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Assessment of Material Standardization in Primary Tooth Obturation: An Observational Study

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ABSTRACT

Background: The success of pulpectomy in primary teeth relies heavily on optimal obturation to ensure the longevity of treated teeth. Standardizing obturation material volumes is critical for preventing complications such as voids or overfilling.

Aim: This study aimed to evaluate the impact of material volume on obturation quality in primary tooth pulpectomy using zinc oxide eugenol (ZOE) and Metapex, with assessments conducted via cone-beam computed tomography (CBCT).

Materials and Methods: Twenty extracted primary teeth were randomly divided into two groups: Group 1 (Metapex) and Group 2 (ZOE). Obturation volumes were varied (0.03-0.8 ml) and measured using pre-calibrated syringes. CBCT imaging was employed to evaluate obturation quality based on grading criteria from Grade A (suboptimal) to Grade D (extrusion). Statistical analysis using ANOVA was conducted to assess differences in material performance.

Results: Optimal obturation (Grade C) was achieved with 0.12 ml of Metapex at 12mm and 0.05 ml of ZOE at 10mm. Excess volumes resulted in overfilling (Grade D). CBCT analyses confirmed that material standardization and precise volume control significantly influenced outcomes.

Conclusion: Standardized obturation material volumes are essential for achieving optimal fillings and minimizing complications in pediatric endodontics. Advanced imaging techniques enhance treatment precision and patient outcomes.

***Keywords:** Pediatric Endodontics, Root Canal Obturation, Cone-Beam Computed Tomography.*

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INTRODUCTION

Over the years, the field of endodontics has undergone significant advancements, with modern practices differing greatly from traditional methods. In pediatric dentistry, the primary objective of pulp therapy is to preserve the integrity of the primary dentition until natural exfoliation occurs.[1] This is essential for ensuring proper development and maintenance of the craniofacial complex. Premature loss of primary teeth can lead to functional and aesthetic issues, impacting the child's overall growth and development. Dental caries is the most common cause of early primary tooth loss, and endodontic therapy provides an effective alternative to prevent such losses.[2]

The cornerstone of a successful endodontic procedure lies in achieving a biomechanically sound root canal system and a three-dimensional (3D) seal of the root canal space. Obturation, the process of filling and sealing the cleaned and shaped root canal, is crucial for preventing reinfection and maintaining the tooth's long-term prognosis. The purpose of obturation is to replace the space previously occupied by the pulp tissue with a filling material, thereby eliminating potential pathways for infection through the periodontium or the crown. The success of the treatment is directly influenced by the quality of the seal achieved during obturation.[3]

Various materials are available for pulpectomy in pediatric dentistry, with zinc oxide eugenol (ZOE) and Metapex (calcium-iodoform-based) being the most commonly used. The choice of material, along with the proper quantity and application, plays a vital role in ensuring effective and durable root canal fillings. The relationship between the working length and the volume of obturation material used is particularly significant in achieving optimal filling and successful treatment outcomes.[4]

The advent of cone-beam computed tomography (CBCT) has revolutionized endodontic procedures by providing detailed 3D imaging of the tooth and surrounding structures. CBCT enables accurate volumetric analysis, allowing clinicians to assess the quality and completeness of obturation in three dimensions. This level of precision not only ensures the standardization of material amounts used during obturation but also aids in monitoring treatment outcomes over time.[5]

In pediatric patients, reducing the amount of obturation material minimizes procedural complexity and discomfort, leading to a more positive dental experience. Standardizing the volume of obturation material ensures efficient root canal treatment while reducing the risk of complications. This study aims to evaluate the standardization of obturation material in primary tooth pulpectomy using CBCT, thereby contributing to improved treatment protocols and patient care in pediatric dentistry.

MATERIALS AND METHOD:

Study Design and Setting: This observational study was conducted at Krishnadevaraya College of Dental Sciences, with ethical approval obtained from the Institutional Review Board prior to the commencement of the study.

Sample Selection: The sample size of 20 was calculated using a formula for comparing two independent groups with a continuous outcome. Assuming a 95% confidence level ($Z\alpha/2 = 1.96$) and 80% power ($Z\beta = 0.84$), the formula considers the estimated variance (σ^2) and the minimum detectable difference (d) between the groups. Based on these assumptions, a sample size of 10 per group was determined, resulting in a total

sample size of 20 for the study. This calculation was based on estimated values for variance and effect size, or conservative assumptions in the absence of prior data**.** A total of 20 extracted primary teeth, including molars and canines, were selected based on predefined inclusion and exclusion criteria.

Inclusion Criteria:

1. Primary teeth with complete root formation and no evidence of resorption.
2. Teeth with no structural defects or fractures

Exclusion Criteria:

1. Teeth with extensive caries leading to significant loss of tooth structure.
2. Teeth with pathological resorption or fractures.

Grouping of Samples

The selected teeth were randomly divided by flip of a coin into two groups, with 10 teeth in each group:

Group 1: Metapex Plus (Meta-Biomed) – a calcium-iodoform-based material.
Group 2: DPI Zinc Oxide Powder ZOE Cement.

Preparation of Samples:

1. The teeth were decoronated using a high-speed bur to standardize the working length.
2. Access cavities were prepared, and root canals were cleaned and shaped using manual K-files.
3. The working lengths were determined using a radiographic method, and the working lengths were set at 12 mm, 10 mm, and 8 mm for each sample.

Obturation Procedure:

Root canals in Group 1 were obturated with Metapex Plus, while Group 2 received DPI Zinc Oxide Powder ZOE Cement. The materials were injected incrementally into the canals using pre-calibrated syringes to ensure precise volume measurement. The volumes of the obturation materials were varied to assess their impact on the quality of the root canal filling. In Group 1, 0.12 ml and 0.5 ml of Metapex Plus were used, while in Group 2, 0.05 ml and 0.8 ml of DPI Zinc Oxide Powder ZOE Cement were injected. These varying volumes were carefully measured to evaluate their effect on achieving optimal obturation.

CBCT Analysis:

After obturation, CBCT imaging was performed to evaluate the quality of the root canal filling. The 3D images allowed for a detailed assessment of the completeness of the obturation, which was graded as Grade C (Optimal Filling) or Grade D (Extrusion). Additionally, the distribution of the obturating material along the working length was analyzed to ensure it was evenly and adequately filled. The presence of any voids or extrusion of the material beyond the apex was also evaluated, helping to identify potential issues such as material leakage or incomplete filling.

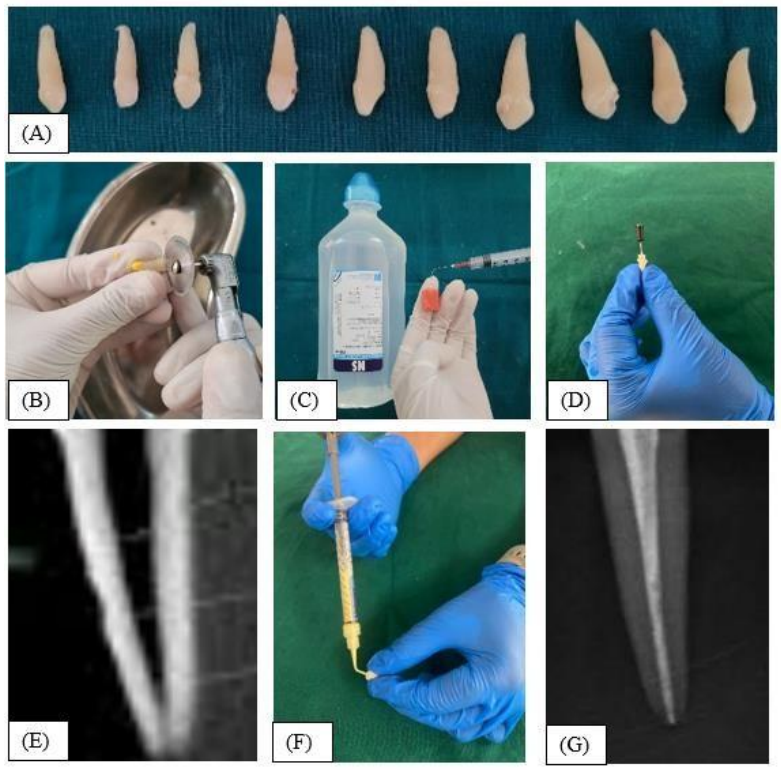

Fig – 1 (A) 10 primary canine extracted for the study (B) Teeth were sealed with GIC and sliced at the apices to leave 6 mm of working length. (C)Irrigating the canal with 1% sodium hypochlorite and saline. (D) Cleaning shaping of the extracted tooth (E) Pre obturation CBCT scan (F) Obturating the teeth with metapex and ZOE (G) Post obturation CBCT

Statistical Analysis

The compiled data were analyzed using SPSS software (version 27). The data were analyzed using descriptive statistics to summarize the results, and statistical tests were applied to compare the quality of obturation between the two groups (Metapex Plus and DPI Zinc Oxide Powder ZOE Cement). One-way ANOVA was performed to compare the mean volume of material injected at different working lengths (12mm, 10mm, and 8mm). A p-value of <0.05 was considered statistically significant.

RESULTS

The results for both Metapex and Zinc Oxide Eugenol (ZOE) showed similar patterns in terms of material usage and the quality of obturation. Smaller volumes of material typically resulted in satisfactory or acceptable fillings, effectively sealing the root canal. In contrast, larger volumes led to overfilling, causing extrusion beyond the apex and compromising the quality of the obturation. These findings indicated that controlling the volume of material used was essential for achieving optimal results and avoiding complications. Both materials exhibited comparable outcomes, with excessive material volume negatively impacting the quality of the filling.

S.No	Average Working length	Working Length	Volumetric analysis	Index
1	10mm	8mm	0.05ml	Grade A
2	10mm	12mm	0.12ml	Grade C
3	10mm	10mm	0.5ml	Grade D
4	10mm	09mm	0.07ml	Grade B
5	10mm	10mm	0.1ml	Grade C

Table 1: shows the volumetric analysis after using metapex as obturating material

In Group 1 (Metapex), the mean volume of material injected for optimal filling (Grade C) was 0.12 ml at a working length of 12mm. For extrusion (Grade D), the mean volume injected was 0.5 ml at a working length of 10mm. Similarly, in Group 2 (Zinc Oxide Eugenol), the mean volume injected for optimal filling (Grade C) was 0.05 ml at a working length of 10mm. Extrusion (Grade D) occurred when the mean volume of 0.8 ml was injected at a working length of 8mm. These findings demonstrate the relationship between the volume of obturation material and the resulting filling quality at different working lengths.

Group	Mean Volume (ml)	Standard Deviation (ml)	F-Statistic	P-Value
8mm	0.05	0	2.317	0.099
9mm	0.07	0	2.317	0.099
10mm	0.3	0.23	2.317	0.099
12mm	0.12	0	2.317	0.099

Table 2: Comparison of mean volume, standard deviation, and ANOVA results for different working lengths in root canal obturation using metapex

The study assessed the volume of obturation material used at different working lengths (8mm, 9mm, 10mm, and 12mm) in primary tooth pulpectomies as shown in table 2. The mean volume of material ranged from 0.05 ml (for 8mm) to 0.30 ml (for 10mm). The standard deviation was lowest for the 8mm and 12mm groups (0.00 ml), indicating consistent volumes, and highest for the 10mm group (0.23 ml). An ANOVA test was performed to compare the volumes across groups, yielding an F-statistic of 2.317 and a p-value of 0.099. The results suggest that there were no statistically significant differences in the volumes used at different working lengths, indicating similar performance across the groups.

S.No	Average Working length	Working Length	Volumetric analysis	Index
1	10mm	10mm	0.03ml	Grade B
2	10mm	9mm	0.5ml	Grade A
3	10mm	10mm	0.05ml	Grade C
4	10mm	12mm	0.5ml	Grade B
5	10mm	8mm	0.8ml	Grade D

Table 3: Shows the volumetric analysis after using Zinc oxide eugenol as obturating material

The table 3 show that the volume of obturation material used in primary teeth ranged from 0.03 ml to 0.8 ml, with the mean volume being 0.35 ml and a standard deviation of 0.26 ml, indicating moderate variability in the amounts used. The volumes were associated with different grades of obturation quality, with Grade A representing optimal fillings (0.5 ml), Grade B indicating acceptable fillings (0.03 ml, 0.5 ml), Grade C representing satisfactory fillings (0.05 ml), and Grade D associated with material extrusion (0.8 ml). The higher volumes (0.5 ml and 0.8 ml) were linked to Grade D, suggesting that excessive material could lead to complications such as overfilling, while smaller volumes resulted in satisfactory or acceptable fillings.

Group	Mean Volume (ml)	Standard Deviation (ml)	F-Statistic	P-Value
8mm	0.8	0	0.933	0.451
9mm	0.5	0	0.933	0.451
10mm	0.13	0.22	0.933	0.451
12mm	0.5	0	0.933	0.451

Table 2: Comparison of mean volume, standard deviation, and ANOVA results for different working lengths in root canal obturation using metapex

The analysis of obturation material volumes across different working lengths (8mm, 9mm, 10mm, and 12mm) revealed no significant differences. The mean volumes varied from 0.5 ml to 0.8 ml, with the 8mm and 12mm groups using the highest volumes of 0.8 ml and 0.5 ml, respectively, while the 9mm and 10mm groups had volumes of 0.5 ml and 0.13 ml, respectively. The standard deviations were minimal, ranging from 0.00 ml to 0.22 ml. ANOVA results showed an F-statistic of 0.933 and a p-value of 0.451, indicating that the differences in volumes across the groups were not statistically significant.

The extent of fill in the root canal was graded from Grade A to D based on the following criteria: Grade A indicated less than half of the canal was obturated, Grade B represented a filling that was greater than half but less than optimal, Grade C was considered an optimal fill, and Grade D indicated extrusion of material beyond the apex. Grade D was a modification of the grading criteria employed by Subba Reddy and Shakunthala. The results revealed that smaller volumes of obturation material generally resulted in acceptable to optimal fillings, while larger volumes caused overfilling, leading to extrusion beyond the apex. Both Metapex and Zinc Oxide Eugenol (ZOE) showed similar trends, where controlling the volume of material was crucial for ensuring the quality of obturation and minimizing complications.

DISCUSSION

Endodontic treatment follows strict protocols to ensure a three-dimensional seal of root canals. Key steps include access cavity preparation, infected pulp removal, biomechanical preparation, irrigation, drying, and obturation using suitable materials. In pediatric endodontics, zinc oxide eugenol (ZOE) and Metapex are widely used for obturation in primary teeth due to their proven efficacy. Volumetric analysis, enabled by cone-beam computed tomography (CBCT), has emerged as a critical tool to standardize the amount of obturation material based on working length. CBCT provides detailed three-dimensional imaging to evaluate filling quality and detect underfilling, overfilling, or voids, ensuring precise material usage and successful outcomes.

This study graded the extent of root canal filling into four categories: Grade A indicated less than half the

canal was filled, Grade B represented more than half but less than optimal filling, Grade C corresponded to optimal filling, and Grade D denoted material extrusion beyond the apex. The criteria for Grade D were modified from the grading system proposed by Subba Reddy and Shakunthala. Results demonstrated that in the Metapex group, optimal filling (Grade C) was achieved with 0.1 ml of material at a working length of 10 mm. Conversely, the ZOE group exhibited overfilling (Grade D) at the same working length when 0.8 ml of material was used. These findings highlight the importance of precise material measurement, particularly in pediatric cases where narrow, curved canals pose challenges.[6,7]

Recent studies corroborate the importance of volumetric analysis in obturation. Spiral computed tomography research showed that Lentulo-spiral obturation techniques achieved higher filling percentages and fewer voids compared to conventional methods, indicating superior canal sealing properties.[8,9] Additionally, rotary systems have been shown to outperform hand K-files in achieving optimal fillings with reduced underfilling or overfilling, as demonstrated in primary teeth studies.[10] Nano-CT imaging studies further confirmed that the choice of obturation technique and material significantly influences voids and filling quality, with advanced systems like GuttaCore delivering superior outcomes.[11]

This study emphasizes that standardizing obturation materials and correlating working length with appropriate material volume can significantly enhance the success of pediatric endodontic treatments. Advanced imaging techniques such as CBCT enable precise assessment and adjustment, ensuring minimal voids and optimal fillings, which align with findings from contemporary literature. These approaches not only improve clinical outcomes but also provide a more comfortable experience for pediatric patients.

CONCLUSION

In conclusion, the study highlights the importance of standardizing obturation material volumes for effective root canal treatment in primary teeth. The results revealed that Metapex achieved optimal fills (Grade C) at specific volumes, while excessive volumes of Zinc Oxide Eugenol (ZOE) resulted in material extrusion (Grade D). Advanced imaging with CBCT allowed precise volumetric analysis, ensuring a three-dimensional evaluation of filling quality and reducing complications like overfilling and voids. Comparisons with contemporary studies showed that modern obturation techniques, such as Lentulo-spiral systems and rotary systems, consistently enhance accuracy and reduce voids. These findings reinforce the need for precise protocols and advanced diagnostic tools to improve pediatric endodontic outcomes, ensuring effective treatments with minimal patient discomfort.

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Nil

CONFLICTS OF INTEREST

There are no conflicts of interest

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