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Evaluation of primary teeth root canal orifices with naked eye and using magnifying loupes – An in vivo study☆

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ABSTRACT

Background: Knowledge of the anatomy and morphology of root canal orifices and variations are vital elements affecting treatment outcomes.

Aim: The objective of this study was to evaluate variations in the number of root canal orifices and their patterns in primary teeth, as identified by both the naked eye and under magnifying loupes.

Materials and methods: Total of 173 primary teeth was scheduled for pulpectomy over a period of 18 months. Two examiners assessed the number and pattern of the root canal orifices. After access cavity preparation, the operator recorded the number of root canal orifices with naked eye, and examiner recorded the same using magnifying loupes (3.5×). After cleaning and shaping, the same protocol was used. Collected data were statistically analyzed using SPSS version 23.0 and compared using a paired *t*-test.

Results: The overall variation in the in the identification of root canal orifices between the naked eye and magnifying loupes (3.005 ± 0.971) was statistically significant after access cavity preparation ($P \leq 0.05$).

Conclusion: Magnifying loupes significantly enhances the determination of the number and pattern of root canal orifices in primary teeth. Therefore, the application of magnifying loupes is essential for accurately assessing variations in root canal orifices in primary dentition.

1. Introduction

Several preventative measures against dental caries have been applied in the field of pedodontics; nonetheless, premature primary tooth loss due to caries remains a significant challenge.[1] Patient's quality of life may be significantly affected by endodontic diseases.[2] Recent advancements in pulpectomy techniques have guided in a significant shift in root canal therapy for primary teeth.[3] Proper cleaning, shaping, and obturation of the entire root canal system are essential for ensuring the efficacy of endodontic therapy.[4] The clinician's inability to identify canals results in insufficient debridement of the infected pulp chamber and may lead to the failure of endodontic therapy. Therefore, the operator should be aware of the continual morphologic variations in primary teeth.[5]

Typically, the primary anteriors have a single root and canal.[6,7] Cleghorn et al. and Ahmed (2013) indicated that maxillary primary molars typically possess two to four roots, with three-rooted variations being predominant.[3,6] Additionally, the prevalence of the second mesiobuccal (MB2) root canal in these molars is reported to be as high as 95 %.[7] Conversely, primary mandibular molars may exhibit one to four roots, with two roots being the most frequently observed configuration. The mesial roots may have two or three canals.[6] The distal roots usually

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have one or two canals.[6] Currently, the magnification devices used in dentistry include loupes, dental operating microscopes (DOMs), orascopes, modular endoscopes (microendoscopes), and miniature endoscopy systems.[8] Magnifying loupes and DOMs are the most commonly used magnification devices.[8] Loupes are not as expensive as microscopes and are easy to carry and store. Based on the optical technique used to achieve magnification, binocular magnifying loupes are classified into three different types: single-lens, Galilean system, and prism.[9] Loupes are available with magnifications ranging between 2× and 6x. In pediatric dentistry, the use of magnifying loupes makes the treatment more practical, accurate, and efficient[10] because they improve the practitioner's visual perception, and offer enhanced operating field visibility, resulting in outstanding diagnostic abilities and ideal treatment outcomes.[11]

Despite significant research on the variability in the number and pattern of root canal orifices in permanent teeth, information about the same in the primary teeth is scarce, where studies using cone beam computed tomography (CBCT) and in vitro studies predominated.[3,5,12–14] Moreover, literature on the routine use of magnifying loupes and their role in identifying additional canals in the primary teeth is also lacking. Therefore, this study aimed to assess the variations in the number and pattern of root canal orifices in the primary teeth identified with the naked eye and under magnifying loupes.

2. Materials & methods

The present observational study was conducted at the Department of Pediatric and Preventive Dentistry of the University. The study protocol was approved by the Medical Research Ethics Committee of the same university (October 26th' 2021, REF NO: CSP/21/SEP/99/490). The STROBE ("strengthening the reporting of observational studies in epidemiology") checklist and statement were followed.[15] Parents/caregivers were provided with detailed information regarding the objectives and advantages of the study and were given the opportunity to participate voluntarily. Written informed consent was obtained from the parents/caregivers of all participants prior to their involvement in the study. The study period was 18 months from July 2021 to December 2022. The study cohort was selected using the convenience sampling method.

2.1. Inclusion and exclusion criteria

All patients aged <10 years who required pulpectomy in any of the primary teeth were included in the study. Children with developmental anomalies of the teeth and those who did not consent to participate in the study were excluded.

2.2. Examiner training and calibration

Two examiners underwent training and calibration under the supervision of an experienced pediatric dentist. Additionally, the examiners received training in the application of magnifying loupes. Each examiner examined 20 extracted teeth and documented the number and pattern of root canal orifices following access opening and cleaning and shaping procedures while using loupes. The examiners re-examined the extracted teeth after two weeks, and the intraclass correlation coefficient was determined. A pilot study was conducted on 20 patients reporting to the department, where the number and pattern of root canal orifices after access opening and cleaning and shaping were recorded using loupes by the examiners and evaluated by an experienced pediatric dentist. Inter-observer reliability was calculated.

2.3. Clinical procedure

2.3.1. Access cavity preparation – scoring with naked eye and using loupes

Patients reporting to the department, who required pulpectomy, were allotted to postgraduate students. Patients were instructed to lie in an almost supine position with the head, knees, and feet at approximately the same level. The mandibular and maxillary teeth were viewed through direct and indirect vision, respectively. Under local anesthesia (2 % lignocaine with 1:100,000 epinephrine) and rubber dam isolation, postgraduate students prepared an access cavity using a sterile medium-size round bur (BR-41) and non-end cutting bur (EX-24) (Mani Inc., Utsunomiya, Japan) in a high-speed handpiece. Following access cavity preparation, they completely removed the coronal pulp remnants and irrigated the pulp chamber with 2.5 % sodium hypochlorite (Prime Dental Products Pvt. Ltd., Mumbai, India). Root canal orifices were identified by carefully exploring the developmental grooves using a DG16 sharp endodontic explorer (Hu-Friedy, Chicago, IL, USA). After access cavity preparation, the assigned postgraduate student evaluated the number of root canal orifices with the naked eye (NE_0) and recorded it in a proforma. Subsequently, a trained examiner examined the same patient, identified the root canal orifices using magnifying loupes (ML_0) (3.5 ×), and recorded the number of root canal orifices in a separate proforma. Magnifications on the lower end between 2.0 × and 3.5 × loupes are suitable as general purpose dental loupes or starter magnification loupes for new users.[8]

2.3.2. Cleaning and shaping – scoring with the naked eye and using loupes

The postgraduate students performed cleaning and shaping using either hand K and H files or nickel-titanium rotary files (Mani Inc., Utsunomiya, Japan) and recorded the number of root orifices observed with the naked eye (NE_1) separately in each proforma. Thereafter, examiner examined the patient using magnifying loupes (ML_1) to record the number and pattern of the root canal orifices on the proforma. Calcium hydroxide and iodoform paste (Metapex; Meta Biomed, Republic of Korea) was used for root canal obturation. Damp cotton pellets were then applied gently to enhance the flow of the obturation material into the canals. Finally, the access cavity was restored with Type IX Glass ionomer cement (GC Fuji Inc., Japan).

3. Outcomes

3.1. Number of root canal orifices

The number of root canal orifices in anterior teeth was recorded as one when single root canal orifice was examined. In case of more than one orifice, it was recorded as buccal and lingual/mesial and distal, depending on the location of the root canal orifices. The number of root canal orifices in posterior teeth was recorded with their nomenclature as Mesio Buccal (MB), Disto Buccal (DB), Palatal (P), Mesiolingual (ML), and Distal (D). Additional canals were recorded as Middle mesial (MM), Middle Distal (MD), MB2, MB3, DB2, DB3, P2, P3. Sometimes in the mandibular molars, ribbon shaped canals appear, which were prepared as if they were two separate canals.[7]

3.2. Patterns of root canal orifices

The pattern of posterior teeth canal orifices was depicted by connecting the root canal orifices, which were represented as oval shaped/triangular/rectangular patterns. The illustrated patterns signified the outline of the access cavity in primary teeth.[8]

3.2.1. Statistical analysis

Statistical analyses were conducted using SPSS version 23.0 (SPSS, Chicago, Illinois). Descriptive statistics were employed to evaluate the number and pattern of root canal orifices and their variations. The differences in the number of root canal orifices observed in primary teeth between assessments with the naked eye and using magnifying loupes (3.5 ×) were analyzed using a paired *t*-test, with statistical significance set at $p < 0.05$.

4. Results

The study investigated variations in the root canal orifices of primary teeth under magnification loupes. It involved 173 teeth from 134 patients (50 male and 30 females; average age, 10 years), comprising 22 primary anterior teeth, 27 maxillary first molars, 34 maxillary second molars, 35 mandibular first molars, and 55 mandibular second molars. The primary anterior teeth included maxillary central incisors, maxillary lateral incisors, and maxillary and mandibular canines.

4.1. Examiner calibration

Regarding inter-examiner reliability, the intraclass correlation coefficient for the naked eye and magnifying loupes was 0.99 and 1, which indicated good and excellent inter-examiner reliability, respectively. Cohen's kappa value for inter-rater agreement indicated almost perfect agreement (0.81–0.99), and a final consensus was obtained.

4.2. Central and lateral incisors and canines

Out of the 22 primary anterior teeth examined, there were 10 maxillary central incisors, 4 maxillary lateral incisors, 6 maxillary canines, and 1 mandibular canine. Upon observation with both the naked eye and magnifying loupes, all these teeth displayed a single canal without any variation (Fig. 1A). depicts a single root canal orifice. No notable differences were noted among the different root canal orifice variants.

4.3. Maxillary first molars

Twenty-six of the 27 primary maxillary first molars evaluated had three root canal orifices (MB, distobuccal [DB], and palatal [P]), as shown in (Fig. 1B), and MB2 was identified using magnifying loupes in one primary maxillary first molar following access cavity preparation (3.037 ± 0.192). As P-value >0.05 statistical significance cannot be obtained. (Table 1). It was found that 26 out of 27 teeth (96.3 %) presented with a triangular pattern and one tooth had an outline of a rectangular pattern.

4.4. Maxillary second molars

Of the 34 primary maxillary second molars evaluated, 24 had three root canal orifices (MB, DB, and P), as shown in (Fig. 1C), and in 10 of them, an additional canal, denoted as MB2/DB2, was observed under magnifying loupes after access cavity preparation(3.294 ± 0.462) (Fig. 1D). The difference was statistically significant ($P \leq 0.05$). (Table 1). It was found that 23 out of 34 teeth (67.6 %) presented with a triangular pattern and 11 of 34 teeth (32.4 %) had an outline of a rectangular pattern.

4.5. Mandibular first molars

Of the 35 mandibular first molars examined, 14 had three root canal orifices (MB, ML, and D), and in 12 of them, an additional canal, denoted DB or distolingual (DL), was identified using magnifying loupes after access cavity preparation. Out of the 35 mandibular first molars, four canals were identified with both loupes and the naked eye in nine teeth after access cavity preparation (3.61 ± 0.493) (Fig. 1E, F,G), which was statistically significant ($P \leq 0.05$). (Table 1). The findings revealed that among the 35 teeth examined, 13 teeth (37.1 %) exhibited a triangular pattern, while 22 teeth (62.9 %) displayed an outline of a rectangular pattern.

4.6. Mandibular second molars

Of the 55 mandibular second molars examined, three had three root canal orifices (MB, ML, and D) (Fig. 1H); four canals were identified with the naked eye in 24 teeth (3.91 ± 0.287), and an extra canal, (DB or DL), was identified using magnifying loupes after access cavity preparation in 28 teeth (Fig. 1I). The difference was statistically significant ($P \leq 0.05$) (Table 1). After cleaning and shaping procedures, there were no discernible differences in the number of root canal orifices identified between observations made with the naked eye and those made using magnifying loupes across all teeth. Consequently, statistical significance could not be established. It was found that 3 out of 55 teeth (5.5 %) presented with a triangular pattern and 52 of 55 teeth (94.5 %) had an outline of a rectangular pattern.

Overall, statistically significant differences in root canal orifice

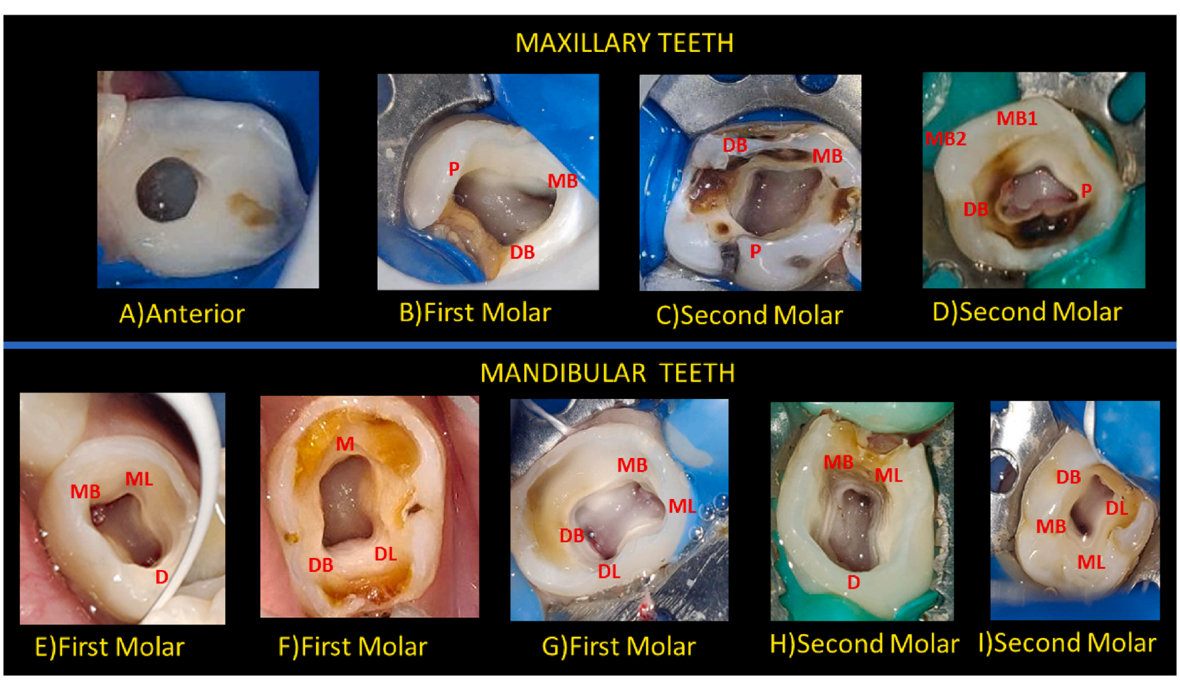

Fig. 1. Variations in root canal anatomy.

Table 1
Shows the overall difference in root canal orifice variations between naked eye and magnifying loupes.

Teeth	After access cavity preparation				After cleaning and shaping				P value	
	Naked eye (NE_0)		Magnifying Loupes(ML_0)		Naked eye(NE_1)		Magnifying Loupes (ML_1)		After access cavity preparation	After cleaning and shaping
	Mean (SD)	N_1	Mean (SD)	N_2	Mean (SD)	N_1	Mean (SD)	N_2		
Primary anterior teeth (N=22)	.[a]	22	.[a]	–	.[a]	–	.[a]	–	.[a]	.[a]
Maxillary 1st Molar (N=27)	3.00(0.00)	26	3.037 (0.192)	1	3.037 (0.192)	–	3.037 (0.192)	–	0.327	.[a]
Maxillary 2nd Molar (N=34)	3.088 (0.287)	24	3.294 (0.462)	10	3.294 (0.462)	–	3.294 (0.462)	–	0.006	.[a]
Mandibular 1st Molar (N=35)	3.235 (0.495)	23	3.617 (0.493)	12	3.617 (0.493)	–	3.617 (0.493)	–	0.001	.[a]
Mandibular 2nd Molar (N=55)	3.39(0.495)	27	3.91(0.287)	28	3.91(0.287)	–	3.92(0.259)	–	0.001	0.322
Overall (N=173)	3.005 (0.885)	122	3.225 (0.991)	51	3.225 (0.991)	–	3.231 (0.972)	–	0.001	0.319

N – Total number of teeth assessed.
N_1 Number of teeth did not have variations in number of root canal orifices between naked eye and magnifying loupes.
N_2 Number of teeth had variations in number of root canal orifices between naked eye and magnifying loupes.
SD – Standard deviation.
Paired *t*-test, statistical significance at $p \leq 0.05$.
[a] P value cannot be estimated because no variation in the data was observed.

identification were observed between the naked eye and magnifying loupes (3.225 ± 0.991) after access cavity preparation ($P \leq 0.05$). (Table 1).

5. Discussion

A comprehensive understanding of both root and root canal morphology is essential for the successful execution of root canal treatment. This study underscores the presence of variations in the number of root canal orifices in primary teeth when observed through magnifying loupes. Notably, these variations were discernible solely under magnification loupes following access cavity preparation. However, there was no observable alteration in the number of root canal orifices after the cleaning and shaping process. Consequently, the utilization of magnification devices such as magnifying loupes in pediatric dentistry holds promise for enhancing treatment outcomes by facilitating improved root canal disinfection while minimizing damage to the remaining tooth structure.

Typically, primary anterior teeth are characterized by a single root and canal.[6,7] In this study, no variations existed as the number of root canal orifices was consistent both after access cavity preparation and cleaning and shaping Nevertheless, various studies have reported instances of accessory roots and additional root canals in primary anterior teeth[3,7,12,16], especially double-rooted primary maxillary canines.[17] Musale & Hegde (2010) documented a successful case of endodontic management involving a unilateral three-rooted primary maxillary canine.[16] While the literature has reported variations in the number of root canals following cleaning and shaping in permanent teeth, our study adopted a similar procedure for assessing root canal orifice variations in primary teeth.[7]

Primary molars designated for pulpectomy remain a distinctive challenge for dental practitioners due to the intricate and irregular morphology of their root canal systems, alongside challenges in patient management and isolation.[3] In the present study, only one primary maxillary first molar showed variation with the existence of MB2 canal orifice among all of the teeth observed under loupes after access cavity preparation. Therefore, significant variations were observed under magnifying loupes in case of the primary maxillary second molar. However, no discernible differences were observed in the number of root canal orifices after the cleaning and shaping process. Previous literature indicates that deciduous maxillary molars may possess two to four roots, with the three-rooted variant being the most prevalent.[3,6] The occurrence of the double-rooted variant, wherein the distobuccal root merges with the palatal root, is also frequently reported.[3]

The double-rooted variant is the most common among primary mandibular molars, which can exhibit one to four roots.[3,7,18] The findings of this study revealed that primary mandibular first and second molars typically possess two roots and two to four canals. Consequently, differences in the number of root canal orifices were detectable under loupes following access cavity preparation. Notably, variations in the number of root canal orifices were observable under loupes exclusively after the initial access cavity preparation. It has been reported in certain population groups that accessory roots may be present in primary mandibular molars, particularly in second molars.[13,18] Typically, the mesial roots of primary mandibular molars are known to have two root canals, although reports of three canals have also been documented. Similarly, the distal root in mandibular primary molars typically exhibits one or two canals, [3] three separate canals in the distal root have been reported in extracted mandibular primary second molars when evaluated using CBCT.[19]

Various methods have been employed to investigate the morphology of root canals in extracted primary teeth, including conventional radiography, computed tomography,[20] and filling of canals with epoxy resin followed by decalcification.[12] The root canal anatomy and morphology of primary teeth have been extensively investigated using cone-beam computed tomography (CBCT). Katge et al. (2022) utilized CBCT to assess the roots and root canal anatomy of primary mandibular lateral incisors, canines, and molars in Indian children. They classified the root canal morphology of all teeth as type I according to Vertucci's classification. While some central incisors and canines exhibited S-shaped canals, none of the lateral incisors displayed such morphology.[21] In the previous study utilizing micro-computed tomography to analyze the root canal morphology of primary molars, double-canal systems were identified in the mesial roots of mandibular molars and MB roots of maxillary molars, findings that align with the results of our study.[22]

The development and widespread usage of magnification in dentistry has enhanced endodontic treatment standards and success.[23] Magnifying loupes, surgical microscopes,[24] and endoscopes[25] are the three most commonly used magnifying devices for root canal treatment. The current study investigated the differences in root canal orifice identification between the naked eye and magnifying loupes, while the utilization of magnifying loupes in pediatric dentistry is uncommon, research suggests that dental loupes can enhance the identification of additional root canals significantly more than relying on the naked eye alone, particularly in permanent teeth.[26] For our study, we employed 3.5× magnification loupes, a choice based on previous research demonstrating a notable improvement in root canal identification with this level of magnification.[27]

DOMs provide a wider range of magnification and offer superior ergonomics compared to magnifying loupes. In a study by Ahmed et al. (2016), micro-computed tomography and a DOM were utilized to identify a distinctive anatomical variation in an extracted double-rooted maxillary deciduous molar.[28,29] However, their outrageous cost and lack of mobility are the two main drawbacks of DOMs. Moreover, children's propensity to constantly change positions creates practical challenges for the use of DOMs in pediatric dentistry.[30]

As part of the limitations of this study, it was noted that managing patients aged 2–5 years posed greater challenges than those aged 6–10 years. While it focused on variations in root canal orifices, a thorough understanding of root canal morphology is essential to prevent complications during pulpectomy, such as ledge creation, file separation, canal transportation, and perforation. Moreover, aside from the number of root canals, factors like morphology and root length can significantly influence the success of pulpectomy, particularly in determining the working length. Future research should aim for more comprehensive investigations to address the limitations of the current study design.

To our knowledge, this is the first in vivo study endeavoring to ascertain additional variations in both the number and pattern of root canal orifices across all primary teeth subsequent to access cavity preparation and cleaning and shaping. Our study was meticulously planned, incorporating robust methodology, calibration protocols, and clearly defined outcomes. The objective was to evaluate whether the utilization of magnifying loupes facilitates the identification of supplementary canals in primary teeth. Scientific literature concerning the application of magnification devices like loupes or DOM in pediatric dentistry remains relatively sparse. While CBCT has been extensively utilized in studies exploring anatomical variations in primary teeth root canals, there is a dearth of data on variations in the number and pattern of root canal orifices clinically assessed in the evidence-based literature. This study serves as a cornerstone for future evidence-based research endeavors, aiming to furnish more dependable and compelling insights into the utilization of these devices in pediatric dentistry.

Bullet points

Why this paper is important to pediatric dentists.

- The study highlights the notable variability of root canal orifices in primary teeth post-access cavity preparation when observed under magnifying loupes.
- This study significantly contributes to existing literature by emphasizing the crucial role of magnifying loupes in identifying root canal orifices in primary teeth. The findings suggest that utilizing magnifying loupes can improve the accuracy of diagnosis and treatment.
- The diverse root and canal morphology of primary teeth requires thorough assessment by pediatric dentists. This is essential before pulpectomy procedures to ensure comprehensive management of the entire root canal system.

Data availability

All data generated or analyzed during this study are included in the article and its supplementary material files. Further queries can be directed to the corresponding author.

Ethical approval and patients consent

The present observational study design followed the "strengthening the reporting of observational studies in epidemiology" (STROBE statement). The "Institutional Ethics Committee of the Sri Ramachandra Institute of Higher Education and Research", Porur, Chennai, approved this study (REF NO: CSP/21/SEP/99/490). Written informed consent in English/Tamil was obtained from the parents/caregivers of all participants.

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Disclosure statement

The research is original, not under publication consideration elsewhere, and **free of conflict of interest.**

Funding sources

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Declaration of competing interest

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