

Comparison of Different Obturation Techniques in Polymer-Based Prototyped Primary Incisors: An *in vitro* Study

Manal A Almutairi*

Division of Pediatric Dentistry, Department of Pediatric Dentistry and Orthodontics, Dental college,
King Saud University, Riyadh, Saudi Arabia

ABSTRACT

Background: Several factors affect the success of pulp therapy of primary teeth, including cleaning and shaping of the root canals and the quality of obturation as the most important steps. Achieving a void-free root canal filling is a challenge in current clinical pulpectomy practice and successful pulpectomy in primary teeth depends on quality of obturation.

Aim: To compare the quality of different obturation techniques in polymer-based prototyped primary incisors using digital radiographic images.

Materials and Methods: Sixty polymer-based prototyped primary incisors were instrumented and randomly divided into six groups of 10 teeth each. Obturation technique was done as follows: Group 1- MetapexR by injection, Group 2- MetapexR by reamer, Group 3- MetapexR by motor driven lentulo spiral, Group 4- ZOE by injection, Group 5- ZOE by reamer and Group 6- ZOE by motor driven lentulo spiral. The quality of obturation was evaluated by using digital radiographic images. The obtained data were analysed using Chi-square test, Kruskal-Wallis, and Mann-Whitney test.

Results: There were significant differences between all groups in the quality of obturation. The best scores for length of obturation were ranked as followed: Group 4, Group 6, Group 1, and Group 2. While the best scores regarding density of obturation were ranked as followed: Group 4, Group 2, Group 1, and Group 3.

Conclusions: Based on results of this study Group 4- ZOE inserted by injection exhibit best scores in quality of obturation, while Group 5- ZOE inserted by reamer exhibit lowest scores.

Key words: Primary teeth, Pulpectomy, Digital radiographic, Zinc oxide eugenol paste, Metapex, Obturation

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Corresponding author: Manal A Almutairi
e-mail ✉: malmutairi1@ksu.edu.sa
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INTRODUCTION

A pulpectomy is one of the treatment options used to maintain primary teeth with radicular pulpal tissue inflammation or become nonvital until regular exfoliation [1,2]. The treatment consists of removing the infected pulp tissue and debris from the canal and obturation with resolvable antibacterial paste [3]. Successful pulpectomy procedure in necrotic primary teeth depends upon aseptic root canal preparation and hermetic seal of the root canal system [4,5].

The ideal biomechanical preparation of primary root canals is challenging due to their unpredictable root canal anatomy [6,7]. Moreover, significant differences in the root canal anatomy among the used specimens (lack of paired samples) may be a source of bias in evaluating the effectiveness of a specific technique in endodontic studies [8,9]. For this reason, the use of prototypes with individualized root canal anatomy may bring advantages in this regard [10]. In addition, bioethical issues of risk

cross-infection from infected specimens are now posing a challenge to this activity in some organizations.

To improve the success of the endodontic treatment, the properties of filling materials and the appropriate insertion into the root canal are critical. The most prevalent root canal filling materials for primary teeth are zinc oxide eugenol paste (ZOE), calcium hydroxide (Ca (OH)₂), and iodoform paste, or a combination [11,12]. ZOE is probably the most used filling material for primary teeth in the United States [13]. However, it is a slowly resorbing material and is difficult to remove if extruded beyond the root apex into periapical areas. On the contrary, Ca (OH)₂-based materials are to resorb simultaneously with physiological root resorption [14]. The ability of these pastes to completely adapt to canal walls or root apical sealing without overfilling and not to create voids in the paste is limited and can depend upon the delivery system used to carry obturating material to the canals [15].

Several techniques have been used to fill the material into the root canals of primary teeth. An ideal filling technique should assure complete filling of the root canal without overfill and minimal or no voids [16]. The most common obturation technique used with ZOE paste in clinical

practice are lentulo spiral/paste carriers, either handheld or rotary, while Ca (OH)₂/iodoform combination pastes such as VitapexR, MetapexR are available in premixed syringes, and the material is carried to the root canal directly through disposable tips [17]. Other techniques may be used to deliver the obturation material to the roots of primary teeth canal, including an endodontic pressure syringe, a disposable tuberculin syringe, an Injection Technique, a Navi Tip syringe and reamer [18]. However, there is at present no agreements as to which technique provides the best sealing of root canal filling material in primary teeth. Therefore, this in vitro study aimed to compare the quality of different obturation techniques in polymer-based prototyped primary incisors using digital radiographic images. The tested null hypothesis was there is no difference in the combination of filling pastes and method of obturation.

MATERIAL AND METHODS

The Ethics Committee approved this study protocol of the College of Dentistry Research Center at King Saud University, Riyadh, Saudi Arabia, under the research number FR-0597. In this study, the sample size was calculated at the level of significance $\sigma = 0.05$ with e size 0.5 through power=0.95 to be at least 60 teeth/10 per group.

Sixty artificial resin primary maxillary central incisors with standardized internal anatomy (Denarte, Sao Paulo, Brazil) were used in this study. All resin-based primary maxillary central incisors were accessed from the palatal surface with a 1012 diamond spherical drill (KG Sorensen, Cotia, Sao Paulo, Brazil). Root canal length (17 mm) was established by introducing a #15 Kerr file into the root canal until it was visible at the apex, and the working length was set 1 mm short. The ProFileR (DENTSPLY, Maillefer, Ballaigues, Switzerland) reciprocating instrument was enlarged sequentially to size 30-35/0.04 in a rotary handpiece (Bien-Air Dental, Langgasse 60, Biel, Switzerland) at 300 rpm with the minimum torque was used to clean and shape the root canal with three pecking movements, followed by irrigation until reaching the working length. The root canals were irrigated with 10 ml normal saline after each filing step. Next, the canals were dried with absorbent paper points (Spident, Incheon, Korea). In each session, to overcome biases resulting from operator fatigue, only five root canals were prepared. All root canals were prepared by a single trained operator.

After the preparations, the apexes of the prepared roots were covered with red modelling wax (Golden Modelling Wax, Telangana, India) to produce a halo space to serve as a collection area for any extruded canal filling material. Finally, the roots were mounted in 2x2 cm cold cured acrylic resin (Major Ortho, Major Prodotti Dentari S.p.A., Moncalieri, Italy) blocks from 1 mm below the cemento-enamel junction.

Obturation Technique: Sixty Teeth were randomly divided into six groups (n=10), according to filling paste: MetapexR (Meta biomed co., Ltd, Chungcheongbuk-do,

korea) or ZOE paste (Pulpdent, Watertown, MA, USA) and application methods as follows:

Group 1: Prepared canals were filled with MetapexR by injection. Commercially available MetapexR paste in a syringe form (Meta biomed co., Ltd, Chungcheongbuk-do, korea). Initially, placed the disposable tip and was fitted it beforehand in the prepared canal. Once the syringe reached the apex, it was continuously pressed and slowly withdrawn gradually until the paste filled the canal orifice.

Group 2: Prepared canals were filled with MetapexR by using a hand reamer. A 21 mm reamer of size 30 was used to deliver filling paste into canal according to working length. The reamer was smeared with filling paste inserted into the canal and rotated in the counterclockwise direction. Then pumped it up and down with a wiping motion against the canal walls. It was then withdrawn it from the canal. This process was repeated until the canal orifice appeared to be filled with the cement dispensed.

Group 3: Prepared canals were filled with MetapexR by motor-driven lentulo spiral. A lentulo spiral size (#30) was mounted on slow speed handpiece according to working length. The lentulo spiral coated with the Metapex R, inserted into the canal, and withdrew gently while still rotating. This procedure was repeated 3-5 times until the canal orifices were filled visibly.

Group 4: Prepared canals were filled with ZOE by injection. Achieved a creamy consistency by mixing one volume unit of powder and a two-volume unit of liquid on a dry glass slab at room temperature for 45 seconds. The ZOE paste was inserted on 3 ml syringe (Crystal-ject, Bu Kwang Medical Inc, Korea) and fitted disposable tip (Meta biomed co., Ltd, Chungcheongbuk-do, korea) then filled canal like group1.

Group 5: Prepared canals were filled with ZOE by a hand reamer method like group 2.

Group 6: Prepared canals were filled with ZOE by motor-driven lentulo spiral method like group 3.

To control paste delivery in all groups, a rubber stopper was placed around each instrument at a distance determined by preoperative measurements. When the canals were visibly filled in all groups, a wet cotton pellet was used to lightly tamp the material into the canal. Later, the access cavity was filled with a thick mixture of ZOE.

Radiographic technique. After completion of the pulpectomy procedure and to obtain accurate and consistent radiographs that would allow for good tooth structure visualization and reproducibility, teeth were exposed with digital radiographic at standardized kilovolts (70 kVp), milliamperes (6 mA) for exposure time (0.160s) with a target-film distance of 15 mm so that radiographic errors were minimized. Radiographic evaluation was done in both buccolingual and mesiodistal direction using paralleling cone technique

with both receptor and tooth aligned in the same direction for each tooth in all six groups.

Radiographic evaluation. The quality of obturation was radiographically evaluated by trained and knowledgeable pediatric dentist blinded to filling technique for the length and density of obturation using a modification of the methods reported by Coll and Sadrian 1996 [19] and Sigurdsson et al. [20].

The obturation length of filled root canals was recorded, according to the distance of the filling past from the apex as follows:

Score-1 (under filling): canal filled more than 2 mm short of the apex.

Score-2 (optimal filling): canal having filled ending at the radiographic apex or up to 2 mm short of apex.

Score-3 (overfilling): any canal showing filled outside the root apex.

The density of the root canal filling was recorded as follows:

Score-1 (Unacceptable): presence of more than three voids in different areas of root canal. Score-2 (Acceptable): good filling, in which between one to three voids were observed. Score-3 (Good): optimal filling, with no voids.

Examination of radiographic criteria/scores were performed twice, 72 hours apart, by single investigator who was blind to groups. A data collection form was used to record the required data. The obtained data were statistical analyzed using the Chi-square test, Kruskal-Wallis and Mann-Whitney tests to detect differences and interactions among groups. A P-value of <0.05 was used to report the statistical significance of results. The statistical analysis was carried out with SPSS V21.0 (SPSS Inc., Chicago, Ill, USA).

RESULTS

The Kappa value for intra-examiner reproducibility was interpreted as almost perfect. The intra-observer kappa value for the length of obturation 0.91, indicating almost perfect reliability; the intra-observer kappa value for the density of obturation was 0.98, indicating almost perfect reliability.

Frequency distribution of length of obturation and frequency distribution of density of obturation in all

groups are shown in Figures 1 and 2. Table 1 shows the frequency distribution of the quality of obturation categorized by length and density of obturation in each group. The evaluation length of obturation within different obturation techniques showed that Group 4 (ZOE inserted by injection) exhibited the highest number of the optimally filled canal (80%), followed by Group 6 (ZOE inserted by Motor-Driven Lentulo Spiral, 70%), Group 1 (MetapexR inserted by Injection, 50%), Group 2 (MetapexR inserted by Reamer, 50%), and Group3 (MetapexR inserted by Motor Driven Lentulo Spiral, 40%). However, Group 5 (ZOE inserted by Reamer, 70%) indicated the highest number of underfilled canals. The difference between all groups was statistically significant regarding the length of obturation (p<0.05).

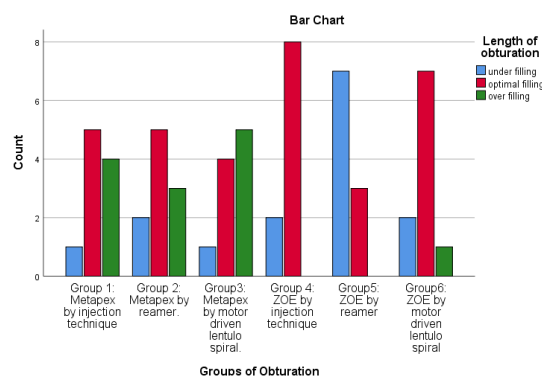


Figure 1: Frequency distribution of length of obturation in all groups.

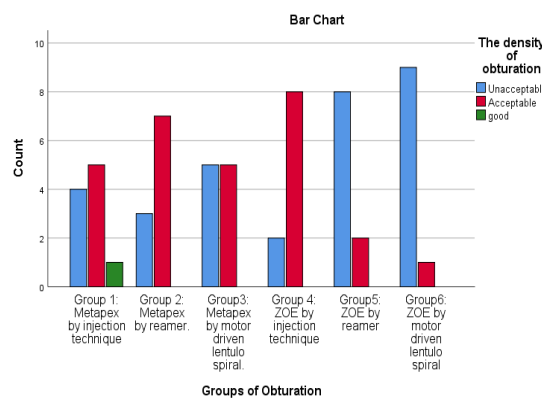


Figure 2: Frequency distribution of density of obturation in all groups.

Table 1: Distribution of all experimental groups according to the quality of obturation.

Group	Quality of obturation		Total	P value*	Unacceptabl e	Acceptable	Good	Total	P value*	
	Length of obturation									Density of obturation
	Under-filling	Optimal filling								Over-filling
Group 1: Metapex by Injection	1(10.0)	5(50.0)	4(40.0)	10(100.0)	0.008	4(40.0)	5(50.0)	1(10.0)	10(100.0)	0.025

Group 2: Metapex by Reamer	2(20.0)	5(50.0)	3(30.0)	10(100.0)	3(30.0)	7(70.0)	0(0.0)	10(100.0)
Group3: Metapex by Motor Driven Lentulo Spiral	1(10.0)	4(40.0)	5(50.0)	10(100.0)	5(50.0)	5(50.0)	0(0.0)	10(100.0)
Group 4: ZOE by Injection	2(20.0)	8(80.0)	0(0.0)	10(100.0)	2(20.0)	8(80.0)	0(0.0)	10(100.0)
Group 5: ZOE by Reamer	7(70.0)	3(30.0)	0(0.0)	10(100.0)	8(80.0)	2(20.0)	0(0.0)	10(100.0)
Group6: ZOE by Motor Driven Lentulo Spiral	2(20.0)	7(70.0)	1(10.0)	10(100.0)	9(90.0)	1(10.0)	0(0.0)	10(100.0)

*p<0.05 statistically significant; p> 0.05 statistically non-significant NS

Regarding the density of obturation, Group 4 (ZOE inserted by injection) showed the highest number of the acceptably filled canal (80%), followed by Group 2 (MetapexR inserted by Reamer, 70%), Group 1 (MetapexR inserted by injection technique, 50%) and Group 3 (MetapexR inserted by Motor-Driven Lentulo Spiral, 50%). On the other hand, the highest number of the unacceptable filled canal was observed in Group 6

(ZOE inserted by Motor-Driven Lentulo Spiral, 90%), followed by Group 5 (ZOE inserted by Reamer, 80%). The difference between all groups was statistically significant regarding the density of obturation (p<0.05). Analysis of data with the Kruskal-Wallis test showed a significant difference between experimental groups in quality of obturation (p<0.05) (Table 2).

Table 2: Mean and Sum Rank scores of qualities of obturation in all groups.

Groups of Obturation	Quality of Obturation	N	Mean Rank	Kruskal-Wallis H	p-value*
Group 1: Metapex by injection	Length of obturation	10	38.15	16.751	0.005
Group 2: Metapex by reamer		10	33.55		
Group3: Metapex by motor driven lentulo spiral		10	40.4		
Group 4: ZOE by injection		10	26.8		
Group 5: ZOE by reamer		10	15.05		
Group 6: ZOE by motor driven lentulo spiral		10	29.05		
Group 1: Metapex by injection	The density of obturation	10	35.15	15.072	0.01
Group 2: Metapex by reamer		10	36.65		
Group3: Metapex by motor driven lentulo spiral		10	30.75		
Group 4: ZOE by injection		10	39.6		
Group 5: ZOE by reamer		10	21.9		
Group 6: ZOE by motor driven lentulo spiral		10	18.95		

*p<0.05 statistically significant; p> 0.05 statistically non-significant NS

Comparing the two techniques using Mann Whitney’s test, found no significant difference in the quality of

obturation between the two filling pastes in both injection technique and motor-driven lentulo spiral

technique ($p > 0.05$). Conversely, the application technique using reamer showed a statistical difference between

ZOE and MetapexR in quality of obturation ($p < 0.05$) (Table 3).

Table 3: Mean and sum rank scores of qualities of obturation in two filling paste.

Application technique	Filling paste	N	Mean Rank	Sum of Rank	Mann-Whitney U	p-value*	
Injection	Length of obturation	Metapex	10	12.6	126	29	0.061
		ZOE	10	8.4	84		
	The density of obturation	Metapex	10	9.9	99	44	0.588
		ZOE	10	11.1	111		
Reamer	Length of obturation	Metapex	10	13.45	134.5	20.5	0.015
		ZOE	10	7.55	75.5		
	The density of obturation	Metapex	10	13	130	25	0.028
		ZOE	10	8	80		
Motor Driven Lentulo Spiral	Length of obturation	Metapex	10	12.55	125.5	29	0.084
		ZOE	10	8.45	84.5		
	The density of obturation	Metapex	10	12.5	125	30	0.057
		ZOE	10	8.5	85		

* $p < 0.05$ statistically significant; $p > 0.05$ statistically non-significant NS

DISCUSSION

The ultimate aims of root canal filling are to confirm that the paste is well adapted to the canal walls, that the root is fully filled over its length (apical sealing without overfilling), and that no voids or gaps are created in the paste [1,8]. One of the causes that contributes to deficiencies in the length and density of obturation is the procedure used to deliver the obturation material through the root canal [8,10,13-15].

Different obturation methods have been studied in vivo and in vitro in various studies, such as the penetration of dye, bacteria, or radioisotopes, clearing techniques following tooth sectioning, and radiographic assessment [5,8,9,11-13]. For radiographic evaluation both traditional radiographs and new digital radiographs have been used in the past for this reason [8,15,21-24]. Previous research has shown the advantages of digital radiograph for evaluating filled canals [8,10,24]. The present study used digital radiograph for evaluating filled canals. The majority of the evaluations, on the other hand, were limited to natural primary teeth and compared two or three methods. The present study aims to fill this gap, since the best technique of root canal obturation in primary teeth is still required. Differently from previous studies, in which the sample consisted of natural extracted teeth [8,14,15]; this study assessed the quality of root canal obturation using polymer-based prototyped primary maxillary central incisors. When evaluating the consistency of a root canal filling, it's important to understand the anatomic diversity of the root canals rather than a single tooth, since procedure

problems are actually more common in variations in regular root canals than in standardization anatomy. According to previous studies, the use of these prototyped resin replicas is very promising and has the ability to be used for educational purposes, endodontic testing, and analysis due to sample standardization, which allows laboratory-based studies to test root canal instrumentation [10,22].

The present study used both filling pastes of obturation to compare quality of obturation because the evidence suggests that zinc oxide/iodoform/calcium hydroxide (ZO/iodoform/CH) and zinc oxide eugenol (ZOE) may be a better choice for pulpectomy [23]. The purpose of this research was to compare the efficiency of different obturation techniques in primary teeth. The cost-effectiveness, ease of availability, and material manipulation of six different obturation methods were considered in this report.

In the present study, modifications were used for the criteria of obturation of Coll et al. Sigurdsson et al. [19,20]. Other criteria in the literature were reported by Memarpour et al. [15] The root canal filling was considered in this study as acceptable regarding density of obturation if observed one to three voids in the canal. The ideal filling technique should provide a minimum number of voids, since voids in the obturating material will provide channels for leakage [1,8,15].

Different studies reported that the lentulo spiral is an effective technique for obturation of primary teeth [5,22]. However, in the present study, the motor driven lentulo spiral technique demonstrated the worst results

regarding density of obturation as 90% of root canal fillings with ZOE inserted by motor driven lentulo spiral technique and 50% of root canal fillings with MetapexR inserted by motor driven lentulo spiral technique were considered unacceptable in quality of obturation. Wherever, the obturations completed with ZOE by injection technique were considered optimal length and acceptable obturation technique in 80% of prepared canal. These results are inconsistent with previous studies which had reported poor results regarding obturation density when using ZOE by this technique [21,22,24]. However, this technique still exhibited the disadvantages reported by previous study [15], including the possibility of ZOE being locked in the needle during injection and the need for repeatedly changing the needle, and even some cartridges fractured. In the present study, in order to overcome such a problem, the needles used were plastic and disposable tip with disposable syringe.

For the obturations completed with MetapexR, though, were considered good or acceptable in all obturation techniques of prepared canal. Similar results were seen in a *vitro* study conducted by Aragao et al. [10]. They found VitapexR, and ZOE performed better effectiveness of canal filling with syringe [10]. These results are inconsistent with the study reported by Guelmann et al. [8] in which VitapexR syringe technique displayed poor results.

The results also demonstrated an influence of the application technique in quality of obturation. A statistically significant difference was noticed regarding quality of obturation when using reamer. Removing and reinserting the reamer on a regular basis is time-consuming. These results which study indicated worse scores in quality of obturation by this technique that could be because use by hand, have a major tendency to be underfilled and created void. The hand reamer's design allows it to delivered paste in an uneven manner into root canals and allowing the paste to underfilled and create unacceptable density in the root canals. The results of this study inconsistent with finding of Nagar et al., who observed a higher number of voids with an insulin syringe than with a conventional hand reamer [25]. The discrepancies in the results from other studies may be explained by differences in the methods used.

The results of this investigation should consider the limitations of the study, including the limited sample size in each group. Additionally, since the present study used two-dimensional radiographic to evaluate the quality, and since the voids are three-dimensional objects, it seems logical that the recorded may be different than the three-dimensional radiographic images. Despite the advantage of using cone beam computed tomography (CBCT) for evaluation quality of obturation has limitation for use in polymer-based prototyped primary maxillary central incisors. The major difference in composition of polymer-based prototyped compare to filling show greater distortion in the image. According to Akhil et al., digital radiograph performed better than CBCT in detected voids. In day practice, digital radiograph

provides easy accessible, user friendly, use low radiation, and are less expensive compared to CBCT [25]. However, further studies should be performed with larger sample size and using Micro-CT for higher resolution tomographic technique to evaluate the obturation quality.

CONCLUSION

Based on the results of the current *in vitro* study, the following conclusions can be made:

- All tested filling pastes and techniques may be used to obturate primary teeth.
- Injection technique produced the best results in both length and quality of obturation.
- Group 4- ZOE inserted by injection exhibit best scores in quality of obturation, while Group 5- ZOE inserted by reamer exhibit lowest scores.
- Obturation technique by using reamer showed a statistical difference between ZOE and MetapexR in quality of obturation.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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