ORIGINAL RESEARCH

Comparative Evaluation of *Myristica fragrans* Essential Oil-Zinc Oxide Mixture with Zinc Oxide Eugenol in Root Canal Filling of Primary Teeth: An *In Vivo* Study

Jyothsna V Setty[1], Ila Srinivasan[2], Roopashree T Sathiesh[3]

Abstract

Background: This is a preliminary investigation to assess the efficacy of *Myristica fragrans (M. fragrans)* as pulpectomy obturation material.

Objective: To assess the clinical and radiographic efficacy of *M. fragrans* as pulpectomy obturating material and compare it with zinc oxide eugenol, the gold standard in the obturation of primary teeth.

Materials and methods: This is a triple-blind, randomized, and controlled clinical trial performed on children aged between 4–8 years with primary molars requiring pulpotomy. A total of 50 teeth were randomly assigned into two groups—group I received *M. fragrans* with zinc oxide eugenol, and group II zinc oxide eugenol. Teeth were then filled with glass ionomer cement and were restored using stainless steel crowns. Clinical and radiographic evaluation was done by a blinded calibrated evaluator at 3, 6, and 12-month follow-up periods. The data obtained were subjected to statistical analysis.

Results: Clinical and radiographic success in both groups was 100% throughout the follow-up period. Extruded material in the *M. fragrans* group showed resorption during the follow-up period.

Conclusion: *Myristica fragrans (M. fragrans)* can be suggested as a pulpectomy obturating material for primary teeth. However, further clinical studies with long-term follow-ups are needed to give more affirmative results.

Keywords: *Myristica fragrans*, Obturation, Primary molar, Pulpectomy, Zinc oxide eugenol.

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Introduction

Primary teeth ensure proper chewing and speaking, preserve space for permanent teeth, and promote good oral hygiene. Maintaining primary teeth also has long-term effects on a person's oral health, as it can impact the development of permanent teeth and jaw structure. Primary teeth root canal treatment mainly aims to eliminate infection and also to maintain the tooth until normal exfoliation in proper function.[1,2]

The root canals of primary teeth are difficult to clean thoroughly due to their intricate and complex morphology. It can also be hard to eradicate all the bacteria present in infected primary root canals, making complete removal of the pulp tissue a challenge.[3–6] Desired properties for an ideal root canal filling material in primary teeth should balance a range of factors, including biocompatibility, resorption rate, adhesion, easy removal if required, radiopacity, nonshrinking, and non-discoloring of primary teeth to ensure optimal results in maintaining the health of the primary tooth.[7] Hence, the obturating material quality determines the success of primary teeth endodontics.[8,9]

Many obturating materials have been used for primary teeth root canals. These include zinc oxide eugenol, calcium hydroxide, iodoform-based pastes, vitapex, maisto paste, KRI paste, and end of las. Reported success rates in studies on these obturating materials to date are between 68.7 and 100%. However, each of these materials has its own limitations.[9–14]

Phytotherapeutic substances have been tried in various aspects of dentistry. The probable shift of modern medicine toward herbal agents is because they are natural, economical, and are with minimum side effects. *M. fragrans* (nutmeg) is one such jewels from mother nature's treasure with a wide spectrum of beneficial pharmacological effects. Nutmeg extract has shown hepatoprotective, antioxidant, memory enhancing, anticancer, aphrodisiac antidiabetic, antidepressant, hypolipidemic, and hypocholesterolemia effects, antimicrobial, antibacterial, anti-inflammatory and anticarcinogenic activities, which are accepted in scientific literature.[15]

Myristica fragrans (M. fragrans) is also shown to be very effective against primary root canal microorganisms.[16] Therefore, in our study, we considered evaluating *M. fragrans* efficacy in primary

[1,2]Department of Pediatric Dentistry, Mathrusri Ramabai Ambedkar Dental College & Hospital, Bengaluru, Karnataka, India

[3]Department of Pharmacognosy, Government College of Pharmacy, Bengaluru, Karnataka, India

Corresponding Author: Jyothsna V Setty, Department of Pediatric Dentistry, Mathrusri Ramabai Ambedkar Dental College & Hospital, Bengaluru, Karnataka, India, Phone: +91 9449819468, e-mail: jyothsnasrikanth@gmail.com

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teeth obturation in comparison with zinc oxide eugenol, a gold standard amongst all obturating materials.

Materials and Methods

Preparation of *M. fragrans* Essential Oil

Essential oil of *M. fragrans* was prepared using the Clevenger method of hydrodistillation. Nutmeg kernels collected for the study were authenticated and certified at the Regional Institute of Ayurveda. Ground powder of nutmeg (50 gm) was placed in a 500 mL distillation flask with a two-thirds volume of distilled water. The heat was applied using a heating mantle, and the volatile oil was carried with the steam to a cold condenser. The lighter oil rises to the top of the separator. This process was continued for about 12 hours until the oil inside the water ran out and stopped collecting. The calibrated trap was used to measure the volume of essential oil collected.[17] Analysis of the essential oil for phytochemicals was performed by gas chromatography-mass spectrometry (GC-MS) at Auriga Research Private Limited, Bengaluru, Karnataka, India, under standard protocols.[16,17]

Study Design

This study was a triple-blind (participants, evaluator, and statistician), randomized controlled clinical trial conducted in the Department of Pediatric Dentistry on children aged between 4 and 9 years. This investigation was conducted as per Consolidated Standards of Reporting Trials (CONSORT) guidelines (Flowchart 1).

The estimated sample size using the G*Power software version 3.1.9.2. Considering 64% effect size (d), 80% power of the study and 5% margin of error were rounded off to 50, anticipating 20% attrition. The total sample was further subdivided into 25 samples in each group; group I—*M. fragrans* with zinc oxide and group II—zinc oxide eugenol.

Participants and Recruitment

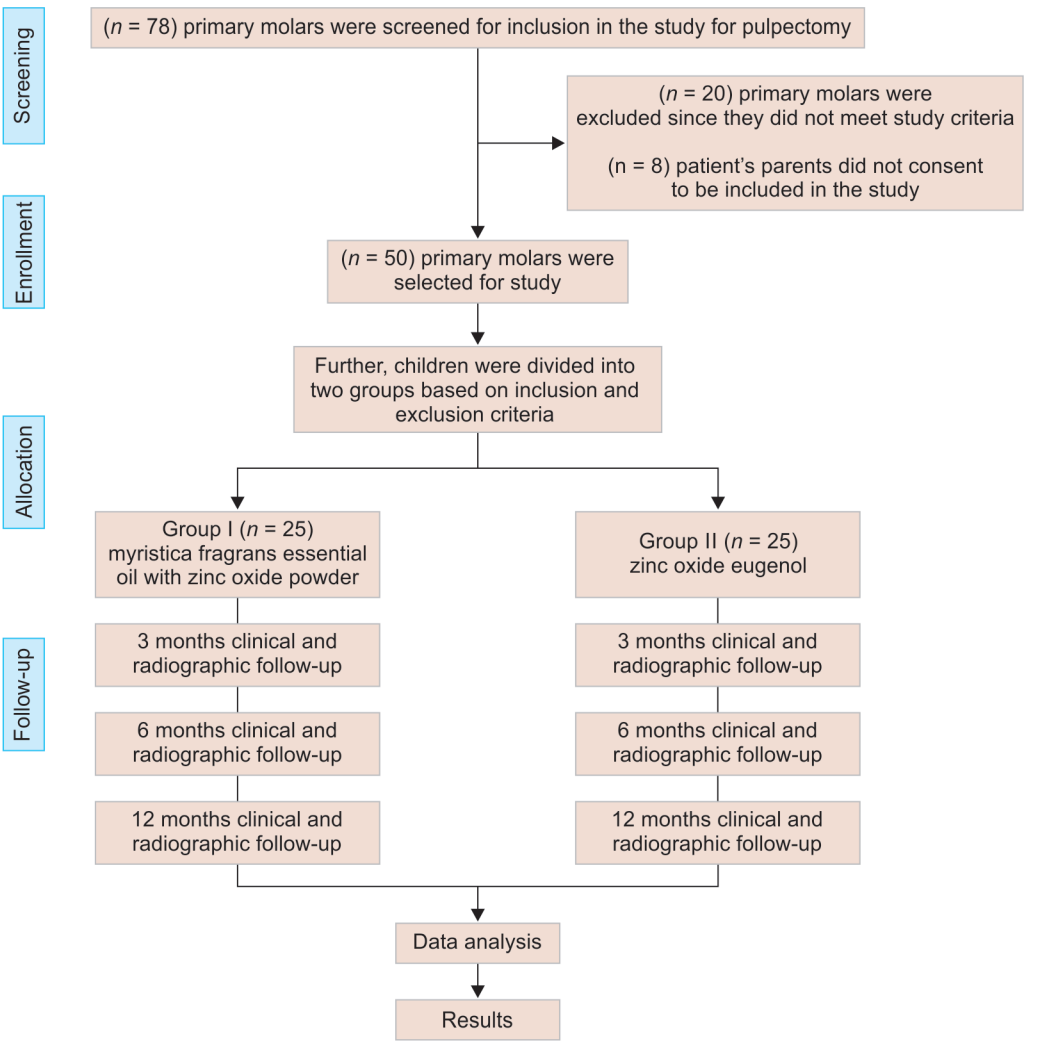
Participation in our study was completely voluntary; parents/guardians were fully informed about the treatment procedure and the study. Assent from the child and informed written consent from the parent/guardian was obtained prior to the treatment. The study was initiated after the ethics committee and review board approved it, and the trial with the Clinical Trials Registry – India (CTRI/2020/05/025148) was registered.

Study participants fulfilling the inclusion and exclusion criteria were randomized using computerized randomization (random.org)

Inclusion Criteria[18–20]

- Patients aged 4–8 years with no history of systemic illness.
- Teeth with caries, diagnosed as having irreversible pulpitis.

Flowchart 1: CONSORT flowchart



- Teeth that are restorable.
- Teeth with two-thirds of root length intact.

Exclusion Criteria[18–20]

- Teeth with pathologic and preshedding mobility.
- Teeth with perforation of the pulpal floor.
- Teeth with the missing succedaneous tooth.
- Presence of resorption (external or internal).
- Presence of pulp canal calcifications.
- Medically compromised patients.

Clinical Procedure

Lignocaine hydrochloride 2% containing adrenaline 1:80,000 concentration was used to obtain local anesthesia of the selected tooth. The pulpectomy procedure was done under rubber dam isolation. A spoon excavator and fine-barbed broaches were used to remove the coronal and radicular pulp, respectively. Copious saline irrigation was performed to remove dentinal debris and pulp tissue remnants. Working length at 1–2 mm short of the apex on the radiograph was set for all the canals. H-file in sequential pullback direction up to a maximum of 35 was used for cleaning and shaping. Sterile paper points were used to achieve dry canals. Obturation of the root canals using the mixture of essential oil of *M. fragrans* with zinc oxide powder for group I and zinc oxide eugenol mix for group II using pluggers and reamers was performed. The access cavity was sealed with glass ionomer cement, and the final restoration was done by the placement of a stainless-steel crown.[2,4,6,11] All the teeth were evaluated for signs and symptoms at the follow-up periods of 3, 6, and 12 months intervals both clinically and radiographically, and the success of the treatment procedure was evaluated based on Coll and Sadrian criteria.[10,11,20]

Results

Phytochemical analysis of the essential oil of *M. fragrans* using GC/MS detected over 20 chemical compounds; nutmeg oil constitutes three groups of volatile components—oxygenated hydrocarbons, hydrocarbons, and aromatic hydrocarbons. Oxygenated hydrocarbons include the compounds that contain ketone, or ester, terpene alcohol (terpinen-4-ol), alcohol, and phenylpropenes (elemicin and safrole); hydrocarbons mostly include terpene compounds, monoterpenes (sabinene and α-pinene) and the aromatic compounds are safrole, myristicin, elemicin, safrole, and isoeugenol. These aromatic compounds impart a distinctive aroma to nutmeg.

In group, I and group II, the mean age of children was 5.33 and 5.52, respectively. Both age and sex distribution were not statistically significant. The maximum number of teeth recruited in our study were mandibular second molars, with 18 in group I and 16 in group II, followed by mandibular one molar with seven teeth in group I and nine teeth in group II. The difference in the distribution of teeth between the groups was not statistically significant. There was no statistical difference in clinical and radiological findings between group I and group II during the preoperative (pre-op) period. The obturation quality between group I and group II showed that 80% were optimally filled, 16% overfilled, and 4% underfilled in group I as compared to 68% were optimally filled, 24% overfilled, and 8% underfilled in group II. However, this difference was not statistically significant.

Comparison of clinical and radiological findings such as pain, redness, swelling, tender on percussion, presence of sinus, furcal radiolucency, internal/external resorption, and root resorption as compared with material resorption showed no statistical difference between groups with the exception of the resorption of the extruded material observed in group I. Resorption of extruded material was noticeable in group I as shown in Table 1.

Discussion

Zinc oxide eugenol has been a gold standard amongst all obturating materials. However, it has many disadvantages. Resorption with zinc oxide eugenol is at a slow rate, and it may be retained even after tooth exfoliation. Often unresorbed material has been reported to have caused deflection of permanent successor tooth. Calcium hydroxide is another widely used material in dentistry. Since the time of its introduction by Herman in 1930, and has shown a success rate of 86.7–94.2%. It is depleted from the root canals at a faster rate than physiologic resorption of the root.[4,5,11,21–25]

Iodoform-based pastes have also been tried,[25] but there are some safety concerns about the use of iodoform and or its combinations since allergic reactions to iodine in some individuals can occur. They can also cause discoloration of teeth and cemental necrosis.[26,27]

Recently phytotherapeutic drugs have been used in dentistry for various treatment modalities. *M. fragrans* (nutmeg) is a gift of one nature with wide beneficial pharmacological activities which has been considered for research. Since *M. fragrans* has excellent antibacterial, anti-inflammatory activity, analgesic activity, and osteoblastic activity also in its spectrum.[15–17] This study was conducted to evaluate its efficacy in primary teeth obturation.

In this study, first and second lower primary molars were included in children aged 4–8 years old so that at least two-thirds of intact root length was present. According to Coll and Sadrian,[11] higher success was seen in teeth with no resorption keeping in view the expected minimum posteruptive time of 12–18 months to pass for a tooth to develop a carious pulpal involvement[28] the lower age limit of 4 years was selected. Children below 4 years of age have lower levels of cooperation, decreasing the ease of carrying

Table 1: Comparison of resorption of extruded material between different time intervals in each study group using Cochran's Q test

		Post-op 3 months		*Post-op 6 months*		*Post-op 12 months*		
Groups	*Extruded material*	*n*	*%*	*n*	*%*	*n*	*%*	*p-value*
Group I	Resorbed	4	16%	4	16%	4	16%	1.00
	Not resorbed	0	0%	0	0%	0	0%	
	Not applicable	21	84%	21	84%	21	84%	
Group II	Resorbed	0	0%	0	0%	0	0%	1.00
	Not resorbed	6	24%	6	24%	6	24%	
	Not applicable	19	76%	19	76%	19	76%	

out the procedure. Wright GZ stated that children between 4 and 8 years of age are considered to be potentially cooperative and, therefore, can be managed by nonpharmacological behavior management.[29] Thus, in the present study age group of 4–8 years was taken into consideration with the mean age of 5.33 (Table 1).

The distribution of teeth in both the groups in the present study shows mandibular molars over maxillary molars as they have high caries prevalence.[30–33]

A total of 50 teeth indicated for pulpectomy were included, with 25 in each group. Participants were randomly allocated by computerized random allocation (random.org) to prevent selection bias.

It was found that the entire sample gave a history of pre-op pain. Rifkin,[34] in their study, found that about half of the individuals who had carious exposed teeth had a history of pain as their presenting symptom. Mani et al.[23] reported a history of pre-op pain in about 88% of cases. Thomas et al., in their study, found that 60% of cases had a history of pre-op pain.[35]

Preoperatively (pre-op) two patients in each group presented with swelling, and three cases in group II (zinc oxide eugenol) presented with sinus, but these differences were not statistically significant.

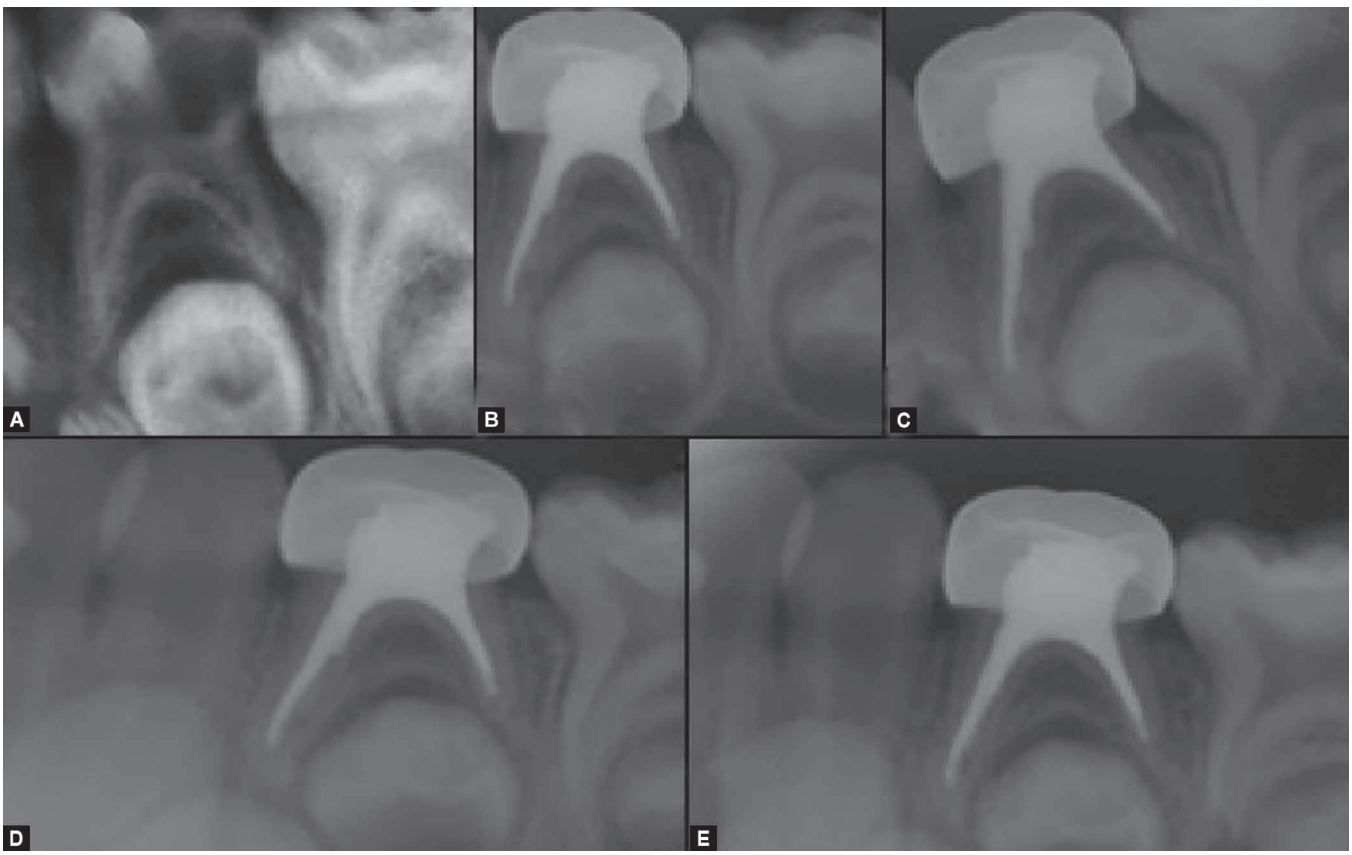
In the present study, all teeth exhibited tenderness on percussion; this was higher than Mani et al.,[23] Damle and Nadkarni[24] Gupta and Das[36] Rewal et al.,[19] who reported tenderness on percussion at baseline in about 66, 75, 74.28, and 90.4%, respectively. A certain amount of subjectivity exists in the evaluation of tenderness to percussion at both the operator level as well as the response of the child patient. This may account for a wide range of tenderness on percussion seen in various studies and in the present study at baseline.

Among the obturated teeth, it was found that groups I and II had 80 and 68% optimally filled, 16 and 24% overfilled, and 4 and 8% underfilled teeth, respectively. However, this difference was not statistically significant. Coll and Sadrian[11] reported a success rate of 89% for optimal fill, 87% for underfilled teeth, and 58% for overfilled teeth.[11]

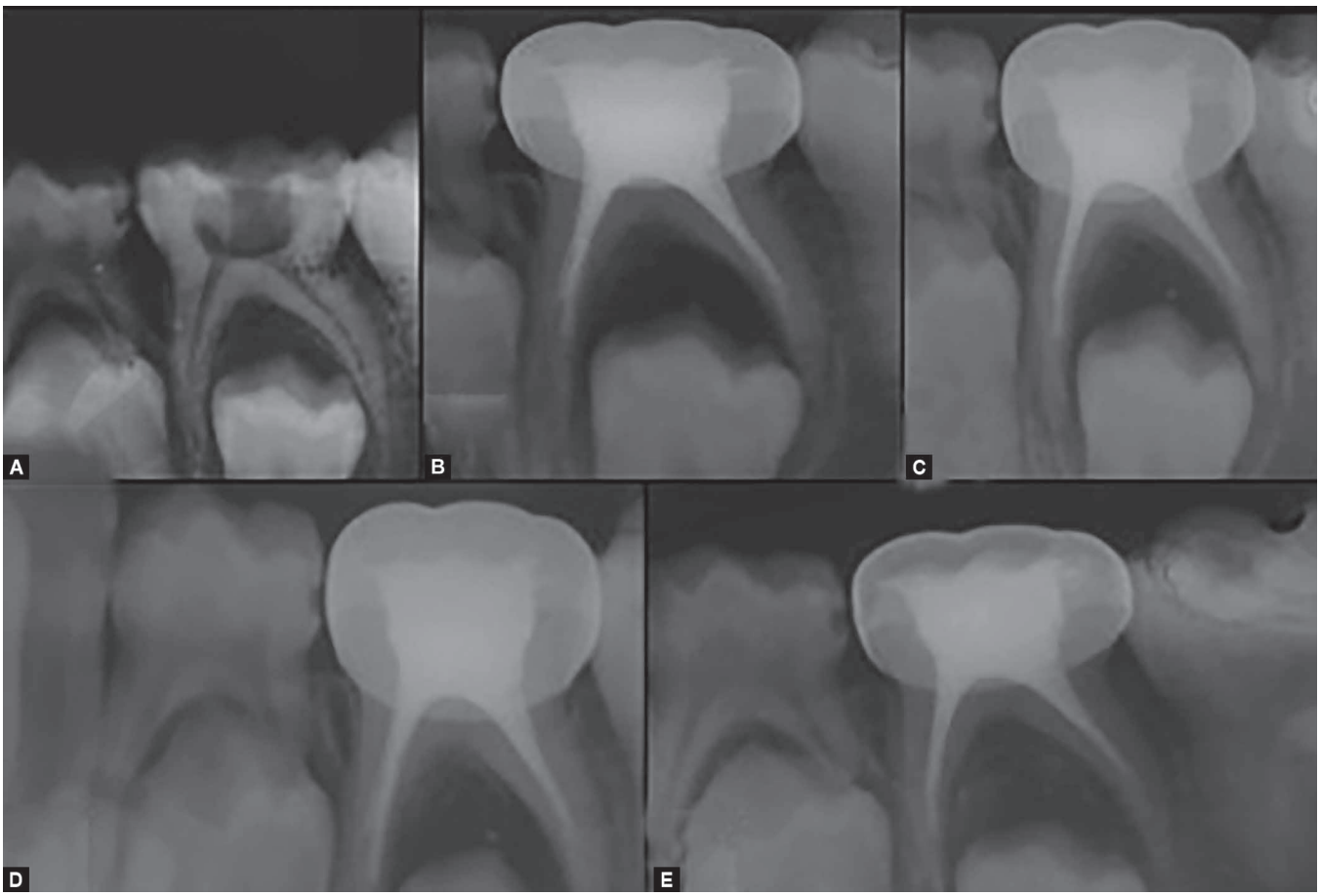
In the present study, clinical and radiographic follow-up of both the material *M. fragrans* with zinc oxide (Fig. 1) and zinc oxide eugenol (Fig. 2) showed no signs of failure throughout the follow-up period. This result is similar to Ozalp et al.,[37] with zinc oxide eugenol showing 100% success. However, zinc oxide eugenol has shown a wide range of variations in the success rates of different studies, Reddy and Fernandes 80%, Mani et al.,[23] 83.3%, Nadkarini and Damle[24] 88.6%, Mortazavi and Mesbahi[21] 78.5%, Trairatvorakul and Chunlasikaiwan[38] 85%, etc.,

Resorption of the overfilled material was studied in group I; there were four overfilled teeth, and six teeth in group II were overfilled during obturation. Follow-up periods of 3, 6, and 12 months showed resorption of extruded material in all the teeth in group I (Fig. 3), and none of the teeth with extruded material showed material resorption in group II. This finding with zinc oxide eugenol is consistent with the studies done by Sadrian and Coll, Reddy and Fernandes, Mani et al., Ramar and Mungara, Gupta and Das, and Rewal et al. who also revealed the retention of zinc oxide eugenol.[11,23,36,39,40]

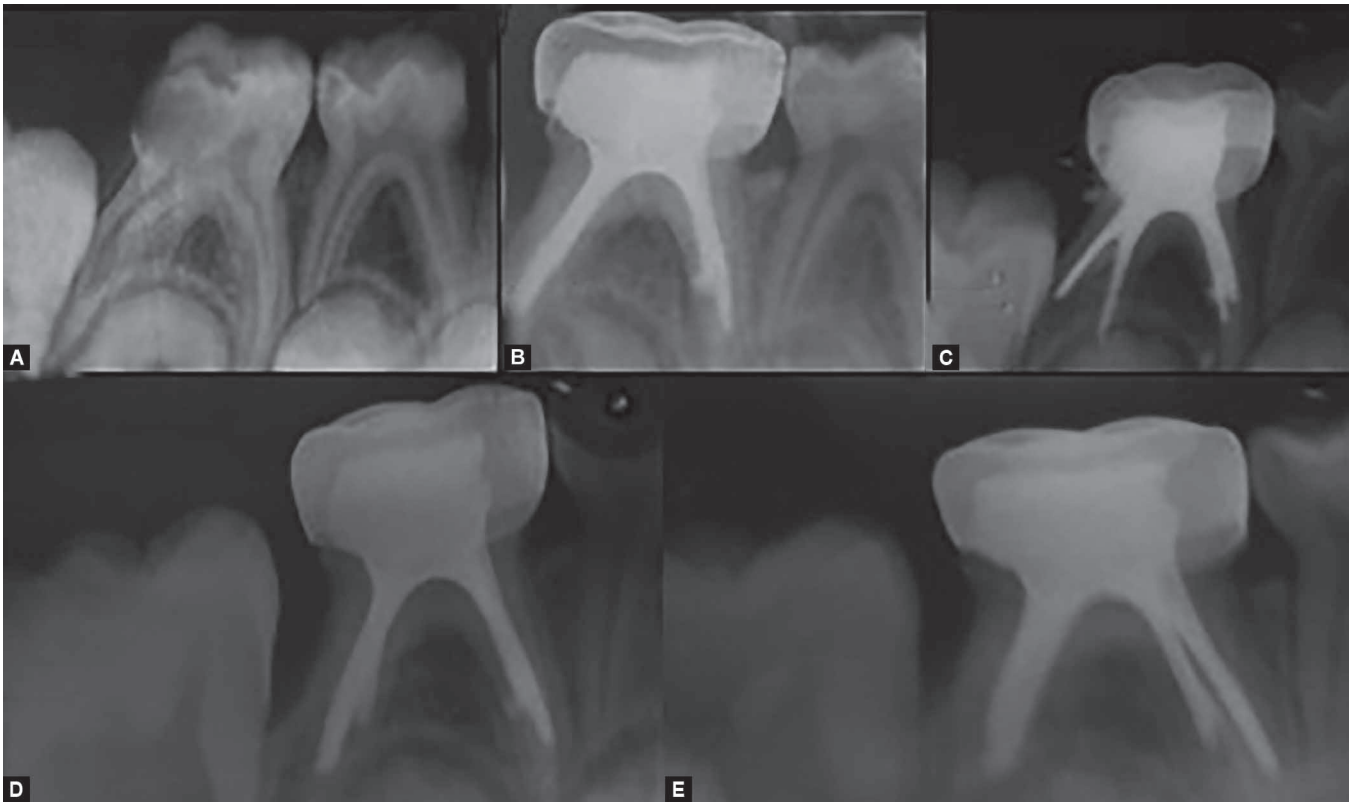
In this study, there was no difference observed in the rate of resorption of the obturation material and tooth root during



Figs 1A to E: Group I: (A) Pre-op; (B) Immediately postoperative (post-op); (C to E) 3, 6, and 12 months follow-up



Figs 2A to E: Group II: (A) Pre-op; (B) Immediately post-op; (C to E) 3, 6, and 12 months follow-up



Figs 3A to E: Group I (sample with extruded obturating material): (A) Pre-op; (B) Immediately post-op; (C to E) 3, 6, and 12 months follow-up

the study period. This result with zinc oxide eugenol is not in accordance with the studies conducted by Trairatvorakul and Chunlasikaiwan,[38] Subramaniam and Gilhotra,[41] and Al Ostwani et al.[42]

This is the first clinical trial to use zinc oxide powder combined with the essential oil of *M. fragrans* as an obturating material in primary teeth and to compare it with zinc oxide eugenol, the gold standard in primary tooth obturation to date. High clinical and radiographic success is shown in this study, along with the advantage of resorption of extruded material. This can be due to the presence of a large number of pharmacologically active constituents with a wide array of beneficial activities.[15–17,43–45]

However, further research with a larger sample size, wider clinical presentations, and longer follow-ups under controlled conditions should be conducted to confirm the clinical applicability in the obturation of primary teeth.

Conclusion

This present study is the first trial using *M. fragrans* for obturation in primary teeth. Results of this study show it is an effective obturating material for primary teeth and can be used in primary teeth pulpectomies.

Limitations

Since this present study is the first trial using *M. fragrans* in pulpectomy obturation, clinical trials with more sample size, longer duration of follow-ups, diverse clinical and radiographic presentations, and well-controlled clinical conditions will be affirmative.

Patient Consent Statement

The author(s) have obtained written informed consent from the patient's parents/legal guardians for the publication of the case report details and related images.

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