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# EVALUATION OF TURMERIC AND THYME AS ROOT CANAL IRRIGANTS ON PRIMARY TEETH

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## *ABSTRACT*

**Objectives:** To assess the antimicrobial effect of turmeric and thyme as root canal irrigants on *Enterococcus Faecalis* bacteria lives in primary teeth root canals. **Subjects and methods:** This study was carried out with informed consent, on fifty-four children suffering from non-vital primary molars indicated to pulpectomy and selected from Outpatient clinic of pedodontics and oral health department, Faculty of Dental Medicine, Al-Azhar University. Children′s teeth (54) were divided into three equal groups (18 eac): Group A: Molars roots of this group were irrigated with Turmeric solution. Group B: Molars roots of this group were irrigated with Thyme solution. Group C: Molars roots of this group were irrigated with sodium hypochlorite (NaOCl) solution (control group). Microbiological culturing and counting of *Enterococcus Faecalis* were done after The collection at baseline and post-treatment samples for each group. **Results:** NaOCl group had the highest antibacterial efficacy (83.4%) against E. faecalis, followed by Turmeric extract group (56.7%), then Thyme oil group (55.6%). **Conclusion:** NaOCl is still the irrigant of choice and has superior antibacterial effect than that of Turmeric and Thyme needs more investigation and additives to increase their efficacy.

**KEYWORDS**: Turmeric, Thyme, NaClO, E. Faecalis, root canal irrigation.

## INTRODUCTION

Dental caries is a complex, dynamic disease caused by biofilms that cause dental hard tissue demineralization. Dental caries can destroy the tooth crown and occurs throughout life in both primary and permanent dentitions [(1)].

Pulpectomy is complete removal of the pulp tissue. The purpose of pulpectomy is to sterilize the root canal. In primary teeth, biomechanical preparation is used not only to remove pulpal tissues but also reshape, clean and prepare the canal for endodontic filling. Because of the intricate root canals of primary teeth, it is impossible to remove all the residual tissue. Mechanical instrumentation alone is not adequate to clean this tubular network. To obtain better debridement, irrigants have been employed in conjunction with mechanical equipment [(2)].

Endodontic infections are polymicrobial in origin, however the anaerobic bacteria are the most common especially Enterococcus faecalis. The host's reaction to the microbial invasion is a mix of non-specific inflammatory mechanisms and a particular immunologic response. The removal of

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all bacteria from the root canal system is critical to the effectiveness of root canal treatment [3].

Irrigation of the root canals becomes an important aspect of chemomechanical preparation. In clinical practice, a variety of irrigating chemicals are used, depending on their antibacterial potency, cleaning efficiency, and biological compatibility. Although sodium hypochlorite (NaOCl) is considered an ideal root canal irrigant. It cannot be used at required concentrations because it has undesirable effects or limitations such as unpleasant taste/odor, toxicity, ineffectiveness in removing smear layer, and incomplete eradication of microbes from infected canals. Moreover, the use of NaOCl may produce significant pain, edema of adjacent soft tissues, ecchymosis, and paresthesia due to tissue response[4].

As a result, finding the best irrigating solution for endodontic therapy in primary and permanent teeth is still a working progress. Natural products, which were first used to treat elements many years ago, are now being seen as a viable alternative to commercially available chemical formulations [5].

Curcuma longa (turmeric) belongs to the Zingiberaeceae family and has been used as traditional medicine since antiquity [6].Curcumin (diferuloylmethane) is turmeric's major yellow bioactive component, and it has been proven to have anti-inflammatory, antioxidant, antibacterial, antifungal, antiprotozoal, and antiviral properties [7] .C. longa showed promising results in in the elimination of E. Faecalis which is one of the common organisms responsible for root canal failure. C. longa may be a good cost-effective alternative to all the historical intracanal medicaments with fewer side effects and least resistance developed by the species [8].

Thymus vulgaris (Thyme plant) is a perennial sub-shrub with small grey or green leaves. It is native to the Mediterranean region and is cultivated in many countries. Several studies showed that extracts from thyme have antimicrobial, anti-inflammatory and wound healing activities [9]. Thyme essence could be considered as a natural irrigator with a comparable antiseptic effect to sodium hypochlorite [10]. Annihilating the bacteria is the major object of performing pulpectomy, and many chemical irrigants are used to achieve this goal. Meanwhile, the urge to substitute medicinal plants for chemical irrigants is expanding, and thymus vulgaris essential oil could replace the conventional disinfectants in dentistry [11].

## SUBJECTS AND METHODS

### Study setting and population:

This study was performed on (54) children suffering from carious lesions in primary molars with pulp involvement. Patients were selected from the Pedodontics Outpatients Clinic, Faculty of Dental Medicine, Boys, Cairo, Al-Azhar University.

### Ethical consideration:

This study was approved by Ethical Committee Ref No. 518/2837 of Faculty of Dental Medicine, Boys, Cairo, Al-Azhar University. All parents signed an informed written consent form before treatment beginning.

### Sample size:

A sample size of (18) in each group has an 80% power to detect an increase of 0.38 with a significance level (alpha) of 0.05 (two-tailed). In 80% (the power) of those experiments, the p-value was less than 0.05 (two-tailed) so the results were deemed "statistically significant". In the remaining 20% of the experiments, the increase was deemed "not statistically significant" [12].

### Eligibility criteria of population :

The patients (3-8 years) were selected after preoperative radiographic and clinical evaluation. The teeth included in the study met all of the following inclusion criteria: primary teeth with necrotic canals; the teeth were infected with either abscess, sinus tract or obvious inter radicular radiolucency, patients who had not received antibiotics four weeks prior to microbial sampling.

We excluded from the study patients who met any of the following criteria: teeth with un-restorable crowns, presence of any systemic disorder, teeth with abnormal anatomy & calcified canals, teeth with evidence of extensive internal/ external pathological root resorption.

This study was undertaken on (54) primary molar teeth indicated for pulpectomy, the teeth were classified into three equal groups. Each group was formed of 18 teeth. The groups were classified according to received irrigant as follows:

**Group 1:** Teeth were received 20 mg/ml of Turmeric powder in absolute ethanol. Turmeric rhizomes were ground to form a coarse powder. Ethanolic extract of turmeric was prepared using (99%) purity turmeric powder (2gm) which was added to (100ml) of absolute ethanol (20mg/ml).

**Group 2:** Teeth received Thyme essential oil (2%). Fresh Thymus vulgaris were crushed and extracted by conventional steam distillation using a Clevenger apparatus for 3 hours. The essential oil was then dried over sodium sulfate and stored at 4°C in dark vials until use. The oil was diluted to 2 % using absolute ethanol (2 ml oil 98 + ml ethanol).

**Group 3:** Teeth were irrigated with sodium hypochlorite (2.5%) (Control group). Commercially available of sodium hypochlorite (5 %) was diluted to (2.5 %) using saline. All materials in three groups were prepared in the Faculty of Science, Sohag University.

**Sampling procedure:** [5]

The patients were instructed to rinse his/her oral cavity for 30s with 5ml povidone iodine. Patients were instructed not to take antimicrobial drugs at least one week before the treatment. After local anesthesia administration, rubber dam was placed, operative field including the tooth, clamp, and surroundings was cleaned with povidone iodine. A high-speed hand piece and sterilized round bur (330) under constant water coolant to remove all carious tissue and to access the root canals of primary teeth. The pulp tissue was extirpated. Then using sterile paper points the pre-irrigation sample was collected. Paper points were placed into the canal till the apical foramen and was moved circumferentially along the walls of the canal without being lifted, they were left for 1 minute in the canal. Then with sterile tweezers the paper points were removed from the root canal and immediately placed in nutrient broth medium.

The mechanical preparation using the files was performed. The canal's diameter was increased up. The canal was irrigated after each file size with respective solution of 5 ml related to each group of patients for about 30 seconds Then the canal was finally irrigated with 10 ml of the respective irrigant solution, the canals were dried with sterile paper points, the post-irrigation samples of the root canal contents were taken in the same manner as mentioned before. The samples were transferred immediately to the microbiological lab at Microbiology Department, Faculty of Medicine, Sohag University for culturing procedure.

**Observation:**

Two microbial samples from root canal of pulpectomized primary tooth before irrigation and post irrigation were taken and sent to bacterial lab for bacterial investigation and counting.

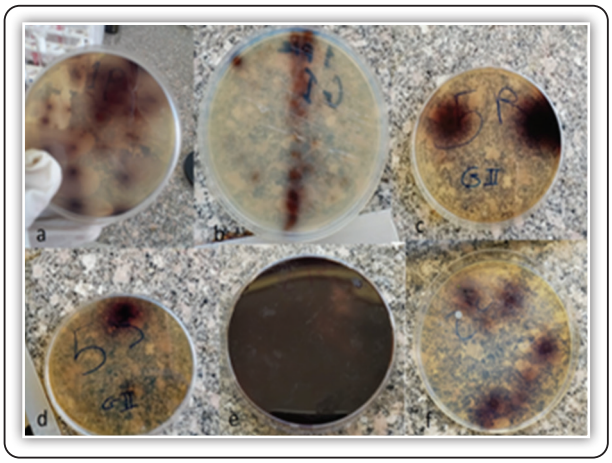


FIG (1) A photograph showing a bile-esculin after its inoculation with *E. Faecalis* For Turmeric Group; (a) pre-irrigation sample (b) post-irrigation sample, For Thyme Group; (c) pre-irrigation sample (d) post-irrigation sample, and For NaClO Group; (e) pre-irrigation sample (f) post-irrigation sample

**Data management and Statistical analysis:**

The collected data was revised, coded, tabulated, and analyzed using SPSS program software, version 22.0. Pearson Chi-Square test was applied to gauge the difference between categorical data. Paired t-test and ANOVA were used to compare between sample means for quantitative data with normal distribution. Statistical significance level was set at 5% ($p \leq 0.05$ is considered statistically significant).

## RESULTS

Children ages ranged from 3-8 y with mean age for group A (5.1), mean age for group B (4.8) and mean for group C (5.3). In comparison between ages of groups found that no significant difference.

Regarding jaw, in group A, (33.3%) teeth was in upper jaw, while (66.7%) was in lower jaw. In group B, (38.9%) teeth were in upper jaw, while (61.1%) was in lower jaw. In group C (44.4%) teeth was in upper jaw, and other (55.6%) was in lower jaw. There was no statistically significant difference between (Group A), (Group B) and (Group C) where (p-value=0.612).

Regarding Side**:** In group A, (55.6%) teeth was in right side, while (44.4%) was in left side. In group B, (44.4%) teeth were in right side, while (55.6%) was in left side. In group C, (61.1%) teeth were in right side, while (38.9%) was in left side. There was no statistically significant difference between (Group A), (Group B) and (Group C) where (p-value=0.411).

For group A (Turmeric), the mean was (19.50) before irrigation, while the mean was (8.44) after irrigation. There was a statistically significant difference between (Pre) and (Post) groups where (p=0.001).

For group B (Thyme), the mean was (19.78) before irrigation, while the mean was (8.78) after irrigation. There was a statistically significant difference between (Pre) and (Post) groups where (p=0.002).

For group C (Sodium hypochlorite) the mean was (25.39) before irrigation, while the mean was (4.22) after irrigation. There was a high statistically significant difference between (Pre) and (Post) groups where ($p<0.001$). Percentages of E. faecalis bacterial reduction after irrigation were 56.7, 55.6 & 83.4 for turmeric solution, thyme solution, and sodium hypochlorite respectively. There was no significance difference between groups.

The highest bacterial reduction was found in (Group C), followed by (Group A) while the least bacterial reduction was found in (Group B).

**TABLE (1)** Comparison of bacterial count between pre & post-treatment in all groups.

| Groups | Pre –treatment Mean±SD | Post-treatment Mean±SD | Paired t test |
|---|---|---|---|
| Group A | 19.50±13.49 | 8.44±7.84 | P=0.001* |
| Group B | 19.78±15.07 | 8.78±8.99 | P=0.002* |
| Group C | 25.39±18.69 | 4.22±5.77 | P<0.001** |
| Within group significance | P1=0.958<br>P2=0.272<br>P3=0.295 | P1=0.897<br>P2=0.104<br>P3=0.08 | |

**statistically significant*

***statistically highly significant*

*P1: difference between group A & B*

*P2: difference between group A& C*

*P3: difference between group B& C*

**TABLE (2):** Comparison of bacterial reduction percentage between all studied groups

| | **Group A** | **Group B** | **Group C** |
|---|---|---|---|
| **% Of reduction** | **56.7%** | **55.6%** | **83.4%** |
| **Paired t test** | **P1=0.947**<br>**P2=0.08**<br>**P3=0.07** | | |

**statistically significant*

*P1: difference between group A & B*

*P2: difference between group A& C*

*P3: difference between group B& C*

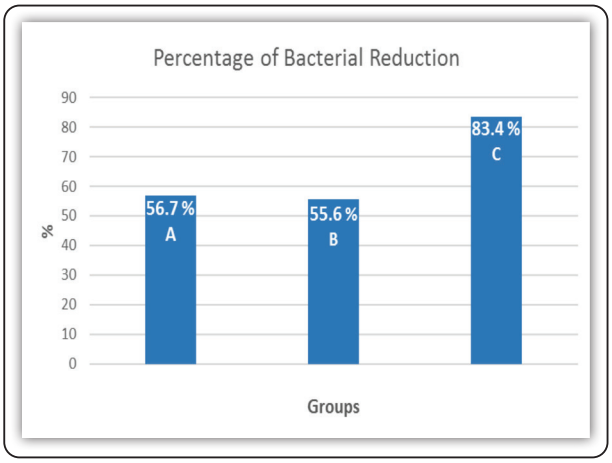


FIG (2) Percentage of bacterial reduction in all groups

## DISCUSSION

The success of endodontic therapy in primary teeth strongly depends on achieving an adequate level of disinfection within their root canals. Mechanical instrumentation alone is unlikely to be sufficient in attaining such disinfection, considering the root resorption process and the complex anatomy of the root canal system, characteristic of primary molars, and the risk of damage to the permanent germ [13].

For primary teeth, root canal irrigation is an important aspect of non-vital pulp treatment. The shape and irregularity of primary teeth hinder the selection of an irrigating solution for root canals [14]. Studies on root canal microbiota in primary teeth found that anaerobic microorganisms were the most common microorganisms in the root canals of primary teeth with necrotic pulp and periapical lesions, accounting for over 70% of the microbiota in the root canals of primary molars that had been treated unsuccessfully [14,15].

A favorable outcome of endodontic treatment of teeth with apical periodontitis depends on effective control of root canal infection. Enterococcus faecalis has been the focus of interest in endodontics in recent years because of its high prevalence of occurrence in persistent lesions [16].

E. faecalis is the most isolated microorganism from the root canals of failed endodontic cases. It has several virulence characteristics that allow it to live and thrive as a pathogen in root canals. It can live as a solitary organism or as a large component of the flora in the root canal. As a result, E. faecalis was chosen as the study's test organism [17].

NaOCl is employed as an appropriate irrigator for endodontically-treated tooth. It is efficient against various bacteria and can solve necrotic pulp tissues. However, it has a number of drawbacks, including toxicity to periapical tissues, difficulty to eliminate smear layer, changes in the physical structure of canal dentin, unpleasant odour and taste. Also it can harm permanent tooth follicles, peripheral tissues, and the oral mucosa when used in the root canal treatment of deciduous teeth [18].

Due to the adverse effects and safety problems of conventional medication, phytotherapeutics or ethnopharmacology is now the recommended strategy. The main benefits of herbal irrigants are their simplicity of use, longer shelf life, cost effectiveness, and lack of germ resistance [19].

Herbal extracts offer the advantages of having minimal adverse effects, being inexpensive, being better tolerated by patients, and being renewable. Active components in herbal extracts such as triphala, curcuma longa, acacia nilotica, and morinda citrifolia include alkaloids, volatile essential oils, glycosides, resins, tannins, and other compounds that have antibacterial, anti-inflammatory, and antioxidant effects [20].

Fifty-four primary molar teeth were randomly classified according to irrigant used into 3 equal groups to examine the impact of turmeric extract, thyme oil, and sodium hypochlorite against Faecalis. Percentages of E. faecalis bacterial reduction after irrigation were 56.7, 55.6 & 83.4 for turmeric solution, thyme solution, and sodium hypochlorite respectively. However although NaClO recorded the highest level of bacterial reduction, there was no statistically significant difference.

Absolute ethanol was not chosen as one of the groups in this investigation since earlier research has shown that it produces no zones of inhibition[21-23].

For NaOCl group the ratio of decreased colonial numbers was 83.4%, with higher colonial number decreasing ratio rather than other groups. The researchers discovered that the NaClO group had the best antibacterial activity against E. faecalis, making it far superior to turmeric and thyme. The high antibacterial activity of sodium hypochlorite against E. faecalis is due to its high pH, which disrupts cytoplasmic membrane integrity, causing irreversible enzymatic inhibition and biosynthetic changes in cellular metabolism through the formation of chloramines and phospholipid destruction [24].

This is in agreement exactly with the findings of Tulsani et al, [25], who found that NaClO 2.5% was effective against E. faecalis in necrotic primary anterior teeth.

The Turmeric group had a 56.7% decline in colonial populations. Turmeric's antibacterial impact is assumed to be due to the antibacterial action of Curcumin, one of the components responsible for its biologic activity. Curcumin inhibits bacterial cytokinesis by causing filamentation to form. It also dramatically reduces the production of cytokinetic Z-rings in bacteria without impacting nucleoid segregation and organization. It inhibits the assembly dynamics of FtsZ, an important cell division protein that creates a contractile ring structure (Z ring) at the future cell division site, which slows bacterial cell growth [26].

The current findings are compatible with those of another study by Neelakantan et al, [27,28] ,who assessed the antibacterial efficacy of turmeric and determined that the primary active component of turmeric, curcumin, inhibited bacteria completely.

Turmeric extract demonstrated antibacterial efficiency against E. faecalis in this investigation, and these findings are in agreement with those of Sinha et al [29], who found that turmeric extract had an antibacterial impact against E. faecalis, another study found that turmeric had superior zones of inhibition against E. faecalis [30].

For Thyme group the ratio of decreased colonial numbers was 55.6% with the least percentage of bacterial reduction between groups. Thyme was used in this investigation because it had antibacterial properties against E. faecalis. Thymus vulgaris oil's antibacterial action is mostly due to its phenolic components thymol and carvacrol. The hydroxyl group on these two compounds is thought to interact with the cytoplasmic membrane, changing its permeability and affecting the lipid ordering and stability of its bilayer, leading to an increase in proton passive flux across the membrane, resulting in cytoplasmic membrane disruption and cellular contents leakage [31].

The findings of this study are in agreement with those of Heidari et al [32] who indicated that Thyme oil (2%) might be used as a natural irrigator with an antiseptic efficacy equivalent to sodium hypochlorite against E. faecalis, another study was confirmed by Jafari et al [33] who found Thymus vulgaris oil to be antibacterial against E. faecalis.

Thymus vulgaris extract showed high antibacterial activity against E. faecalis and can be used as a substitute for NaOCl, according to Gupta et al[34], another research found that varied amounts of thyme oil inhibited the development of E. faecalis[35]

## CONCLUSION

Within the constraints of this investigation, it may be stated that: Although, Turmeric and Thyme irrigant solutions exhibit significant bacterial reduction of E. faecalis, further investigation is needed before usage as root canal irrigant. Moreover, 2.5% sodium hypochlorite irrigant solution was superior to Turmeric and Thyme, without significant difference between them.

## REFERENCES


1. Nigel B Pitts , Domenick T Zero, Phil D Marsh, Kim Ekstrand, Jane A Weintraub , Francisco Ramos-Gomez , Junji Tagami , Svante Twetman , Georgios Tsakos , Amid Ismail. Dental caries. Nat Rev Dis Primers, 2016 ;25;1730.
2. Murvindran V, Raj J. Antibiotics as an Intracanal Medicament in Endodontics. J Pharm Sci Res 2014:297-301.
3. Shingare P, Chaugule V. Comparative evaluation of antimicrobial activity of miswak, propolis, sodium hypochlorite and saline as root canal irrigants by microbial culturing and quantification in chronically exposed primary teeth .NCBI 2011:12-21.
4. Basrani B, Haapasalo M. Update on endodontic irrigating solutions. Endod Top 2015:74-102.
5. Verma M , Pandey R , Khanna R , Agarwal J. The antimicrobial effectiveness of 25% propolis extract in root canal irrigation of primary teeth. J Indian Soc Pedod Prev Dent 2014:120-24.
6. Chaturvedi TP. Uses of turmeric in dentistry –an update. Indian J Dent Res 2009:107-09.
7. Neelakantan P, Subbarao C, Subbarao V. Analysis of Antibacterial Activity of Curcumin against Enterococcus faecalis. Int J Curr Res Rev 2011: 37-42.
8. Hemanshi K ,An in vitro evaluation of the antimicrobial efficacy of Curcuma longa, Tachyspermum ammi, chlorhexidine gluconate, and calcium hydroxide on Enterococcus faecalis, J Conserv Dent. 2013: 144–47.
9. Shabnum S. Essential oil composition of thymus vulgaris L. and their uses. J Res Dev 2011: 83–94.
10. Ahmad Jafari1 , Comparative evaluation of antiseptic effects of sodium hypochlorite 2.5%, thyme essence 2% and normal salins in root canal irrigation of primary teeth, Journal of Dental Medicine-Tehran University of Medical Sciences 2014:161-67.
11. Ali Reza Heidari, Evaluation of antimicrobial effect of chlorhexidine and two different concentrations of thyme essence in pulp therapy of deciduous teeth Iranian Journal of Pediatric Dentistry 2015:119-35.
12. Agarwal S, Tyagi P, Deshpande A, Yadav S, Jain V, et al. Comparison of antimicrobial efficacy of aqueous ozone, green tea, and normal saline as irrigants in pulpectomy procedures of primary teeth. J Indian Soc Pedod Prev Dent 2020:164-70.
13. Kargul B, Tanboga I, Altinok B. Conventional ∈ endodontic treatment of primary molars using Metronidazole as an intra-canal medicament: a pilot study. Eur Arch Paediatr Dent 2010; 11: 196– 200
14. Verma MK, Pandey RK, Khanna R, Agarwal J. The antimicrobial effectiveness of 25% propolis extract in root canal irrigation of primary teeth. Journal of Indian Society of Pedodontics and Preventive Dentistry. 2014 1;32(2):120.
15. Toyoshima Y, Fukushima H, Inoue JI, Sasaki Y, Yamamoto K, Katao H, et al. A bacteriological study of periapical pathosis on deciduous teeth. Shoni Shikagaku Zasshi 1988;26:449-58
16. Saha S, Nair R, Asrani H. Comparative Evaluation of Propolis, Metronidazole with Chlorhexidine, Calcium Hydroxide and Curcuma Longa Extract as Intracanal Medicament Against E. faecalis–An Invitro Study. Journal of clinical and diagnostic research: JCDR. 2015,9(11):19-21
17. Sinha DJ, Vasudeva A, Jaiswal N, Garg P, Tyagi SP, Singh J. Antibacterial efficacy of Melaleuca alternifolia (Tea tree oil), Curcuma longa (Turmeric), 2% chlorhexidine, and 5% sodium hypochlorite against Enterococcus faecalis: An in vitro study. Saudi Endod J 2015;5:182-6
18. Nara A, Dhanu, Chandra P, Anandakrishna L, Dhananjaya. Comparative Evaluation of antimicrobial efficacy of MTAD, 3% NaOCl and Propolis against E. faecalis. Int J Clin Ped Dent 3:21-25, 2010
19. Pratishta J, Ranjan M. Role of herbs in root canal irrigation-A review. IOSR J Pharm Biol Sci 2014;9:6-10
20. Vinothkumar TS, Rubin MI, Balaji L, Kandaswamy D. In-vitro evaluation of five different herbal extracts as an antimicrobial endodontic irrigant using real time quantitative polymerase chain reaction. J Conserv Dent. 2013;16(2):167-70
21. Ghonmode WN, Balsaraf OD, Tambe VH, Saujanya KP, Patil AK, Kakde DD. Comparison of the antibacterial efficiency of neem leaf extracts, grape seed extracts and 3% sodium hypochlorite against E. feacalis–An in vitro study. Journal of international oral health: JIOH. 2013 5(6):61.
22. Sinha DJ, Vasudeva A, Jaiswal N, Garg P, Tyagi SP, Singh J. Antibacterial efficacy of Melaleuca alternifolia (Tea tree oil), Curcuma longa (Turmeric), 2% chlorhexidine, and 5% sodium hypochlorite against Enterococcus faecalis: An in vitro study. Saudi Endod J 2015;5:182-6
23. Saxena D, Saha SG, Saha MK, Dubey S, Khatri M. An in vitro evaluation of antimicrobial activity of five herbal extracts and comparison of their activity with 2.5% sodium hypochlorite against Enterococcus faecalis. Indian J Dent Res 2015;26:524-7
24. Byström A, Sundqvist G. Bacteriologic evaluation of the effects of 0.5% sodium hypochlorite in endodontic therapy. Oral Surg Oral Med Oral Pathol. 1983; 55:307-312

25. Tulsani SG, Chikkanarasaiah N, Bethur S. An in vivo comparison of antimicrobial efficacy of sodium hypochlorite and Biopure MTAD™ against enterococcus faecalis in primary teeth: A qPCR study. Journal of Clinical Pediatric Dentistry. 2014 Sep 1;39(1):30-4.
26. Rai D, Singh JK, Roy N, Panda D. Curcumin inhibits FtsZ assembly: an attractive mechanism for its antibacterial activity. Biochem J 2008;410:147–55.
27. Neelakantan P, Subbarao C, Sharma S, Subbarao CV, Garcia-Godoy F, Gutmann JL. Effectiveness of curcumin against Enterococcus faecalis biofilm. Acta Odontologica Scandinavica. 2013 1;71(6):1453-7.
28. Neelakantan P, Subbarao C, Subbarao CV. Analysis of antibacterial activity of curcumin against Enterococcus faecalis. Int J Curr Res Rev. 2011;3:37-42
29. Sinha DJ, Vasudeva A, Jaiswal N, Garg P, Tyagi SP, Singh J. Antibacterial efficacy of Melaleuca alternifolia (Tea tree oil), Curcuma longa (Turmeric), 2% chlorhexidine, and 5% sodium hypochlorite against Enterococcus faecalis: An in vitro study. Saudi Endodontic Journal. 2015 1;5(3):182
30. Chaitanya BV, Somisetty KV, Diwan A, Pasha S, Shetty N, Reddy Y, Nadigar S. Comparison of antibacterial efficacy of turmeric extract, morinda citrifolia and 3% sodium Hypochlorite on Enterococcus faecalis: An In-vitro Study. Journal of clinical and diagnostic research: JCDR. 2016 (10):55-57
31. Ahmad A, Vuuren SV, Viljoen A. Unraveling the complex antimicrobial interactions of essential oils—the case of Thymus vulgaris (thyme). Molecules. 2014; 19:2896–2910.
32. Heidari AR. Comparative evaluation of antiseptic effects of sodium hypochlorite, thyme essence and normal salin in root canal irrigation of primary teeth. Journal of Dental Medicine. 2014;27(3):161-67
33. Jafari A, Heidari A, Kiyani M, Baradaran Nakhjavani Y. Evaluation of antimicrobial effect of chlorhexidine and two different concentrations of thyme essence in pulp therapy of deciduous teeth. Iranian Journal of Pediatric Dentistry. 2015 Aug 10;10(2):35-44.
34. Gupta D, Kamat S, Hugar S, Nanjannawar G, Kulkarni R. A comparative evaluation of the antibacterial efficacy of Thymus vulgaris, Salvadora persica, Acacia nilotica, Calendula arvensis, and 5% sodium hypochlorite against Enterococcus faecalis: An in-vitro study. J Conserv Dent. 2020;23(1):97-101.
35. Al-Badr RJ, Al-Huwaizi HF. Effect of Tea Tree, Thymus Vulgaris and Nigella Sativa Oils on The Elimination of Enterococcus Faecalis (In Vitro Study). Journal of baghdad college of dentistry. 2017 Mar 13;29(1):55-62.