Research Article

Comparison of the quality of three obturation techniques in primary anterior teeth using cone-beam computed tomography: An in vitro study

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Abstract: Background: This study aimed to compare the number of voids of primary anterior teeth obturated with Endoflas by using three different obturation techniques, namely, endodontic pressure syringe, modified disposable syringe, and reamer using cone-beam computed tomography (CBCT). Materials and Methods: Thirty-six single-rooted primary incisors and canines with lengths ranging within 15–22 mm were randomly divided into three groups (12 teeth/group) according to the obturation techniques used. Group A, endodontic pressure syringe; group B, modified disposable syringe; and group C, reamer. A single operator instrumented and obturated all teeth by using Endoflas. An independent evaluator analysed the quality of the obturation techniques by using CBCT imaging to determine the number of voids in the root canals. Fisher's exact test and multiple pairwise comparisons adjusted by the Dunn–Bonferroni method were used to statistically assess the results. Results: All study groups showed no statistically significant difference in the number of voids ($P > 0.05$). Comparing the thirds of each group, the coronal and middle thirds of group A contained the maximum number of voids, followed by groups B and C, with no statistically significant difference. For the apical third, voids were highly presented in group C followed by group B. Meanwhile, group A was found to have no voids. Conclusion: Within the limitations of the current research, we concluded that voids existed in all techniques used; however, they were the least when using endodontic pressure syringes. Thus, an endodontic pressure syringe used with an Endoflas obturation material may be preferred as an obturation technique.

Keywords: cone-beam computed tomography, Endoflas, obturation techniques, primary teeth, pulpectomy, reamer.

Introduction

Dental caries is one of the most prevalent infectious oral-health conditions in humans despite substantial advancements in preventive dentistry [1,2]. A pulpectomy is one of many therapeutic approaches that can be used to maintain the functional state of a primary tooth with severely infected or necrotic pulp until normal exfoliation. This approach involves removing the infected pulp tissue and debris from the canals and filling them with an appropriate resorbable paste [3]. Successful pulpectomy requires obturation to an optimal length with minimum voids [4]. It depends on the appropriate case selection and the usage of a stable, nontoxic material with proper technique of obturation that provides a three-dimensional (3D) seal of the root-canal system to prevent microorganisms and tissue fluids from percolating into the root-canal system [5]. Different obturation techniques and materials have been used to obtain a good apical seal with minimum voids [6]. The most commonly used obturating materials in primary teeth are zinc oxide eugenol, calcium hydroxide, iodoform, and/or a combination of these. However, none of them satisfy all the requirements of an ideal filling material [7,8]. Sanlor Laboratories in Colombia, South Africa introduced Endoflas, a substance combining zinc oxide eugenol (ZOE), iodoform, and calcium hydroxide. Its hydrophilic characteristic allows it to produce a good hermetic seal [9].

Compared with frequently used obturating compounds such as ZOE and Metapex, Endoflas demonstrated noticeably better antibacterial activity and long-term substantivity [10,11]. Obturation should be performed using the most appropriate technique. It depends on the cost effectiveness of the carrier used to transport the material to the canal, the simplicity of obturation, and the control and manipulation of the material for a satisfactory result. Primary endodontic procedures offer treatment choices for teeth with advanced pulpal pathology caused by caries or trauma. The most prevalent application of these techniques uses an endodontic pressure syringe, lentulospiral, incremental technique, disposable injection technique, insulin syringe, mechanical syringe, tuberculin syringe, jiffy tube, reamer, and Navi tip [12,13].

Radiographs, dye penetration, radioisotopes, bacterial leakage, fluid filtration, clearing techniques, and digital radiography methods such as cone-beam computed tomography (CBCT) can be used to evaluate obturation quality in vivo or in vitro [1,3,13]. Charged coupled device, photostimulable phosphorus-coated plate, and complementary metal oxide semiconductor are components of a two-dimensional digital intra-oral receptor [14]. Nevertheless, it does not evaluate the completeness of obturation in three dimensions, which is its main drawback. Thus, dentists needs a relatively new and advanced technology like CBCT Without cutting the research material into sections, CBCT may provide more accurate 3D information on different tooth anomalies, enable the volumetric analysis of root-canal fillings, and help determine the complex morphology of roots canals [1,3,14,15]. Contrary to traditional computed tomography CT, CBCT has fewer artifacts and lower radiation dosage (16). Although an increase in noise is observed in CBCT, its small voxel sizes (76–400 m) and limited field of view provides an excellent image quality for endodontic applications [17,18].

We found no available data comparing the obturation quality of endodontic pressure syringe, modified disposable syringe, and reamer using CBCT Hence, the present *in vitro* study aimed to compare the quality of obturation (number and location of voids) in primary teeth among three obturation techniques, namely, endodontic pressure syringe, modified disposable syringe, and reamer, by using the CBCT image. Null hypothesis stated that no difference in the quality of obturation (number and location of voids) in primary teeth can be found among the three obturation techniques.

Materials and Methods

After obtaining ethical approval from the Ethics Committee, College of Dentistry, University of Baghdad (Ref. 570 on April 17, 2022), this *in vitro* study was performed at the Department of Pediatric and Preventive Dentistry, College of Dentistry, University of Baghdad. Thirty-six single-rooted primary incisors and canines were extracted in children aged 3–13 years owing to various reasons (including (1) abscess, (2) pulpitis, (3) trauma, and (4) orthodontic consideration) [19]. A consent form was obtained from the parents, including approval to use their children's teeth.

The inclusion criteria of teeth were in accordance with those described by Irzooqee et al. [20] as follows:

1. The apical openings were not wider than a #30 K- file.
2. Straight roots were 15–22 mm long when measured from the incisal edge to the root apex.

Teeth exhibiting root canal obstruction, gross decay, or fracture were excluded from the study. The selected teeth were cleaned and preserved in distilled water until use [20].

Using a diamond disc bur and a straight handpiece, all selected teeth were decoronated at 10 mm length [21-23]. A barbed broach was used to remove the infected necrotic pulp tissue. The working length was determined to be 1 mm shorter than the radiographic apex. The canals were biomechanically prepared using K-files (G-star Medical Co., Ltd., Guangdong, China) with 50# K file as the final size [24]. During canal preparation, the canals were repeatedly irrigated with 1 mL of 2.5% sodium hypochlorite (NaOCl) by using 27-gauge side vented closed-ended needles between the used instruments to flush out debris [25]. After instrumentation, 2 mL of 2.5% NaOCl was used to irrigate the canals. The final step was the irrigation with 1 mL of ethylenediamine tetraacetic acid for 1 min, followed by 3 mL of 2.5% NaOCl. We used 5 mL of normal saline between each active irrigant to prevent their interaction, after which 5 mL of

distilled water was used for a final rinse [26, 27]. After the root canals were instrumented, they were dried using absorbent paper points.

The study sample was calculated using G power 3.1.9.7 and then divided using simple random allocation into three experimental groups (12 teeth/group) based on the obturating technique used. Group A used an endodontic pressure syringe, group B used a modified disposable syringe, and group C used a reamer.

The same operator obturated each canal with Endoflas by using the specific obturating method designated for that particular group. A standardized Endoflas mixture was made for each technique, taking into account the technique's limitations and the manufacturer's recommendations. The physical limitations of each technique contributed to the difference in consistencies of the Endoflas mixture [28].

Endodontic pressure syringe (Group A)

According to manufacturer instructions, one scoop of Endoflas powder was combined with one drop of liquid to create a thick consistency paste. A 25-gauge needle was used to extrude the mixture because of the pressure syringe's mechanical design (which functions via a screw mechanism). After inserting the needle into the root canal, it was gradually removed from the canal at a rate of 3 mm every quarter turn of the screw until the canal was visibly full [29].

Modified disposable syringe (Group B)

One scoop of Endoflas powder was mixed with three drops of liquid to create a thin mixture [30]. The disposable tip (Meta Biomed) was fitted to the disposable syringe (Dispo Van, India). The mixture was loaded into the syringe, and any air bubbles were repeatedly eliminated by tapping the syringe against a hard surface. The material flow was then evaluated. A rubber stop was positioned at the desired working length. The tip was inserted into the prepared canals. The syringe was gradually retracted as the substance was introduced until the canal opening was visibly full [30].

Reamer technique (Group 3)

One scoop of Endoflas powder were mixed with two drops of liquid to obtain a medium-consistency paste [31]. A rubber stop was positioned at the desired working length on an endodontic reamer size 30. The rubber stop was then coated with Endoflas and inserted into the canal five to seven times with a vibratory motion and in an anticlockwise rotation until the canal's opening appeared to be filled with paste [32].

To allow the setting of Endoflas, the obturated samples were stored in an incubator for 24 h at 37 °C and 100% humidity [33]. The obturated samples were placed in silicon blocks in a C shape for the CBCT assessment. Each block comprised four teeth.

For each block, CBCT exposure was performed for the quadrant of arch. The field of view was 5 cm height, 5 cm diameter, and 75 μm voxel size. At 6.3 mAs, 90 kVp, and 12 s, the image was captured. The reconstructed image was completed using computer software on a 15.6-inch screen size and a display resolution of 1366 × 768 pixels. Radiologist who was blinded to the groups of the study performed the analysis and measurement of the CBCT data. Interexaminar and intraexaminar calibrations was performed with the help of radiologist to confirm the result. Twelve examination was performed per day to avoid eye fatigue. Kappa analysis was calculated to check intra- and inter-observer agreement.

All images were analyzed with software version 5.4. From the axial view, the root which had to be measured for its voids number was selected. After viewing the entire root length in the sagittal view, the root was divided into three-thirds (coronal, middle, and apical) from the pulp chamber to the apex of each root by using tool measurements and magnification (typically, every root third was about 3 mm),

as shown in Fig. 1. Then, the number of voids in each root third was calculated. Only the confirmed findings were included after three reviews of each case [34].

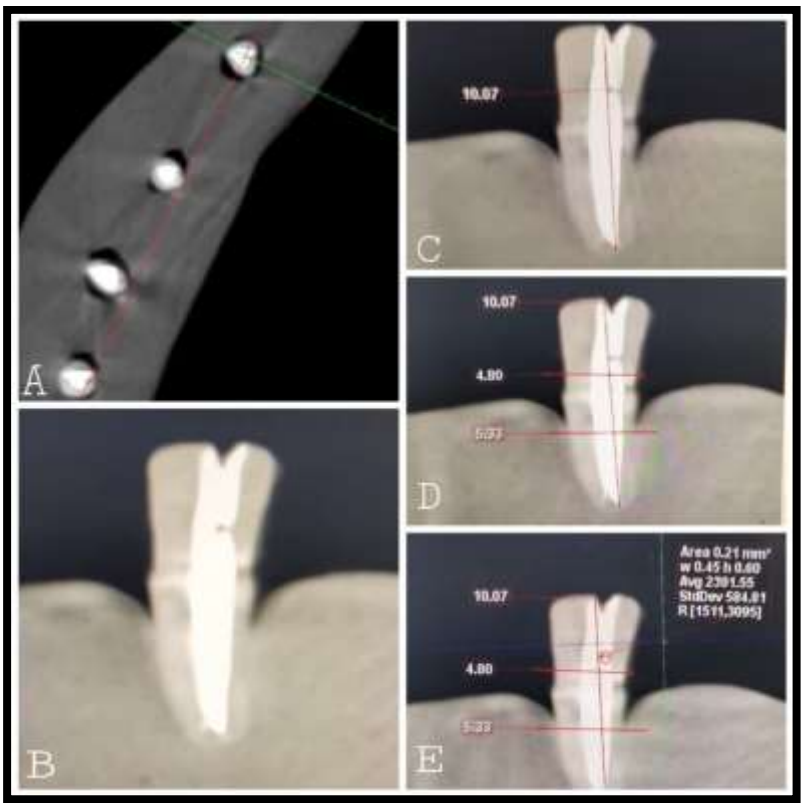

Figure 1: CBCT images: A: axial view of obturated roots, B: sagittal view of single tooth, C: root length measurement, D: root divided into three thirds, and E: determination of voids.

Statistical analysis

Data were entered into a digital database structure on MS Excel with SPSS (version 22, Chicago, IL, USA). The data were analysed using Fisher's exact test and multiple pairwise comparisons (MPCs). The significance level was set at $p < 0.05$.

Results

According to the results shown in Table 1 and Figure 2, all study groups showed voids with no statistically significant difference between groups ($P > 0.05$). Group A had the lowest number of voids followed by Group B, and the highest number of voids was found in Group C. All voids in group A located in the coronal and middle thirds, whereas groups B and C. They were primarily located apically. Comparing the apical third among the different groups, group A was found to have no voids which were statistically significantly less than those of groups B and C (P=0.000).

Table 1: Distribution of voids among thirds and groups.

Thirds**	Presence of voids among Groups*				
	A	B	C	X^2	p-value
C	13	6	6	4.744	0.093
M	13	10	6	3.195	0.202
A	0	15	20	24.535	0.000*
Fisher exact	20.660	4.923	14.500		
p-value	0.000*	0.099	0.001*		
Total	26	31	32	0.877	0.645 N.S

*Group A: Endodontic pressure syringe, Group B: Modified disposable syringe, Group C: Reamer.
**Thirds: C: Coronal third, M: Middle third, A: Apical third.* Significant, p<0.05

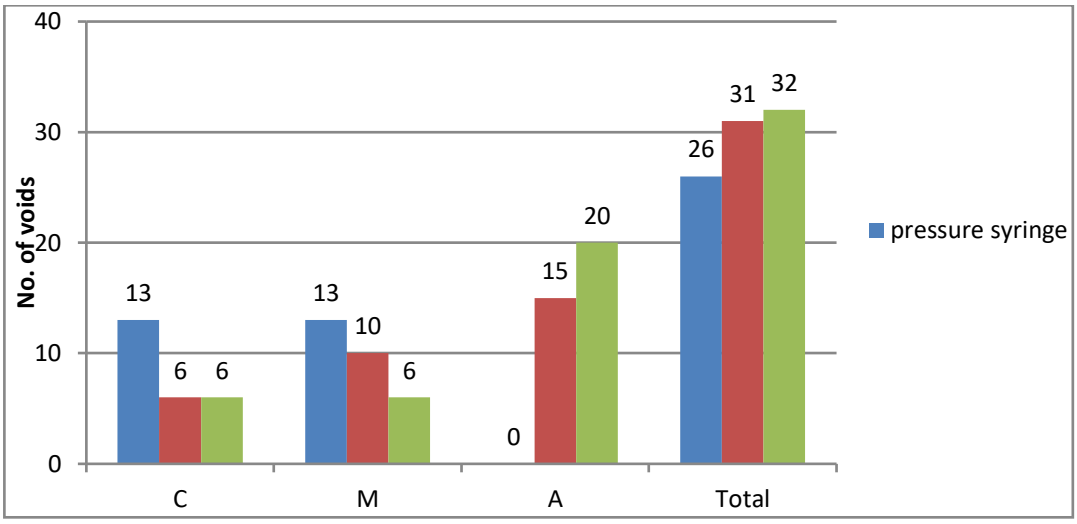

Figure 2: Bar chart showing the number of voids in the study groups in each third, C: coronal third, M: middle third, A: apical third.

Following MPCs in the apical third, the difference between groups B and C was not significant, whereas the difference between groups A and B and between groups A and C were significant. Only the difference between the coronal and the middle thirds was not significant, whereas other results were significant (C-A and M-A), Table 2.

Table 2. Multiple pairwise comparisons between the thirds.

	MPC	Group C**	MPC	MPC in the apical
Group A*	C X M=1		C X M=1 N.S.	A X B<0.001*
	C X A<0.001*		C X A=0.002*	A X C<0.001*
	M X A<0.001*		M X A=0.002*	B X C=0.289

*Endodontic pressure syringe, ** Reamer, *Significant, p<0.05
C: Coronal third, M: Middle third, A: Apical third.

Discussion

The success of pulpectomy treatment cannot be guaranteed if voids remain in the root canals following obturation. The presence of these voids leads to leakage, leading to the regrowth of microorganisms and subsequent infection. The likelihood of developing a post-treatment disease rises when multiple large-sized voids exist [35-37]. The present study compared and evaluated the root-canal obturation of primary teeth using three different obturating techniques. A single biomechanical preparation technique and a single obturating material were used to keep these two variables constant (Endoflas was utilized in this study) [1].

The rationale behind using Endoflas as an obturation material was the discovery that Endoflas resorption is equivalent to the physiological root resorption with no hollow tube effect, making it an ideal obturating material for primary teeth [42-44]. Compared with alternative obturation materials for primary teeth, Endoflas is superior in its ability to decrease inter-radicular radiolucency. The incredible healing qualities and broad antibacterial activity of Endoflas are attributed to the presence of $Ca(OH)_2$ and iodoform, so this reduction makes it reasonable [45]. Furthermore, maintaining an airtight seal demonstrates the resorption of the extruded material without intracanal resorption [46]. It is superior to ZOE and Metapex in terms of entire bone regeneration and 100% reduction in furcal radiolucency owing to its antibacterial characteristics. It can serve as a filling material in mild, humid canals owing to its hydrophilic qualities [47]. According to findings from recent studies, Endoflas can be utilized as an effective obturating material as it has antibacterial qualities that allow it to sterilize dentinal tubules and difficult-to-reach accessory canals [39,44]. Endoflas can also produce a good hermetic seal owing to its hydrophilic property [40,45]. Studies have

shown that the endodontic pressure syringe, modified disposable syringe, and reamer systems used in this study can be successfully used to deliver Endoflas to optimally fill the root canals of primary teeth [30,46].

The reason behind using a modified disposable syringe is that it has several advantages, including the fact that it was intended for single use only and it can be discarded immediately without risk of contamination. For optimal root-canal obturation, the disposable tip can be trimmed to the desired length. Considering that the tip is transparent, the operator may monitor the material's flow, and no risk of fracture exists [30].

The filling quality was subsequently evaluated by CBCT. The added advantage of CBCT was that it allowed for a 3D study of the filled canals in extremely thin slices. This process enabled the detection of more voids inside the fill and along the canal walls [1].

In this study, we found that regardless of the technique utilized to obturate the root canals, all resulting fillings had voids. This finding was in accordance with previous ones. However, no statistical significant difference ($p>0.05$) in the mean number of voids existed across the three groups. These findings agreed with those reported by Nagarathna et al.[46] who revealed that no statistical significant difference existed with respect to the mean number of voids in obturation when using a pressure syringe or hand-instrument technique. The coronal, middle, and apical thirds were examined separately during CBCT evaluation.

In the apical third, group A had no voids, and a statistically significant difference existed among the three groups. This result coincided with those of Vashista et al. [48]. The reason may be that the pressure syringe that was made of a flexible, thin metal tip. This tip enabled easier access into the narrow canal, resulting in more dense filling [49]. The larger number of voids in the reamer technique can be related to air bubbles captured during material manipulation or the repetitive removal and reinsertion of the reamer into the root canal [45].

We also found no significant difference in the number of voids at the apical region between the modified syringe and reamer groups. Although the previous group had a lower mean number of voids, air reaching the chamber of the syringe during material loading may induce voids in obturation when using a modified disposable syringe, thereby generating these voids [30]. Our findings contradicted that of Nagarathna et al. They found a significant difference between the modified disposable syringe technique and the hand-instrument technique in terms of the number of voids in the apical third of the root canal [30]. The discrepant findings may be due to the difference in (1) the hand-instrument technique used (handheld lentulospiral in the study of Nagarathna et al.), and (2) the method used for evaluation (digital radiograph in the study of Nagarathna et al.). The endodontic pressure syringe produced the highest number of voids in the coronal and middle thirds, followed by the modified disposable syringe and reamer technique, with no statistically significant difference between these groups. This result was consistent with that of Pandranki [46]. They reported that the creation of voids in the coronal and middle third of the endodontic pressure syringe group may be due to problems with putting the rubber stopper and withdrawing the needle while expressing the material. This action prompts the operator to constantly take out the syringe, which in turn relocating the filling material, producing voids. Consequently, the filling becomes imperfect.

The present study had some limitations. First, only anterior primary canals were evaluated. No assessment was made regarding the efficacy of the three techniques in obturating the small, narrow, and tortuous canals of primary molar teeth which is challenging for any dentist. Therefore, additional research on posterior primary teeth using a larger sample size is recommended.

Conclusion

Within the limitations of the current research, we concluded that voids were observed in all techniques used; however, the least number of voids was with endodontic pressure syringes. Thus, when used with Endoflas obturation material, an endodontic pressure syringe may be preferred as an obturation technique.

Conflict of interest

The authors have no conflicts of interest to declare.

Author contributions

AHMJ; study conception and design. AFI; data collection. AHMJ and NA.; Methodology. AHMJ, MOMI, OAB and AFI; statistical analysis and interpretation of results. AFI; original draft manuscript preparation. AHMJ and AFI; Writing & editing. Supervision; AHMJ and OAB. All authors reviewed the results and approved the final version of the manuscript to be published.

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Informed consent

Informed consent was obtained from all individuals (or their guardians) who participated in this study.

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مقارنة بين جودة ثلاث تقنيات سد جذور الأسنان الأمامية الأولية باستخدام التصوير المقطعي المحوسب بالأشعة المخروطية: دراسة في المختبر

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المستخلص:

مقارنة عدد الفراغات في معالجة قناة الجذر للأسنان الأمامية الأولية باستخدام ثلاث تقنيات سد مختلفة ، وهي محقنة الضغط اللبية ، والمحاقن المعدلة احادية الاستخدام، والمخرطة باستخدام التصوير المقطعي المحوسب للشعاع المخروطي (CBCT). تم تقسيم اثنين وأربعين من القواطع والأنياب الأولية أحادية الجذور بطول يتراوح من 15 إلى 22 مليمتر بشكل عشوائي إلى ثلاث مجموعات (14 سنًا / مجموعة) وفقًا لتقنيات السد المستخدمة. المجموعة أ: حقنة الضغط اللبية، المجموعة ب: حقنة معدلة ، المجموعة ج: مخرطة. تم تجهيز جميع الأسنان وتثبيتها باستخدام Endoflas بواسطة عامل واحد. تم تقييم جودة تقنيات السد باستخدام التصوير CBCT لتحديد عدد الفراغات في قنوات الجذر بواسطة مقيم مستقل. تم تحليل النتائج إحصائياً باستخدام اختبار Fissure 's exact test and multiple pairwise comparison adjusted by dunn-bonferroni method. عند المقارنة بين ثلثي كل مجموعة ، وجد أن الثلث الإكليلي والثلث الأوسط من المجموعة أ يحتويان على أكبر عدد من الفراغات تليها المجموعة ب بينما الأقل في المجموعة ج مع عدم وجود (P> 0.05). لم تظهر جميع مجموعات الدراسة فروق ذات دلالة إحصائية في عدد الفراغات

فرق معنوي إحصائي. بينما بالنسبة للثلث القمي ، كانت أعلى نسبة من الفراغات موجودة في المجموعة ج تليها المجموعة ب بينما وجدت المجموعة أ بدون فراغات. في حدود الدراسة الحالية ، استنتج أن الفراغات لوحظت في جميع التقنيات المستخدمة ؛ ومع ذلك ، كانوا الأقل مع حقنة الضغط اللبية. وبالتالي ، عند استخدامها مع مادة سد Endoflas ، يمكن تفضيل حقنة الضغط اللبية كتقنية سد.