ORIGINAL RESEARCH

Comparison of Antimicrobial Efficacy of *Morinda citrifolia*, Triphala, and *Camellia sinensis* Extracts as Root Canal Irrigants in Primary Molars: A Randomized Clinical Trial

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Abstract

Objective: To evaluate the reduction of microbial loading using *Morinda citrifolia (M. citrifolia)*, *Triphala,* and *Camellia sinensis (C. sinensis)* as irrigating agents in deciduous molars after pulpectomy.

Materials and methods: A controlled, randomized clinical trial involving 150 multirooted deciduous molars from both genders between 6 and 9 years old children were included, 30 molars irrigated with *M. citrifolia* (group I), Triphala (group II), *C. sinensis* (group III), chlorhexidine (CHX) (group IV), and saline (group V) each. In all cases, two microbiological samples from within the canal were taken with sterile paper points, one before the first irrigation and the other immediately after pulp extirpation. Cleaning and shaping were completed with intermittent irrigation with 10 mL of experimental irrigants in the initial visit. After 3 days, reentry to the root canal was obtained, rinsed with 5 mL of the test irrigants, and the second microbial sample was collected. All the microbial samples obtained were cultured under anaerobic conditions on blood agar. The colony-forming units (CFUs) were counted using a colony counter. Data was analyzed using paired student *t*-test and Tukey's *post hoc* test.

Results: After analysis of the pre- and postsamples in all groups, a strong significant decrease in bacterial load ($p \leq 0.001$) was found with CHX, *M. citrifolia*, and Triphala.

Conclusion: *Morinda citrifolia (M. citrifolia)* and *Triphala,* with effective antimicrobial efficacy, can be suggested as an alternative root canal irrigant as CHX, while *C. sinensis* was found ineffective in reducing microbial count as normal saline.

Keywords: *Camellia sinensis*, Deciduous molar, *Morinda citrifolia*, Triphala.

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Introduction

Maintaining the health of primary teeth is crucial for the balanced development of occlusion, retention of proper arch length, optimal mastication function, clear speech, and the overall preservation of the stomatognathic system. Pediatric endodontic treatment's focus is on sustaining the viability of primary teeth, recognizing their pivotal role in overall oral development, and fostering an environment conducive to the successful emergence of permanent teeth.[1] The constant increase in resistant microbial strains and the hazards associated with the accidental swallowing of synthetic irrigants have increased the need for biocompatible alternatives in endodontic treatment. Several herbal products have been tried as irrigants for the root canal system. The surge in popularity of herbal or natural products in contemporary times can be attributed to their notable qualities like their robust antimicrobial properties, high biocompatibility with minimized risk of adverse reactions, and further added with anti-inflammatory and antioxidant properties.[2,3]

Morinda citrifolia (M. citrifolia) (noni or Indian mulberry) has a wide range of therapeutic effects and is biocompatible, so it is not likely to cause severe injuries like sodium hypochlorite (NaOCl) accidents. Its extract contains antibacterial compounds like alizarin and L-asperuloside with additional anticancer, antioxidant, anti-inflammatory, and analgesic properties.[4]

Triphala is a traditional medicine constituting a mixture of three plant extracts, namely *Terminalia chebula*, *Terminalia bellirica*, and *Emblica officinalis*. It possesses excellent antibacterial and anti-inflammatory properties. Its fruit's citric acid content, combined with tannins, quinones, flavonoids, gallic acid, and vitamin C, makes it well-suited for efficiently removing the smear layer.[5]

White tea, derived from *Camellia sinensis (C. sinensis)*, represents an unfermented tea crafted from the fresh growth buds and young leaves of the plant. Due to the absence of oxidation in its processing, white tea boasts the highest content of antioxidants and catechins while containing the least amount of caffeine. This tea is characterized by a pale color and a subtle, sweet taste. Its composition primarily includes fluoride, tannins, and flavonoids.[6]

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Nevertheless, the impact of *M. citrifolia*, Triphala, and *C. sinensis* as endodontic irrigants in deciduous molars remains unexplored. Thus, this current study was undertaken to assess the reduction in bacterial load following the application of commercially available *M. citrifolia* juice, Triphala juice, and *C. sinensis* as irrigating solutions in primary teeth. The objective is to compare these outcomes with those achieved using chlorhexidine (CHX) and normal physiological saline.

Materials and Methods

This research, spanning 24 weeks, took place at the Department of Pediatric and Preventive Dentistry in Rungta College of Dental Sciences and Research, Bhilai, Chhattisgarh, India. The study protocol received approval from the Institutional Ethical Committee (RCDSR/IEC/MDS/2018/07). The investigation focused on individuals seeking routine endodontic therapy in the Department of Pediatric and Preventive Dentistry. Participation was voluntary, ensuring the participants' anonymity. Prior to the study, written informed consent was obtained from the subjects' parent/guardian. Stringent measures were in place to maintain the confidentiality of collected data.

Screening for the study involved patients who presented for routine endodontic therapies at the Department of Pediatric and Preventive Dentistry. After a thorough clinical and radiographic examination, a total of 183 patients aged 6–9 years were included in the research.

Sample Size Estimation

The determination of the sample size was based on insights from a pilot study that involved 25 microbiological samples extracted from multirooted teeth. These samples, five for each irrigating solution, were excluded from the final study. G*Power software (version 3.0) was utilized to estimate the sample size. A total of 150 samples (30 per group) were deemed adequate, considering an α of 0.05, power of 95%, and effective size (difference in percentage reduction in bacterial colony counts from preirrigation to postirrigation) set at 0.6. The unweighed κ-test was employed to assess intraexaminer variability yielding a score of 0.85.

Inclusion Criteria

Included in the study were patients with unremarkable medical histories, multirooted primary molars retaining a minimum of two-thirds of their roots, deemed suitable for pulpectomy. Furthermore, eligible cases were those clinically and radiographically diagnosed with at least one of the following conditions: necrotic pulp canal, abscess, or sinus tract. The presence of sufficient coronal structure was also a prerequisite to ensure proper facilitation of isolation, temporization, and restoration.

Exclusion Criteria

Patients with systemic illnesses were not considered for inclusion in the study. Also, patients with endodontically treated teeth, patients on antibiotic therapy within 3 months of selection, teeth with perforated pulpal floor, periapical pathology with excessive root resorption, acute periapical abscess, and excessive tooth mobility were excluded.

Study Design

Sampling Procedure

The selected patients were randomized nonprobablistically using a lottery method to implement a random allocation sequence, thereby assigning participants to intervention in a 1:1:1 ratio. Flowchart 1 depicts the flowchart of complete consolidated data of the present study.

A total of 150 teeth were randomly assigned to five groups, each containing 30 samples.

Group I (30 multirooted teeth): *M. citrifolia*
Group II (30 multirooted teeth): Triphala
Group III (30 multirooted teeth): *C. sinensis*
Group IV (30 multirooted teeth): CHX
Group V (30 multirooted teeth): Saline

Preclinical Laboratory Procedure

Thioglycolate broth serves as both transport and growth media, preserving the vitality of bacterial samples. To prepare the broth, 30.05 gm of thioglycolate particles were suspended in 1000 mL of distilled water and boiled to dissolve the particles. The resulting broth was autoclaved at 121°C and 15 psi for 30 minutes. The necessary quantity was then transferred to a sterilized test tube with an airtight seal to prevent spillage and contamination.[7]

Isolation and Operatory Field Disinfection

All dental procedures on the teeth were conducted by a sole operator. A preoperative radiograph was taken using a standardized parallel cone technique. To achieve oral cavity antisepsis, the patient was instructed to rinse with 0.12% CHX for 60 seconds. Local anesthesia for mandibular and maxillary primary molars was induced using lignocaine containing 1:80,000 adrenaline (Lignox, Warren, Mumbai, India), administered through either an inferior alveolar nerve block or buccal and palatal infiltration. The tooth surface was cleansed with pumice and isolated with a rubber dam. The operatory field underwent disinfection by swabbing with 30% hydrogen peroxide, followed by 5% povidone-iodine tincture for 3 minutes to eliminate surface contaminants. Both solutions were subsequently neutralized with a 5% sodium thiosulfate solution.

Clinical Procedure

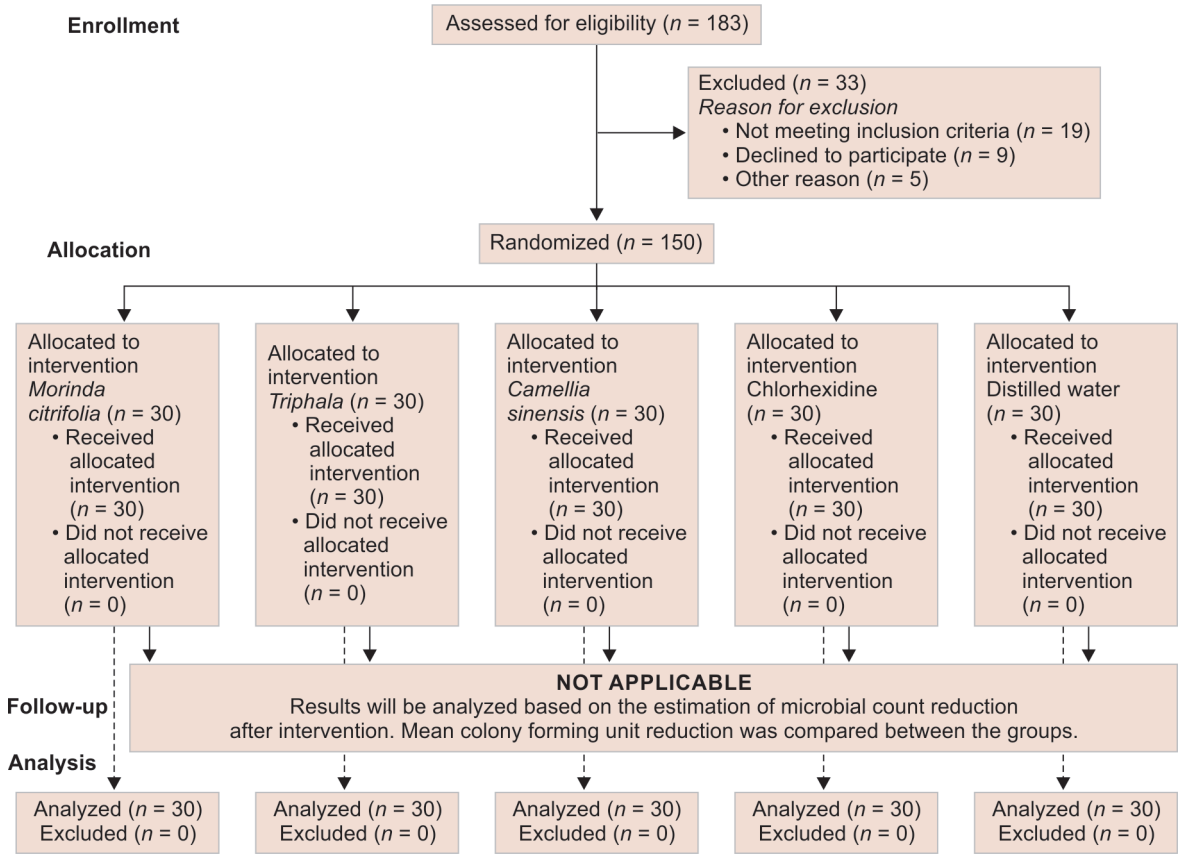
Carious tissue was eliminated using a sterile round diamond bur(BR 41: Prima Dental India (P) Limited, India). An autoclaved high-speed air rotor was used, and the cavity wall and operating field were disinfected, as mentioned above. Another new bur (BR 41: Prima Dental India (P) Limited, India) was used to access the pulp chamber. Then, the pulpal roof was removed using Predator safe-ended tip diamond burs (165-014: Prima Dental India (P) Limited, India), and the coronal pulp was removed. Root orifices were overlaid with a small cotton pellet to avoid penetration of disinfectants, and disinfection of the pulp chamber was achieved.

Collection of Microbiological Samples

The length of the canal was estimated arbitrarily based on the preoperative intraoral radiograph. Following the exposure of root orifices, canals were accessed using a #10 size K file (Mani, Inc., Tochigi, Japan) under aseptic conditions. The initial pretreatment root canal culture sample (sample no: 1) was obtained with sterile paper points placed in either the palatal canal of maxillary molars or the distal canal of mandibular molars for one minute. The sample was immediately transferred into 10 mL thioglycolate broth for microbial culture and transported within 10 minutes for anaerobic culturing.

After the first sample, the working length was established using Ingle's radiographic method. Cleaning and shaping were performed with traditional stainless steel 0.02 taper K files (Mani,

Flowchart 1: Consolidated standards of reporting trials flowchart



Inc., Tochigi, Japan) up to size #30. A 10 mL solution of the respective test group *M. citrofilia* (Kapiva Ayurveda, Adret Retail, India); Triphala (Morpheme Remedies, India); *C. sinensis* (Teamonk Global, India); CHX (Prevest Den Pro, India); and saline was intermittently irrigated during canal instrumentation using a sterile disposable 27-gauge needle attached to a luer-loc disposable syringe. After completing root canal preparation, 5 mL of the same respective irrigant was used as a final rinse. The canals were dried, sterile cotton was placed, and the access cavity was sealed with Cavit™ (3M ESPE AG, Germany) as an intermediate restorative material.

The patient was recalled after 3 days to obtain a postirrigation sample. The canals were reaccessed and rinsed with 5 mL of the respective test solutions, and the second sample was collected using sterile paper points. Following the second sample collection, the teeth were conventionally obturated using Metapex (META-BIOMED CO., LTD., Korea) and restored with Fuji 9 glass ionomer cement (GC Europe, Leuven, Belgium), followed by stainless steel crown cementation.

Laboratory Procedures

Aerobic culturing technique: The pre- and postoperative samples were promptly transferred into 10 mL of thioglycolate broth within 10 minutes. Subsequently, the samples underwent vortex mixing for 1 minute. Undiluted samples were then inoculated onto blood agar plates (MP1301; HiMedia Laboratories Private Limited, Mumbai, India) using sterile spreaders and were incubated at 37°C for 24 hours. Bacterial growth was quantified as colony-forming units (CFUs) through a manual counting technique.[8]

Anaerobic Culturing Technique

To create an anaerobic environment, the lids of the test tubes were slightly opened, and paper points were promptly inserted into 10 mL thioglycolate broth. These samples were transported immediately to the microbiological lab within 10 minutes. The pre- and postoperative samples in 10 mL thioglycolate broth underwent vortex mixing for 1 minute. For anaerobic incubation, undiluted samples were inoculated onto basal agar plates (M1635; HiMedia Laboratories Pvt. Ltd., Mumbai, India), placed in a GasPak jar, and incubated for up to 72 hours. The growth was observed in each medium after the respective incubation period. Colonies were counted the following day using a microbial colony counter (LA 660, HiMedia Laboratories Pvt. Limited, Mumbai, India).

Statistical Analysis

The acquired data was organized into a table, and statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, Illinois, United States of America) version 17 for Windows. A paired *t*-test was conducted to identify intragroup significance in the reduction of bacteria from the preoperative sample to the postoperative sample. For intergroup comparison, a *post hoc* test was employed. Significance was evaluated at a 5% level of significance.

Results

A total of 150 pulpectomized teeth were addressed in pediatric patients with an average age of 7.6 years. A total of 300

microbiological samples were collected, comprising 60 samples from each group (30 preoperative and 30 postoperative samples). The basal bacterial growth in preirrigation samples exhibited similarity across all groups on both agar media ($p > 0.05$), with colony counts ranging between 138 and 147 CFU/mL. The intragroup comparison of CFUs in blood agar media and anaerobic basal agar media reveals a statistically significant reduction of bacteria observed in CHX (97.29–97.91%), Triphala (93.08–95.15%), and *M. citrifolia* (83.61–85.22%) groups from preirrigation count to postirrigation count (Tables 1 and 2). Least reduction was noticed with saline (34.24–35.16%) and *C. sinensis* (23.99–44.8%), with no significant difference between pre- and posttreated bacterial counts. CHX showed the highest microbial reduction, followed by Triphala and *M. citrifolia*. The least microbial reduction was reported with *C. sinensis* and saline.

Upon conducting pairwise comparisons using Tukey's *post hoc* test, a noteworthy difference emerged between each group on both agar media ($p < 0.05$), except for the bacterial counts between the *C. sinensis* and saline groups in blood agar media ($p = 0.965$) (Table 3).

Follow-up

All 150 pulpectomized molars across the various groups underwent a comprehensive one-year follow-up. Clinical assessments included a thorough review of pain history, tenderness to palpation/percussion, pathological mobility, swelling, and/or sinus opening. Radiographic evaluations involved examining the presence or absence of furcation/periapical radiolucency, any disruption in lamina dura, pathological external or internal root resorption, or pulpal obliteration.[9] Remarkably, no failures were observed in any of the groups throughout the 3-, 6-, 9-, and 12-month follow-up periods, both clinically and radiographically.

Discussion

Utilizing mechanical instrumentation alone results in a 50% reduction during the pulpectomy procedure. The subsequent flushing action of irrigating solutions can enhance bacterial count reduction to 90% in root canals.[10] However, the degree of reduction depends on various factors, including the volume

Table 1: Intragroup comparison of overall mean pre- and postoperative CFUs/mL in *M. citrifolia*, Triphala, *C. sinensis*, CHX, and saline groups on blood agar media

Irrigant		*Mean (CFU/mL) ± standard deviation*	*N*	*Mean difference ± standard deviation (CFU/mL) (i – j)*	*Percentage of reduction*	*t-value*	*p-value*
MC	Pre (i)	138.53 ± 41.34	30	115.83 ± 5.76096	83.61%	39.759	0.03#
	Post (j)	22.70 ± 12.94					
Triphala	Pre (i)	143.10 ± 27.03	30	133.20 ± 3.42419	93.08%	34.227	0.002*
	Post (j)	09.90 ± 11.56					
C. sinensis	Pre (i)	139.10 ± 27.79	30	33.37 ± 3.31506	23.99%	31.784	0.18$
	Post (j)	105.73 ± 12.63					
CHX	Pre (i)	140.46 ± 26.02	30	136.66 ± 2.89007	97.29%	40.022	0.001*
	Post (j)	03.80 ±12.54					
Saline	Pre (i)	146.90 ± 26.54	30	34.24 ± 2.01014	23.31%	19.020	0.35$
	Post (j)	112.66 ± 26.79					

Statistical test, paired *t*-test; $, nonsignificant ($p > 0.05$); #, significant ($p < 0.05$); *highly significant ($p < 0.001$); *N* = number of samples, CFU/mL, colony-forming unit per milliliter; CHX, chlorhexidine

Table 2: Intragroup comparison of overall mean pre- and postoperative CFUs/mL in *M. citrifolia*, Triphala, *C. sinensis*, CHX, and saline groups on anaerobic basal agar media

Irrigant		*Mean (CFU/ mL) ± standard deviation*	*N*	*Mean difference ± standard deviation (CFU/mL) (i – j)*	*Percentage of reduction*	*t-value*	*p-value*
M. citrifolia	Pre (i)	141.00 ± 39.81	30	120.17 ± 5.31039	85.22%	30.181	0.04#
	Post (j)	20.83 ± 12.53					
Triphala	Pre (i)	133.76 ± 29.04	30	127.16 ± 3.49461	95.15%	32.593	0.002*
	Post (j)	06.5 ± 12.41					
C. sinensis	Pre (i)	146.80 ± 30.13	30	44.8 ± 3.29172	30.51%	35.179	0.23$
	Post (j)	102.00 ± 14.21					
CHX	Pre (i)	137.20 ± 31.32	30	134.34 ± 4.10784	97.91%	26.859	0.001*
	Post (j)	02.86 ± 13.01					
Saline	Pre (i)	139.76 ± 38.24	30	35.16 ± 1.76497	25.16%	19.925	0.44$
	Post (j)	104.60 ± 37.63					

Statistical test, paired *t*-test; [$, nonsignificant ($p > 0.05$); #, significant ($p < 0.05$); *highly significant ($p < 0.001$)]; *N*, number of samples, CFU/mL, colony-forming unit per milliliter; CHX, chlorhexidine

Table 3: Pairwise intergroup comparison of mean reduction in the bacterial count on Blood agar media and anaerobic basal agar media

	Blood agar			*Anaerobic basal agar*		
Pairwise comparison	*Difference in reduction (CFU/µL)*	*95% CI*	*p-value*	*Difference in reduction (CFU/µL)*	*95% CI*	*p-value*
MC vs Triphala	17.37	14.73–20.01	0.0000	6.99	4.30–9.68	0.0000
MC vs CS	−82.46	−85.10 to −79.82	0.0000	−75.37	−78.06 to −72.68	0.0000
MC vs CHX	20.83	18.19–23.47	0.0000	14.17	11.48–16.86	0.0000
MC vs saline	−81.83	−84.47 to −79.19	0.0000	−85.01	−87.70 to −82.32	0.0000
Triphala vs CS	−99.83	−102.47 to −97.19	0.0000	−82.36	−85.05 to −79.67	0.0000
Triphala vs CHX	3.46	0.82–6.10	0.0036*	7.18	4.49–9.87	0.0000
Triphala vs saline	−99.20	−101.84 to −96.56	0.0000	−92.00	−94.69 to −89.31	0.0000
CS vs CHX	103.29	100.65 to 105.93	0.0000	89.54	86.85–92.23	0.0000
CS vs saline	0.63	−2.01–3.27	0.9645$	−9.64	−12.33 to −6.95	0.0000
CHX vs saline	−102.66	−105.3 to −100.02	0.0000	−99.18	101.87 to −96.49	0.0000

CI, confidence interval; MC, *M. citrifolia*; CS, *C. sinensis*; CHX, chlorhexidine; CFU/mL, colony forming unit per milliliter; $p = 0.0000$, highly significant; *significant; $, not significant ($p > 0.05$)

and frequency of the irrigant, the type and concentration of the irrigant, and the characteristics of the irrigating needle.[11] In this study, all parameters influencing bacterial count were standardized, employing a consistent technique across all groups. According to the American Academy of Pediatric Dentistry (2021), there is no substantial difference in the success of endodontic procedures when using irrigants such as 1–5% NaOCl, CHX, or sterile water/saline. Nevertheless, challenges arise from the tissue irritation properties of NaOCl and the cytotoxic effects of commercially available irrigating solutions like MTAD, Qmix, CHX, etc., limiting their application in pediatric dentistry.[12] Herbal irrigants are gaining popularity for endodontic irrigation due to their effective antimicrobial efficacy, minimal cytotoxicity, and negligible impact on the microhardness and flexural strength of root dentin.[3]

The ongoing study unveiled a substantial and statistically significant distinction between conventional CHX and the evaluated herbal irrigants. Greater bacterial count reduction was noticed with Triphala and *M. citrifolia*. However, *C. sinensis* (white tea) irrigants have shown the least reduction, similar to saline, with no significant difference.

Triphala is a renowned Indian Ayurvedic polyherbal medicine with a synergistic effect, comprised of dried fruit extracts from three medicinal plants: *Terminalia bellerica*, *Terminalia chebula*, and *Emblica officinalis*. It encompasses tannins, quinones, flavones, flavonoids, flavonols, gallic acid, and vitamin C, collectively enhancing its extensive range of antibacterial effectiveness.[13,14] Prabhakar et al.[13] and Pujar et al.[14] have found that Triphala had more antibacterial potency on *E. faecalis* biofilm, and Susan et al. have proved its chelating property to hold promising results in removing the smear layer.[15]

Because of its healing attributes, such as antioxidant, anti-inflammatory, and radical scavenging activity, Triphala may present a potential advantage as a safe alternative to traditional root canal irrigants. The efficacy of Triphala has been demonstrated with substantial bacterial reduction, aligning with the findings of a 2019 *in vivo* study by Divya and Sujatha. In that study, 5 mg/mL Triphala powder dissolved in dimethyl sulfoxide extract showed significant results.[16] Commercially available ayurvedic herbal formulations were used in the present study. The actual effective concentration of the herbal agents in the formulation is difficult to compute. Reshma Raj et al. examined the Ayurvedic formulation Triphala as a root canal irrigant, finding it to be noncytotoxic to normal mouse fibroblast cells. Moreover, Triphala exhibited efficacy similar to that of 5.25% NaOCl in removing the smear layer in both the coronal and middle thirds of the root.[17]

Morinda citrifolia (M. citrifolia), commonly known as noni or Indian mulberry, emerges as the initial herbal juice recognized as a potential substitute for traditional irrigants. This herbal juice possesses a diverse array of therapeutic effects, encompassing hypotensive, analgesic, antihelminthic, antibacterial, antiviral, antifungal, antitumor, anti-inflammatory, and immune-enhancing properties. The antibacterial efficacy of *M. Citrifolia* is primarily ascribed to compounds such as acubin, L-asperuloside, alizarin, and certain anthraquinones.[18] Murray et al. were the pioneers in noting the efficacy of *M. citrifolia* in smear layer removal. Their findings indicated that *M. citrifolia* was as effective as NaOCl and even more so than CHX.[19] They emphasized the biocompatibility of *M. citrifolia*, noting its oxidation properties, which reduce the risk of significant injuries in the event of accidental extrusion beyond the root apex. Numerous studies have documented the antimicrobial efficacy of *M. citrifolia* juice against *E. faecalis* and *C. albicans*, with a reported minimal inhibitory concentration of 6%.[19–22]

Podar et al. employed a 6% *M. citrifolia* solution as an irrigant for permanent teeth, observing a noteworthy reduction in both aerobic and anaerobic bacteria CFUs. This herbal solution was found to be highly effective, surpassing the efficacy of 3% NaOCl.[8] In a separate investigation, Chandwani et al. determined that *M. citrifolia* juice exhibited efficiency comparable to 1% NaOCl in deciduous molars, leading to a significant decrease in microbial count postirrigation. Their suggestion was to potentially enhance the antibacterial effectiveness of the herbal irrigant by increasing the quantity of irrigant and adhering to a multivisit protocol for pulpectomy.[23] The current findings show similar efficacy of *M. citrifolia* with significant reduction of both aerobic and anaerobic bacteria postirrigation. In addition, its demineralizing effect on root dentin aids in smear layer removal permits rapid negotiation of ribbon-shaped canals, and supports further percolation and disinfection of accessory canals (Gondi et al.).[24]

The perennial plant *C. sinensis*, widely recognized commercially for green tea, offers a plethora of health benefits. It exhibits extensive antimicrobial effectiveness against various pathogens, encompassing fungal pathogens, gram-positive bacteria, and

Gram-negative bacteria. Notably, gram-positive bacteria are particularly susceptible to the polyphenols present in *C. sinensis*.[6] The antioxidant potential of green tea polyphenols is linked to the arrangement of aromatic rings and hydroxyl groups. The active component, epigallocatechin gallate (EGCG), disrupts the bacterial cell membrane and impedes deoxyribonucleic acid supercoiling, ultimately resulting in cell destruction. It has proven effective against the resistant bacterial species *E. faecalis*, showing comparable efficacy to NaOCl with no significant difference.[25] *C. sinensis* has been identified as a safe alternative to synthetic root canal irrigants, exhibiting no adverse effects on the microhardness of root dentin.[24]

The antimicrobial efficacy of *C. sinensis* depends on the degree of fermentation, preparation method, and manufacturing season. During the fermentation process, there is a chance for the destruction of catechins like EGCG, which are responsible for antibacterial properties.[26] However, in the current study, unfermented tea from *C. sinensis* (white tea) was specifically employed. This tea, derived from new growth buds and young leaves of the plant, was chosen to maximize its antioxidant potential.

The findings of the current study demonstrated the least reduction in bacterial count with C. sinensis compared to *M. citrifolia*, Triphala, and CHX. Despite this, the bacterial reduction achieved with *C. sinensis* was greater than that with normal saline. However, statistically, no significant difference was observed in their antibacterial efficacies. In a study by Salem et al., a high clinical success rate was observed in teeth treated with 3.5% green tea extract compared to 0.9% normal saline.[27] Agarwal et al. observed a relatively lower reduction in bacterial count following irrigation with green tea compared to ozone treatment. However, it was still found to be more effective than normal saline.[28] Likewise, in the present study, teeth treated with *C. sinensis* (white tea) were deemed clinically and radiographically successful, demonstrating a slightly higher effectiveness compared to normal physiological saline.

To the best of our knowledge, no previous study has assessed the *in vivo* antimicrobial activity of Triphala, *M. citrifolia*, *C. sinensis*, and 2% CHX comparatively as root canal irrigants in deciduous molars. Among the three tested herbal irrigants, Triphala and *M. citrifolia* have demonstrated superior bacterial reduction along with clinical success. These findings align with the results reported in the study conducted by Choudhary et al.[29] They assessed the efficacy of commercially available *M. citrifolia* juice and Triphala juice in comparison with CHX against *Enterococcus faecalis* and *Candida albicans*. The results suggested positive outcomes in reducing bacterial count.

Conclusion

Within the confines of the current study's limitations, the conclusion is drawn that commercially available Triphala and *M. citrifolia* juice as root canal irrigants are effective enough to cause a significant bacterial reduction in primary molars, comparable to that of CHX. *C. sinensis* (white tea) exhibited a lower reduction in bacterial load, yet it was more effective than normal saline. These herbal irrigants used in the study were cost-effective, had longer shelf lives, and had no reported history of microbial resistance development. Their ease of availability and low toxicity with profound therapeutic benefits make them safer alternative treatments to conventional synthetic irritants in primary teeth. However, further clinical trials with extended follow-up periods are warranted to substantiate their efficacy as irrigating solutions.

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