

A comparative evaluation of the obturation quality in primary mandibular molars using a novel obturating material versus Endoflas: a double blinded randomized clinical trial

Avaliação comparativa da qualidade de obturação em molares inferiores decíduos utilizando um novo material obturador versus Endoflas: um estudo-clínico randomizado duplo-cego

Bhuvaneswari NATARAJAN¹ , Lavanya GOVINDARAJU¹ 

1 - Saveetha Institute of Medical and Technical Sciences, Saveetha Dental College and Hospitals, Department of Pediatric and Preventive Dentistry, Chennai, Tamil Nadu, India.

How to cite: Natarajan B, Govindaraju L. A comparative evaluation of the obturation quality in primary mandibular molars using a novel obturating material versus Endoflas: a double blinded randomized clinical trial. *Braz. Dent. Sci.* 2026;29:e4937. <https://doi.org/10.4322/bds.2026.e4937>

ABSTRACT

Pulpectomy in primary teeth requires thorough debridement and obturation with a material that is biocompatible, resorbable, and aligned with the physiological root resorption process. While zinc oxide eugenol and Endoflas are commonly used, they present limitations such as inconsistent resorption, limited antimicrobial action, and potential tissue irritation. A novel obturating material comprising Zinc oxide, Calcium hydroxide, and Metronidazole was developed to overcome these challenges. **Objective:** To compare the obturation quality in primary mandibular molars using a novel obturating material versus Endoflas. **Material and Methods:** A double-blinded, randomized clinical trial was conducted in 20 children aged 3-7 years, indicated for pulpectomy. Group I received the novel obturating material, and Group II received Endoflas. All procedures followed standardized protocols, and obturation quality was assessed radiographically using the Coll and Sadrian criteria by two calibrated evaluators. Statistical analysis included the Chi-square test and Mann-Whitney U test (significance level set at $p < 0.05$). **Results:** Both groups were demographically comparable. Optimal filling was observed in 40% of Group I and 30% of Group II. Overfilling and underfilling scores were similar between groups. No statistically significant differences were observed in filling quality ($U = 49.500$, $p = 0.96$), age ($p = 0.61$), or treated tooth distribution ($p = 0.83$). **Conclusion:** The novel obturating material showed comparable clinical performance to Endoflas in terms of radiographic obturation quality. Its formulation may offer improved antimicrobial benefits and could be considered as an alternative material in primary tooth pulpectomy.

KEYWORDS

Endoflas; Metronidazole; Obturation; Primary teeth; Pulpectomy.

RESUMO

A pulpectomia de dentes decíduos requer debridamento minucioso e obturação com material biocompatível, reabsorvível e compatível com o processo fisiológico de reabsorção radicular. Enquanto o óxido de zinco e eugenol e o Endoflas são amplamente utilizados, eles apresentam limitações como reabsorção irregular, ação antimicrobiana limitada e potencial irritação tecidual. Um novo material obturador que contém óxido de zinco, hidróxido de cálcio e metronidazol foi desenvolvido para superar estes desafios. **Objetivo:** Comparar a qualidade da obturação de molares inferiores decíduos utilizando um novo material versus Endoflas. **Material e Métodos:** Um ensaio-clínico randomizado duplo-cego foi conduzido com 20 crianças de 3-7 anos, com indicação de pulpectomia. O grupo I recebeu o novo material obturador já o Grupo II recebeu o Endoflas. Todos os procedimentos seguiram protocolos padronizados, e a qualidade da obturação foi avaliada radiograficamente utilizando o critério de Coll e Sadrian por dois avaliadores calibrados. A análise estatística incluiu teste

qui-quadrado e teste U de Mann-Whitney (nível de significância definido $p < 0.05$). **Resultados:** Ambos os grupos foram demograficamente comparáveis. Observou-se obturação ideal em 40% do Grupo I e em 30% do Grupo II. As pontuações de sobre-obturação e sub-obturação foram semelhantes entre os grupos. Não foram observadas diferenças estatisticamente significativas na qualidade de obturação ($U = 49.500$, $p = 0.96$), idade ($p = 0.61$), ou distribuição de dentes tratados ($p = 0.83$). **Conclusão:** O novo material obturador mostrou desempenho clínico comparável ao Endoflas em relação a qualidade radiográfica da obturação. Esta nova formulação pode oferecer benefícios antimicrobianos aprimorados e pode ser considerada como uma alternativa para pulpectomia de dentes decíduos.

PALAVRAS-CHAVE

Endoflas; Metronidazol; Obturação; Dente decíduo; Pulpectomia.

INTRODUCTION

The retention of primary teeth plays a vital role in ensuring adequate space for the proper eruption and alignment of the permanent teeth [1]. Preserving the arch length, which has an essential impact on the permanent dentition's development and the eruption pathway of successor teeth, depends vitally on retaining the integrity of the primary arch [2]. The fundamental objective of pulp therapy is to preserve the structural and functional integrity of the primary tooth and its surrounding periodontal tissues [3,4].

Pulpectomy serves as an effective therapeutic approach for restorable primary teeth diagnosed with irreversible pulpitis, aiming to achieve total debridement of the inflamed or necrotic pulp tissue [5]. Decontamination of the primary root canals completely, regardless of infection, and achieving optimal obturation with a bioresorbable material that exhibits a resorption rate in alignment with the primary roots while exhibiting rapid elimination in the event of accidental extrusion beyond the apical foramen are the two major concerns in pulpectomy [6,7].

Zinc oxide eugenol was the most common obturating material used for primary teeth. However, its principal limitation lies in its delayed resorption, which may ultimately contribute to the displacement or misalignment of the developing succedaneous tooth [8,9]. Also it has been reported to exhibit limited antimicrobial action. Subsequent to the use of zinc oxide eugenol, calcium hydroxide-iodoform paste emerged as an obturating material owing to its strong antimicrobial efficacy and favourable resorption characteristics upon accidental extrusion [10,11]. Nevertheless, clinical observations have reported that the material tends to resorb more rapidly than the physiologic roots of the primary

teeth, potentially resulting in the 'hollow tube effect' [12]. To address the limitations associated with calcium hydroxide-iodoform paste, Endoflas was subsequently introduced. This material combines zinc oxide eugenol, calcium hydroxide, and iodoform, and was designed to integrate the antimicrobial efficacy, resorbability, and sealing ability deemed essential for an ideal obturating material in primary teeth [13,14]. However, despite its favourable properties, Endoflas has been associated with certain drawbacks, including the risk of foreign body reaction owing to the presence of Eugenol and iodoform, and possible discolouration of teeth [15].

Despite the availability of numerous obturating materials, a clear consensus on the ideal choice among paediatric dentists remains elusive. This ongoing pursuit led to the development of a novel obturating material incorporating zinc oxide, and metronidazole, aiming to enhance antimicrobial efficacy and clinical outcomes. The physical characteristics of an obturating material such as flowability, viscosity, adaptability to canal walls, and resorption behaviour play a critical role in determining the quality of obturation. Therefore, evaluation of obturation quality becomes essential when introducing any new obturating material. Hence, the present study aimed to compare and evaluate the quality of the obturation in primary mandibular molars using the novel obturating material and Endoflas.

MATERIALS AND METHODS

Trial design and setting

A double-blinded, randomized clinical trial was conducted over a three-month period (March-May 2025) in the department of pediatric and preventive dentistry at a dental institution in Chennai, Tamil Nadu. The study protocol was

approved by the Institutional Ethical Committee (Ref. No. SRB/SDC/PEDO-2304/25/003) and was prospectively registered with the Clinical Trials Registry – India CTRI/2025/03/082876. The trial was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki of 1964 and its subsequent amendments. Written informed consent was obtained from the parents or legal guardians of all participants prior to enrolment. The study design, execution, and reporting followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines to ensure methodological rigor and transparency.

Sample size

The sample size was determined based on the data obtained from a preliminary pilot study conducted on 6 primary molars (3 in each group), where the difference in optimal obturation rates between the novel obturating material and Endoflas was observed to be approximately 20%. Using this data, the sample size was calculated with a power of 95% and a significance level of 5%. Based on the pilot results, the required total sample size was determined to be 20 teeth, which was then randomly allocated with an allocation ratio of 1:1 into two groups: Group I (novel obturating material) and Group II (Endoflas), each comprising 10 teeth.

Eligibility criteria

Children between the ages of 3 and 7 years with any one of the primary mandibular molars exhibiting spontaneous/ nocturnal pain, or presence of a fistula or abscess, or a deep carious lesion with pulp exposure where haemostasis could not be achieved after coronal pulp extirpation were included in the trial. Radiographic inclusion criteria consisted of primary mandibular molars with evident pulpal involvement, furcation radiolucency, and discontinuity or widening of the lamina dura. Teeth were excluded if the radiographic evidence showed root canal obliteration, internal resorption, or physiological root resorption exceeding one-third of the total root length.

Formulation of the novel obturating material

The novel obturating material was formulated using a standardised combination of calcium hydroxide, zinc oxide, and metronidazole.

The base mixture consisted of 60% calcium hydroxide and 40% zinc oxide by weight, to which 2% metronidazole was incorporated.

Precisely 600 mg of calcium hydroxide powder and 400 mg of zinc oxide powder were weighed using a high-precision digital analytical balance (± 0.001 g accuracy). Twenty milligrams of metronidazole powder was prepared by finely triturating the commercially available tablets with a mortar and pestle, followed by sieving to ensure uniform particle distribution. The metronidazole powder was thoroughly blended with the calcium hydroxide-zinc oxide mixture to obtain the final 2% (w/w) concentration. Barium sulphate was added as a radio opacifier.

The dry components were initially mixed manually to ensure even distribution and then subjected to further homogenisation using a magnetic stirrer for one hour. Subsequently, 2 mL of distilled water and silicon oil was added with the aid of a calibrated micropipette to facilitate paste formation. The mixture was then vortexed for 15 minutes, followed by continuous mechanical mixing for 24 hours to ensure complete integration of the components and uniform paste consistency. The final formulation was stored in a sterile, air-tight container in a dry environment until further testing.

Randomization and allocation concealment

Participants were allocated into two groups using a computer-generated block randomization sequence designed to maintain balanced group sizes. Allocation concealment was validated by employing sequentially numbered, sealed, opaque envelopes, which were opened only after participant enrollment. The randomization sequence was prepared by an independent investigator who had no involvement in the clinical procedures or outcome evaluation, thereby minimizing the risk of allocation bias.

Blinding

This study employed a double-blind design. The participants were not informed about the type of obturating material used in their respective treatments, thereby minimizing the risk of performance bias. Although radiographic evaluation appears objective, interpretation of obturation quality involves a degree of subjective judgment, particularly when assessing minor voids or determining precise apical termination.

Knowledge of the material used could potentially influence the evaluator's perception or categorization of the obturation quality. Therefore, to prevent detection bias and ensure impartial radiographic assessment, the outcome assessor was blinded to the group allocation.

The radiographs were coded and evaluated independently without disclosure of the material used. However, operator blinding was not feasible due to the inherent differences in material handling characteristics. Efforts were made to ensure that the assessment remained unbiased and standardized across all participants.

Clinical procedure

The clinical protocol for pulpectomy was formulated in accordance with the guidelines recommended by the American Academy of Pediatric Dentistry (AAPD) for pulp therapy in primary teeth (2019) and was adapted from previously published clinical studies evaluating obturation quality in primary molars. All the procedures were conducted by a single paediatric dentist. Following clinical and radiographic confirmation of irreversible pulpitis, local anesthesia was administered using 2% lignocaine with 1:200,000 adrenaline (LOX* 2%, Neon Laboratories, India). The tooth was then isolated using a rubber dam (GDC Marketing, India). Under aseptic conditions, caries removal and access cavity preparation was performed using a No. 330 pear-shaped carbide bur (Mani Inc., Japan) in a high-speed handpiece (NSK PANA AIR PA-SU B2). Coronal pulp was removed with a spoon excavator (Hu-Friedy Mfg. Co.). Canal patency was assessed with a No. 10 K-file (Dentsply Maillefer, USA), and initial enlargement was done with a No. 15 K-file. Working length was determined with an orikam apex locator recording 1 mm short of the 0.0 mark. Instrumentation was carried out using the Kedo-SG Blue rotary system according to the manufacturers instructions. Rotary instrumentation was performed using an Orikam e-connect endomotor (Orikam health care, India) at 300 rpm and 2.4 N/cm torque, with 17% EDTA gel (RC Help, Prime Dental) for lubrication. Canals were irrigated alternately with 0.9% saline and 2% chlorhexidine, with a final rinse of saline. Drying of the canals was done with sterile No. 15 paper points.

In Group I, the obturation was done using the novel obturating material. The material was directly introduced into the prepared and dried root canals using a pre-filled syringe containing novel obturating material. The dispensing tip was positioned as close to the apical region as possible and the material was gently pressed into the canals while the syringe was gradually withdrawn coronally, allowing the material to flow until it reached the pulp chamber. On complete withdrawal of the syringe, a moistened cotton pellet was used to compact the material within the canal, ensuring optimal adaptation and sealing of the root canals. In Group II, the obturation was carried out using Endoflas-FS (SANLOR LABORATORIES) mixed in a powder-to-liquid ratio of 2:1, as per the manufacturer's instructions. Endoflas-FS (Sanlor Laboratories, Colombia, USA) was prepared in a powder-to-liquid ratio of 2:1 to obtain a medium consistency suitable for use as an obturating material in primary molars. The powder was measured using a standardised scoop and dispensed onto a glass slab. It was then gradually incorporated into eugenol using an agate spatula through a folding motion to ensure uniform mixing. Once the desired consistency was achieved, the material was introduced into the thoroughly dried root canals in increments with a No. 20 hand reamer (MANI, Inc., Japan). Final compaction within the canal space was accomplished using moistened cotton pellets, ensuring adequate adaptation of the obturating material.

The difference in insertion technique between the two groups was determined by the inherent handling characteristics and manufacturer recommendations of each material. The novel obturating material was formulated as a pre-mixed injectable paste suitable for direct syringe delivery, whereas Endoflas-FS is conventionally prepared as a powder-liquid mixture and clinically introduced incrementally using a hand instrument to ensure proper canal adaptation. Standardizing a single insertion method was not feasible due to differences in viscosity and delivery form; therefore, each material was used according to its recommended clinical protocol to reflect routine practice. To minimize procedural variability, all obturations were performed by a single experienced operator, and radiographic assessment was conducted by a blinded evaluator to reduce detection bias.

Following obturation, an interim restoration was given using Type II glass ionomer cement (GIC) (Shofu, Japan). Subsequently, intraoral periapical radiographic (IOPAR) imaging was

performed to evaluate the quality of the obturation. Definitive coronal restoration was completed using a preformed stainless steel crown (SSC) (3M ESPE), luted with Type I Glass ionomer cement (GIC) (Shofu, Japan) to ensure an adequate marginal seal.

Outcome assessment

The quality of root canal obturation was evaluated using the classification system originally proposed by Coll and Sadrian [16]. The assessment was based on the radiographic extent of the obturating material within the root canals and are categorized as follows:

Optimal Fill: The root canal filling terminates at the radiographic apex or within 1 mm short of the apex without overextension.

Underfill: The obturation ends more than 1 mm short of the radiographic apex, indicating inadequate canal filling.

Overfill: The obturation material extends beyond the apex into the periapical area.

This classification was employed to ensure standardized and objective evaluation of the obturation outcomes.

Prior to assessing the cases, two evaluators standardised their assessment protocol by analysing five pulpectomy cases that were not the part of the study. The evaluation process entailed a comprehensive review of preoperative and postoperative radiographic evidence. An inter-examiner agreement exceeding 90% was achieved. In instances of rating discrepancies, discussions were conducted until a consensus was reached.

Statistical analysis

The data were systematically compiled and analyzed using IBM SPSS Statistics software, version 30. Descriptive statistics were employed to present the demographic characteristics, with continuous variables expressed as mean and standard deviation, and categorical variables summarized as frequencies and percentages. The Chi-square test was utilized to evaluate differences in categorical variables, including gender distribution and tooth numbers, between the two groups. Given the limited sample size and the non-parametric nature of the data, the Mann-Whitney U test was used for comparing continuous variables such as age and filling

scores. A p-value less than 0.05 was considered indicative of statistical significance.

RESULTS

The demographic data are depicted in Table I. No statistically significant differences were observed between the two groups with respect to age, gender and tooth number. This indicates that the baseline characteristics between the two groups are comparable, demonstrating appropriate group matching for the study.

Analysis of the obturation quality revealed no statistically significant difference between the Novel obturating material and the Endoflas (Mann-Whitney U = 49.500, $p = 0.96$). The distribution of optimal, over-filled, and under-filled obturations was similar across the groups, reflecting comparable treatment outcomes. Notably, the novel obturating material demonstrated a higher proportion of optimal (40%) and under-fillings (30%), whereas Endoflas exhibited the highest incidence of over obturation (50%) and higher proportion of optimal filling (57.1%) for the novel material and Endoflas (42.9%) when compared between the groups (Table II and Figure 1).

Table I - Participant demographics and tooth characteristics

		Group I	Group II	p value
Age		5.30 ± 0.95	5.10 ± 0.74	0.61
Gender	Male	5(45.5%)	6(54.5%)	0.65
	Female	5(55.6%)	4(44.4%)	
Tooth Number	74	1(33.3%)	2(66.7%)	0.83
	75	3(60.0%)	2(40.0%)	
	84	4(57.1%)	3(42.9%)	
	85	2(40.0%)	3(60.0%)	

Statistical significance was set at $p < 0.05$.

Table II - Comparison of the quality of obturation between the groups

Quality of Obturation	Groups		Mann-Whitney U test value	p value
	Group I	Group II		
Optimal	4 (40%)	3(30%)	49.500	0.96
Over	3(30%)	5(50%)		
Under	3(30%)	2(20%)		
Total	10(100%)	10(100%)		

Group I = Novel Obturating Material; Group II = EndoFlas. Mann Whitney U test. Statistical significance was set at $p < 0.05$.

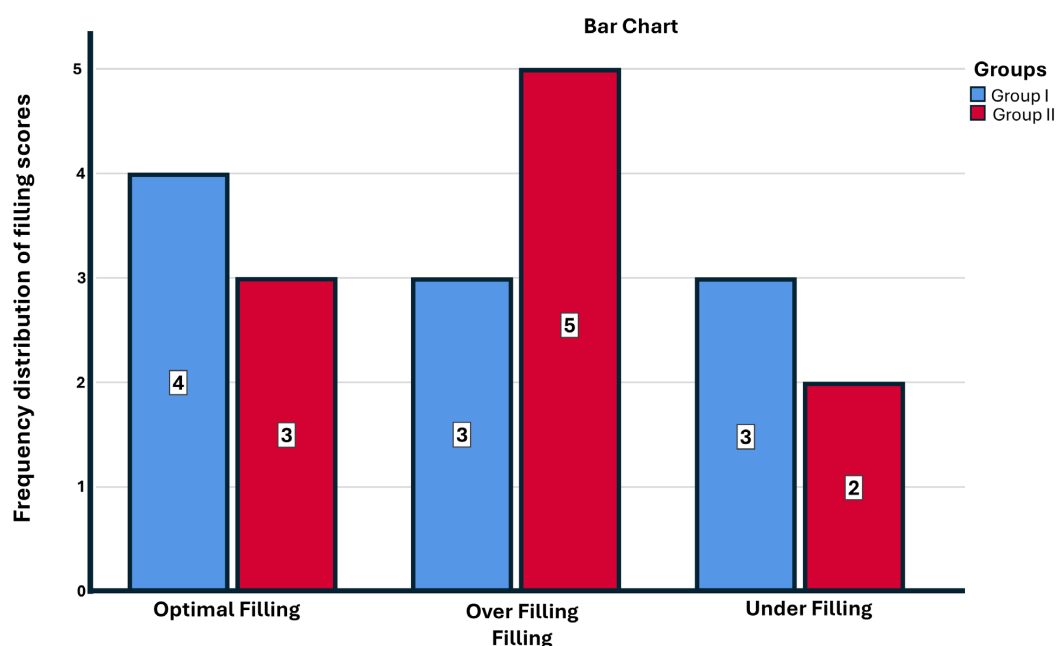


Figure 1 - Quality of obturation between the Groups (Group I - Novel Obturating Material, Group II - EndoFlas)

DISCUSSION

The success of pulpectomy in primary teeth critically depends on the choice of an obturating material that ensures a hermetic seal, supports physiological resorption, prevents reinfection, and exhibits biocompatibility with the periapical tissues and underlying permanent tooth germ [17]. In the present double-blinded randomized clinical trial, the obturation quality of a novel zinc oxide – calcium hydroxide – metronidazole paste was compared with that of Endoflas in primary mandibular molars [18]. The results demonstrated no statistically significant difference between the two groups with respect to obturation quality, suggesting that the novel formulation performs on par with an established standard such as Endoflas in terms of radiographic filling adequacy.

The rationale for incorporating metronidazole into the experimental formulation stems from the persistent challenge of eliminating polymicrobial infections in primary root canals, especially due to the intricate anatomy and presence of accessory canals [19]. Metronidazole has demonstrated selective antimicrobial activity against anaerobic bacteria, such as *Enterococcus faecalis* and *Fusobacterium nucleatum*, which are frequently implicated in pulpal and periapical infections [20]. The integration of metronidazole

thus aims to enhance the bactericidal profile of conventional zinc oxide-iodoform pastes, aligning with current strategies that emphasize both mechanical debridement and intracanal disinfection.

Furthermore, the scoping review conducted by Ridawanty et al. [21] affirmed the superior clinical performance of calcium hydroxide-iodoform pastes over ZOE, particularly with regard to resorbability and biocompatibility [22]. The literature has also indicated rapid resorption of calcium hydroxide-iodoform pastes, such as Metapex, may predispose the tooth to the “hollow tube” effect, potentially compromising the long-term success of pulpectomy [23]. The current experimental formulation builds upon this foundation by eliminating eugenol and incorporating metronidazole to enhance antimicrobial efficacy, while retaining a composition that supports resorption synchronized with root physiology.

Previous literature has consistently underscored the clinical effectiveness of Endoflas, a compound formulation of zinc oxide, eugenol, calcium hydroxide, and iodoform. Subramaniam and Gilhotra [11] reported favorable clinical outcomes with Endoflas due to its capacity for controlled resorption when extruded, while maintaining stability within the canal. However,

concerns have been raised in previous study regarding eugenol-associated tissue irritation and the potential for tooth discoloration [24]. Moreover, a study highlighted that although Endoflas, Metapex, and calcium hydroxide-zinc oxide mixtures yielded similar short-term success, material-specific considerations must guide clinical selection, especially where long-term functionality and esthetics are concerned [25].

In the current study, the rate of optimal obturation was higher in teeth treated with the novel obturating material (57.1%) compared to those obturated with Endoflas (42.9%). Despite this apparent difference, statistical analysis revealed no significant difference between the two groups ($p = 0.96$). Notably, the novel obturating material was associated with a higher incidence of under-obturation, observed in 30% of cases. This could indicate potential handling or flow limitations of the material, warranting further investigation into its physicochemical properties and technique sensitivity during canal filling. Conversely, the novel material demonstrated a lower frequency of over-obturation when compared to the Endoflas group, which may reflect improved apical control or reduced tendency for extrusion beyond the apex [26]. This reduction in over obturation could potentially minimise the risk of post operative inflammation and periapical irritation which in turn can reduce the post operative pain in the children. Such a finding underscores the clinical relevance of the novel obturating material handling properties in achieving favorable endodontic outcomes and warrants further investigation through larger, long-term studies [26,27].

Although the present study was primarily radiographic in nature, clinical observations supported the material's ease of handling and its favourable consistency for delivery and canal adaptation [28]. These findings merit further exploration in clinical settings with longer follow-up durations to evaluate parameters such as postoperative pain, periapical healing, and root resorption dynamics. Additionally, long-term outcomes such as the influence of the obturation material on the eruption path of permanent successors and exfoliation timing should be examined.

It is acknowledged that the limited sample size and relatively short evaluation period constitute notable constraints. Nonetheless, the

rigorous randomization, blinded evaluation, and use of standardized criteria strengthen the internal validity of the findings [16]. As advocated by Elicherla et al. [15], future investigations should employ longitudinal study designs with broader sample representation to substantiate the preliminary outcomes of emerging obturating materials.

An important methodological consideration in the present study is the difference in paste insertion techniques between the two groups. Standardizing a single delivery technique for both materials was not feasible due to differences in viscosity and consistency. Future studies may consider standardizing insertion techniques across materials, where feasible, to further isolate the material-specific effects.

In conclusion, the novel zinc oxide-iodoform-metronidazole paste demonstrated obturation quality comparable to Endoflas in the treatment of primary mandibular molars. Its antibiotic-enhanced formulation offers the potential for superior antimicrobial performance without compromising on sealing ability or handling characteristics. These findings position the novel material as a promising alternative in paediatric endodontics, pending confirmation through extended clinical trials that assess both radiographic and clinical parameters over time.

CONCLUSION

The novel zinc oxide-iodoform-metronidazole paste demonstrated obturation quality comparable to Endoflas in primary mandibular molars. While not statistically superior, its favourable handling, reduced over-obturation, and potential antimicrobial benefits suggest, it may serve as a promising alternative in paediatric endodontics.

Acknowledgements

We extend our gratitude to our pediatric patients and their parents/guardians for their participation and cooperation throughout the study. We also acknowledge the invaluable assistance of the evaluators and statisticians. Finally, we appreciate the support and encouragement of the Department of Pediatric and Preventive Dentistry, whose resources and infrastructure made this research possible.

Data availability

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Author's Contributions

BN: Data Curation, Formal Analysis, Writing – Original Draft Preparation. LG: Conceptualization, Writing – Original Draft Preparation.

Conflict of Interest

The authors have no conflicts of interest to declare.

Funding

The research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Regulatory Statement

This randomized clinical trial was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (2013 revision). Ethical approval was obtained from the Institutional Review Board/Institutional Ethics Committee prior to commencement of the study. Written informed consent was obtained from the parents or legal guardians of all participating children, and assent was obtained from children wherever appropriate. The trial protocol, patient confidentiality, and data handling procedures adhered to institutional and national ethical guidelines governing clinical research.

REFERENCES

- Koaban A, Alotaibi SS, Abu Nakha KM, Bin Huraib S, Alhassan MH, Rubayan AR, et al. Orthodontic space management in pediatric dentistry: a clinical review. *Cureus*. 2024;16(12):e76026. <https://doi.org/10.7759/cureus.76026>. PMID:39835004.
- Arunachalam S, Sivakumar I, Jayaraman J, Sharan J. Does arch length preservation in mixed dentition children affect mandibular second permanent molar eruption? A systematic review and meta-analysis. *BMC Oral Health*. 2021;21(1):395. <https://doi.org/10.1186/s12903-021-01755-1>. PMID:34380483.
- Zhang W, Yelick PC. Vital pulp therapy-current progress of dental pulp regeneration and revascularization. *Int J Dent*. 2010;2010:856087. <https://doi.org/10.1155/2010/856087>. PMID:20454445.
- Baldawa H, Ravindran V, Jeevanandan G, Arthanari A, Teja KV, Spagnuolo G, et al. Histopathological assessment of tricalcium aluminate-free mineral trioxide aggregate and two antibacterial enhanced mineral trioxide aggregates as pulpotomy agents in rat model. *Eur Endod J*. 2024;9(4):344-51. <https://doi.org/10.14744/eej.2024.53315>. PMID:39704633.
- Philip N, Cherian JM, Mathew MG, Thomas AM, Jodhka S, John N, et al. Treatment outcomes of pulpotomy versus pulpectomy in vital primary molars diagnosed with symptomatic irreversible pulpitis: protocol for a non-inferiority randomised controlled trial. *BMC Oral Health*. 2024;24(1):626. <https://doi.org/10.1186/s12903-024-04411-6>. PMID:38807160.
- Brar GS, Bajaj N, Bhola M, Brar JK. Clinical evaluation of root resorption and its correlation with obturation quality in pulpectomized deciduous teeth with different obturating materials: an study. *Contemp Clin Dent*. 2019;10(2):243-8. https://doi.org/10.4103/ccd.ccd_448_18. PMID:32308285.
- Khuzaimah I, Santosa SJ, Pambudi FI, Irnawati D, Nuryono N. Physicochemical and antibacterial properties of ZnO nanoparticles-modified mineral trioxide aggregate hydrated with antibiotic/chitosan solution. *Braz Dent Sci*. 2025;28(2):e4595. <https://doi.org/10.4322/bds.2025.e4595>.
- Saravanan E, Ravindran V, Arthanari A. A comparative evaluation between cheiloscopy patterns and canine relationship in permanent dentition. *J Clin Exp Dent*. 2025;17(6):e718-24. <https://doi.org/10.4317/jced.62752>. PMID:40621146.
- Sairaman S, Solete P, Jeevanandan G, Sena D, Teja KV, Mustafa M. Comparative evaluation of the canal transportation after retreatment with Solite RS3 and Protaper Universal retreatment files: a nano computed tomography study. *Braz Dent Sci*. 2024;27(3):e4369. <https://doi.org/10.4322/bds.2024.e4369>.
- Trairatvorakul C, Chunlasikawan S. Success of pulpectomy with zinc oxide-eugenol vs calcium hydroxide/iodoform paste in primary molars: a clinical study. *Pediatr Dent*. 2008;30(4):303-8. PMID:18767509.
- Gupta S, Das G. Clinical and radiographic evaluation of zinc oxide eugenol and metapex in root canal treatment of primary teeth. *J Indian Soc Pedod Prev Dent*. 2011;29(3):222-8. <https://doi.org/10.4103/0970-4388.85829>. PMID:21985878.
- Mortazavi M, Mesbahi M. Comparison of zinc oxide and eugenol, and Vitapex for root canal treatment of necrotic primary teeth. *Int J Paediatr Dent*. 2004;14(6):417-24. <https://doi.org/10.1111/j.1365-263X.2004.00544.x>. PMID:15525310.
- Subramaniam P, Gilhotra K. Endoflas, zinc oxide eugenol and metapex as root canal filling materials in primary molars—a comparative clinical study. *J Clin Pediatr Dent*. 2011;35(4):365-70. <https://doi.org/10.17796/jcpd.35.4.1377v06621143233>. PMID:22046693.
- Lakshmanan L, Ramakrishnan M, Jeevanandan G. Comparison of obturation quality, instrumentation time and post-operative pain using manual K-files and pediatric rotary files in primary molars: a double blinded randomised clinical trial. *Braz Dent Sci*. 2023;26(2):e3497. <https://doi.org/10.4322/bds.2023.e3497>.
- Elicherla SR, Bandi S, Venkata Saikiran K, Nunna M, Sai Sahiti P, Nuvvula S. The clinical and radiographic success of Endoflas compared with other root canal obturating materials in primary teeth: a systematic review. *Dent Res J*. 2022;19(1):72. <https://doi.org/10.4103/1735-3327.356805>. PMID:36407777.
- Al-wesabi AA, El Motayam K, Alsamad AMA, Abdelgawad F. Clinical and radiographic success following pulpectomy of primary molars with rotary instrumentation versus manual instrumentation: a 12-month randomized clinical trial. *Braz Dent Sci*. 2025;28(1):e4538. <https://doi.org/10.4322/bds.2025.e4538>.
- Gurunathan D, Thangavelu L, Mukundan D. Comparative evaluation of 1% sodium hypochlorite vs other intracanal irrigants during pulpectomy of primary teeth: a systematic review. *World J Dent*. 2024;15(5):451-6. <https://doi.org/10.5005/jp-journals-10015-2399>.

18. Mukundan D, Ravindran V. Comparative evaluation of post operative pain after irrigation with different concentrations of sodium hypochlorite: a split mouth triple blinded randomized controlled trial. *Braz Dent Sci.* 2024;27(3):e4285. <https://doi.org/10.4322/bds.2024.e4285>.
19. Wong J, Manoil D, Näsman P, Belibasakis GN, Neelakantan P. Microbiological aspects of root canal infections and disinfection strategies: an update review on the current knowledge and challenges. *Front Oral Health.* 2021;2:672887. <https://doi.org/10.3389/froh.2021.672887>. PMID:35048015.
20. Kaushik SN, Scoffield J, Andukuri A, Alexander GC, Walker T, Kim S, et al. Evaluation of ciprofloxacin and metronidazole encapsulated biomimetic nanomatrix gel on and. *Biomater Res.* 2015;19(1):9. <https://doi.org/10.1186/s40824-015-0032-4>. PMID:26257918.
21. Ridawanty R, Pratidina NB, Saptarini R. Effectiveness ZnOE, Ca(OH)₂ and iodoform as root canal filling materials for pulpectomy in primary teeth. *DENTA.* 2023;17(2):57-66. <https://doi.org/10.30649/denta.v17i2.3>.
22. Najjar RS, Alamoudi NM, El-Housseiny AA, Al Tuwirqi AA, Sabbagh HJ. A comparison of calcium hydroxide/iodoform paste and zinc oxide eugenol as root filling materials for pulpectomy in primary teeth: a systematic review and meta-analysis. *Clin Exp Dent Res.* 2019;5(3):294-310. <https://doi.org/10.1002/cre2.173>. PMID:31249711.
23. Khadilkar V, Shah N, Harish R, Ayyavoo A, Bang A, Basu S, et al. Indian Academy of Pediatrics revised guidelines on evaluation, prevention and management of childhood obesity. *Indian Pediatr.* 2023;60(12):1013-31. <https://doi.org/10.1007/s13312-023-3066-z>. PMID:38087786.
24. Awad R, Musa M, Elhoumed M, Liu F, Guo Q. Comparison of endoflas and zinc oxide eugenol as root canal filling materials for pulpectomy in deciduous teeth: a systematic review and meta-analysis. *Saudi Dent J.* 2024;36(6):821-9. <https://doi.org/10.1016/j.sdentj.2024.03.007>. PMID:38883905.
25. Orhan AI, Tatli EC. Evaluation of root canal obturation quality in deciduous molars with different obturation materials: an micro-computed tomography study. *BioMed Res Int.* 2021;2021(1):6567161. <https://doi.org/10.1155/2021/6567161>. PMID:34307660.
26. Santoro V, Lozito P, Donno AD, Grassi FR, Introna F. Extrusion of endodontic filling materials: medico-legal aspects. two cases. *Open Dent J.* 2009;3(1):68-73. <https://doi.org/10.2174/1874210600903010068>. PMID:19543544.
27. Alhilou AM. Factors reducing postoperative pain related to root canal treatment: a narrative review of systematic reviews. *Dent J.* 2025;13(3):102. <https://doi.org/10.3390/dj13030102>. PMID:40136730.
28. Liu H, Lu J, Jiang Q, Haapasalo M, Qian J, Tay FR, et al. Biomaterial scaffolds for clinical procedures in endodontic regeneration. *Bioact Mater.* 2022;12:257-77. <https://doi.org/10.1016/j.bioactmat.2021.10.008>. PMID:35310382.

Lavanya Govindaraju**(Corresponding address)**

Saveetha Institute of Medical and Technical Sciences, Saveetha Dental College and Hospitals, Department of Pediatric and Preventive Dentistry, Chennai, Tamil Nadu, India.
Email: glaavuu@gmail.com

Editor-in-chief: Sergio Eduardo de Paiva Gonçalves

Editor: Cristiane Meira Assunção

Date submitted: 2025 Aug 22

Accept submission: 2026 June 25