the clinical outcome of Octenidine Dihydrochloride as a root canal disinfectant.

### CONSENT AND ETHICAL APPROVAL

As per university standard guideline, participant consent and ethical approval have been collected and preserved by the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Buldur B, Kapdan A. Comparison of the antimicrobial efficacy of the endovac system and conventional needle irrigation in primary molar root canals. Journal of Clinical Pediatric Dentistry. 2017;41(4): 284-8.
2. Siqueira JF, Rôgas IN, Lopes HP. Patterns of microbial colonization in primary root canal infections. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2002;93:174–8. Available: https://doi.org/10.1067/moe.2002.119910
3. Stuart CH, Schwartz SA, Beeson TJ, Owatz CB. Enterococcus faecalis: Its role in root canal treatment failure and current concepts in retreatment. J Endod. 2006;32: 93–8.
4. Siqueira JF, Sen BH. Fungi in endodontic infections. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2004;97:632–41. Available: https://doi.org/10.1016/j.tripleo.2003.12.022
5. Buldur B, Oznurhan F, Kaptan A. The effect of different chelating agents on the push-out bond strength of proroot mta and endosequence root repair material. European Oral Research. 2019;53(2):88. Available: https://doi.org/10.1016/j.tripleo.2019.01.002
6. Haapasalo M, Shen Y, Wang Z, Gao Y. Irrigation in endodontics. Br Dent J. 2014;216:299–303.
7. Byström A, Sundqvist G. Bacteriologic evaluation of the efficacy of mechanical root canal instrumentation in endodontic therapy. Scand J Dent Res. 1981;89:321–8.
8. Gernhardt CR, Eppendorf K, Kozlowski A, Brandt M. Toxicity of concentrated sodium hypochlorite used as an endodontic irrigant. Int Endod J. 2004;37:272–80.
9. Chong BS, Pitt Ford TR. The role of intracanal medication in root canal treatment. International Endodontic Journal. 1992;25:97–106. Available: https://doi.org/10.1111/j.1365-2591.1992.tb00743.x
10. Sathorn C, Parashos P, Messer H. Antibacterial efficacy of calcium hydroxide intracanal dressing: A systematic review and meta-analysis. International Endodontic Journal. 2007;40:2–10. Available: https://doi.org/10.1111/j.1365-2591.2006.01197.x
11. Siqueira JF, Lopes HP. Mechanisms of antimicrobial activity of calcium hydroxide: A critical review. International Endodontic Journal. 1999;32:361–9. Available: https://doi.org/10.1111/j.1365-2591.1999.00275.x
12. Evans M, Davies JK, Sundqvist G, Figdor D. Mechanisms involved in the resistance of Enterococcus faecalis to calcium hydroxide. Int Endod J. 2002;35:221–8.
13. Harke HP. [Octenidine dihydrochloride, properties of a new antimicrobial agent]. Zentralbl Hyg Umweltmed. 1989;188:188–93.
14. Bukhary S, Balto H. Antibacterial efficacy of octenisept, alexidine, chlorhexidine, and sodium hypochlorite against Enterococcus faecalis biofilms. J Endod. 2017;43:643–7.
15. Assadian O. Octenidine dihydrochloride: Chemical characteristics and antimicrobial properties. Journal of Wound Care. 2016;25:S3–6. Available: https://doi.org/10.12968/jowc.2016.25.sup3.s3
16. Basrani BR, Manek S, Mathers D, Fillery E, Sodhi RNS. Determination of 4-chloroaniline and its derivatives formed in the interaction of sodium hypochlorite and chlorhexidine by using gas chromatography. J Endod. 2010;36:312–4.
17. Janarthanan S, Subbarao C. Comparative evaluation of the efficacy of diclofenac sodium administered using different delivery routes in the management of endodontic pain: A randomized controlled clinical trial. Journal of Conservative Dentistry. 2018;21:297. Available: https://doi.org/10.4103/jcd.jcd_14_0_17
18. Khandelwal A, Palanivelu A. Correlation between dental caries and salivary albumin in adult population in Chennai: An in vivo study. Brazilian Dental Science. 2019;22:228–33. Available: https://doi.org/10.14295/bds.2019.22/2.1686
19. Sureshbabu MN, Selvarasu K, V JK, Nandakumar M, Selvam D. Concentrated growth factors as an ingenious biomaterial in regeneration of bony defects after...
periapical surgery: A report of two cases. Case Rep Dent. 2019;2019:7046203.
20. Nandakumar M, Nasim I. Comparative evaluation of grape seed and cranberry extracts in preventing enamel erosion: An optical emission spectrometric analysis. J Conserv Dent. 2018;21:516–20.
21. Siddique R, Niveditha MS, Jacob B. Quantitative analysis for detection of toxic elements in various irrigants, their combination (precipitate), and para-chloroaniline: An inductively coupled plasma mass spectrometry study. J Conserv Dent. 2019;22:344–50.
22. Teja KV, Ramesh S, Priya V. Regulation of matrix metalloproteinase-3 gene expression in inflammation: A molecular study. J Conserv Dent. 2018;21:592–6.
23. Siddique R, Sureshbabu NM, Somasundaram J, Jacob B, Selvam D. Qualitative and quantitative analysis of precipitate formation following interaction of chlorhexidine with sodium hypochlorite, neem, and tulsi. J Conserv Dent. 2019;22:40–7.
24. Rajendran R, Kunjusankaran RN, Sandhya R, Anilkumar A, Santhosh R, Patil SR. Comparative evaluation of remineralization potential of a paste containing bioactive glass and a topical cream containing casein phosphopeptide- amorphous calcium phosphate: An in vitro study. Pesquisa Brasileira Em Odontopediatria E Clinica Integra. 2019;19:1–10. Available:https://doi.org/10.4034/pboci.2019.1.919.61
25. Govindaraju L, Neelakantan P, Gutmann JL. Effect of root canal irrigating solutions on the compressive strength of tricalcium silicate cements. Clin Oral Investig. 2017;21:567–71.
26. Manohar MP, Sharma S. A survey of the knowledge, attitude, and awareness about the principal choice of intracanal medicaments among the general dental practitioners and nonendodontic specialists. Indian J Dent Res. 2018;29:716–20.
27. Janani K, Sandhya R. A survey on skills for cone beam computed tomography interpretation among endodontists for endodontic treatment procedure. Indian J Dent Res. 2019;30:834–8.
28. Poorni S, Srinivasan MR, Niveditha MS. Probiotic strains in caries prevention: A systematic review. J Conserv Dent. 2019;22:123–8.
29. Azeem RA, Sureshbabu NM. Clinical performance of direct versus indirect composite restorations in posterior teeth: A systematic review. J Conserv Dent. 2018;21:2–9.
30. R R, Rajakeerthi R, Ms N. Natural product as the storage medium for an avulsed tooth – A systematic review. Cumhuriyet Dental Journal. 2019;22:249–56. Available:https://doi.org/10.7126/cumudj.525182
31. Siddique R, Niveditha MS. Effectiveness of rotary and reciprocating systems on microbial reduction: A systematic review. J Conserv Dent. 2019;22:114–22.
32. Ramaro S, Sathyanarayanaan U. CRA Grid - A preliminary development and calibration of a paper-based objectivization of caries risk assessment in undergraduate dental education. J Conserv Dent. 2019;22:185–90.
33. Ebru-Tirali R, Bodur H, Ece G. In vitro antimicrobial activity of sodium hypochlorite, chlorhexidine gluconate and octenidine dihydrochloride in elimination of microor-ganisms within dentinal tubules of primary and permanent teeth. Medicina Oral Patología Oral Y Cirugia Bucal. 2012:e517–22. Available:https://doi.org/10.4317/medoral.17566
34. de Lucena JMVM, Decker EM, Walter C, Boeira LS, Löst C, et al. Antimicrobial effectiveness of intracanal medicaments on Enterococcus faecalis: Chlorhexidine versus octenidine. International Endodontic Journal. 2013;46:53–61. Available:https://doi.org/10.1111/j.1365-2591.2012.02093.x
35. Eldeniz AU, Guneser MB, Akbulut MB. Comparative antifungal efficacy of light-activated disinfection and octenidine hydrochloride with contemporary endodontic irrigants. Lasers Med Sci. 2015;30:669–75.
36. Guneser MB, Akbulut MB, Eldeniz AU. Antibacterial effect of chlorhexidine-cetrimide combination, Salvia officinalis plant extract and octenidine in comparison with conventional endodontic irrigants. Dent Mater J. 2016;35:736–41.
37. Cherian B, Gehlot PM, Manjunath MK. Comparison of the antimicrobial efficacy of octenidine dihydrochloride and chlorhexidine with and without passive ultrasonic irrigation - An invtro study. J Clin Diagn Res. 2016;10:ZC71–7.
38. Varghese VS, Uppin V, Bhat K, Pujar M, Hooli AB, Kurian N. Antimicrobial efficacy of octenidine hydrochloride and calcium hydroxide with and without a carrier: A broth dilution analysis. Contemp Clin Dent. 2018;9:72–6.

39. Hübner N-O, Siebert J, Kramer A. Octenidine dihydrochloride, a modern antiseptic for skin, mucous membranes and wounds. Skin Pharmacol Physiol. 2010;23:244–58.

40. Beiswanger BB, Mallatt ME, Mau MS, Jackson RD, Hennon DK. The clinical effects of a mouthrinse containing 0.1% octenidine. J Dent Res. 1990;69:454–7.

41. Mutters NT, Neubert TR, Nieth R, Mutters R. The role of Octenidol®, Glandomed® and chlorhexidine mouthwash in the prevention of mucositis and in the reduction of the oropharyngeal flora: A double-blind randomized controlled trial. GMS Hyg Infect Control. 2015;10:Doc05.

42. Ghannoum MA, Elteen AK, Stretton RJ, Whittaker PA. Effects of octenidine and piritenidine on adhesion of Candida species to human buccal epithelial cells in vitro. Archives of Oral Biology. 1990;35:249–53. Available:https://doi.org/10.1016/0003-9969(90)90039-d

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