A Comparative Analysis of Voids and Sealing Ability of Different Obturating Techniques Using CBCT

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Abstract

Aim: To evaluate voids and sealing ability using a disposable syringe, endodontic pressure syringe, and Skinni syringe with NaviTip in primary molars with cone-beam computed tomography (CBCT).

Materials and methods: The 15 extracted primary mandibular molars with at least one root ≥8 mm length and an equal number of mesiobuccal canals were divided into three groups, i.e., obturation using a disposable syringe, an endodontic pressure syringe, and a Skinni syringe with NaviTip, respectively. The evaluation of the apical seal was determined as the measurement between the apical end of the filling material and the radiographic apex. The quality of the filling was determined by the size, number, type, and location of voids present. Statistical analysis was done using the Chi-square test and post-hoc test.

Results: The endodontic pressure syringe score was the highest and statistically significant in obtaining apical seal (p = 0.013). Disposable syringe shows highest size of voids (p = 0.01) in which type I-voids (p = 0.04) and type S-voids (p = 0.07) were statistically significant. The location of voids was maximum at the middle third of the root (p = 0.016).

Conclusion: The endodontic pressure syringe provided the best root canal obturation of primary molars, whereas the disposable syringe was least effective with the maximum number and size of voids.

Clinical significance: Comparing the voids and sealing abilities of different obturating techniques with CBCT would help the pediatric practitioners for better outcome of obturation in primary teeth.

Keywords: Cone-beam computed tomography, Obturation technique, Primary teeth, Pulpectomy.

Introduction

Pulpectomy of primary teeth has been a subject of much controversy, owning to the damage to developing permanent tooth buds and the belief that the tortuous root canals of primary tooth could not be adequately negotiated, cleaned, shaped, and filled, which would lead to needless extraction and sacrifice of such primary teeth. Therefore, the preservation of primary teeth in a healthy state remains the ultimate goal of dentistry, until the succedaneous teeth erupt in the oral cavity.¹

The success of pulpectomy not only depends on proper case selection and root canal filling material used, but also on the proper technique of root canal obturation. The quality of the root filling material is greatly affected by the proper cleaning, shaping, and three-dimensional (3D) hermetic sealing of the root canal system. Obviously, better quality sealing improves the tooth’s prognosis.²

An ideal obturation technique should fill the canal completely and homogeneously without any voids along the whole length of the canal with proper apical seal.³ The presence of voids in root canal filling can provide pathways for leakage. S-voids are very common in the coronal third of the canal filling, whereas I-voids occurs mainly in the apical third.⁴ However, detection of voids is difficult in apical and coronal part of root canal filling. None of the root canal instrumentation and filling methods ensured void-free obturation. To attain the goal, various root canal obturating techniques such as the use of a handheld lentulo spiral paste filler, engine driven lentulospiral paste filler, endodontic plunger, endodontic pressure syringe, reamers, tuberculin syringes, paper points, and the NaviTip system were introduced.⁵,⁶

For evaluating the obturated canal in terms of length of fill, apical seal, voids, and quality of fill, various assessment techniques, including digital radiography, dye penetration procedures, radioisotopes, fluid filtration, bacterial leakage, and CBCT were tried.⁶ It was observed that more advanced technologies such as CBCT provide much better assessment of canals which is used for the 3D imaging of dentofacial structures.⁷ This technique produces images with much thinner slice thicknesses than conventional CT methods, provides a low radiation dose and benefits from a faster scanning system. Cone-beam computed tomography has been used for studying the root canal morphology and efficacy of obturation of primary teeth.⁶ To our knowledge, there have been very few studies that compare voids and sealing ability in primary tooth buds and the belief that the tortuous root canals of primary tooth could not be adequately negotiated, cleaned, shaped, and filled, which would lead to needless extraction and sacrifice of such primary teeth. Therefore, the preservation of primary teeth in a healthy state remains the ultimate goal of dentistry, until the succedaneous teeth erupt in the oral cavity.¹

The 15 extracted primary mandibular molars with at least one root ≥8 mm length and an equal number of mesiobuccal canals were divided into three groups, i.e., obturation using a disposable syringe, an endodontic pressure syringe, and a Skinni syringe with NaviTip, respectively. The evaluation of the apical seal was determined as the measurement between the apical end of the filling material and the radiographic apex. The quality of the filling was determined by the size, number, type, and location of voids present. Statistical analysis was done using the Chi-square test and post-hoc test.

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teeth. Therefore, it seems necessary to conduct a study to compare the voids and sealing ability of three different obturating techniques, such as disposable syringe, endodontic pressure syringe, and Skinni syringe with NaviTip using CBCT in extracted human primary molars.

**Materials and Methods**

The research protocol was reviewed and approved by the institutional ethical committee. The present in vitro study was conducted in the Department of Pedodontics & Preventive Dentistry, Patna, during 2019–2021 and the sample size consisted of 15 extracted primary molar teeth. Inclusion criteria were human primary molar teeth having at least one root with ≥8 mm root length indicated for extraction and root canals without internal resorption, calcifications, and fractures after observation of pre-operative intra-oral periapical (IOPA) X-ray. Exclusion criteria included extensively carious primary molar teeth/unrestorable teeth/caries extending to the roots and furcation, roots showing areas of external resorption on lateral surfaces of root and fractures, and roots showing any developmental root anomalies. The extracted 15 primary molars were immediately placed in 10% formalin (Meru Chem Pvt. Ltd, Mumbai, India) after extraction. Afterwards they were thoroughly cleaned with pumice slurry, rinsed with water, and again stored in 10% formalin. The extracted primary molars with 48 root canals were evaluated visually and radiographically, out of which 30 root canals were found suitable for the study, and care was taken to ensure that an equal number of similar root canals were allotted to the three study groups (e.g., an equal number of mesiobuccal canals of mandibular molars to each group, etc.) to avoid any bias.

The samples were then divided into three groups as:

**Group I:** 10 root canals obturated using the disposable syringe (size 24 gauge, 5/16th inch; DispoVan, HMD, Ballabgarh, Faridabad, Haryana, India)

**Group II:** 10 root canals obturated using the endodontic pressure syringe (Pulpdent, Watertown, Mass., USA)

**Group III:** 10 root canals obturated using the Skinni syringe with NaviTip (29 gauge cannula and 21 mm length; Ultradent Products, Inc., South Jordan, Utah, USA)

Each tooth was placed on an absorbent paper to air dry and mounted in a block of wax approximately 10 mm in height or to the level of the cervical area of each tooth from the apex of the longest root available. Access cavity was prepared with #4 round diamond bur (Dentsply, Mailerfer, Switzerland) and the radicular pulp remnants were removed using barbed broaches (21 mm, Dentsply, Mailerfer, Switzerland), followed by irrigation with 1% sodium hypochlorite (Neelkanth Health Care (P) Ltd, Jodhpur, Rajasthan, India) and normal saline (HIGGS Healthcare, Baddi, Himachal Pradesh, India) alternatively and working length was determined radiographically by subtracting 1 mm from the total canal length. The biomechanical preparation was completed with 35K file (21 mm, Dentsply, Mailerfer, Switzerland) and the canals were dried using sterile paper points and pre-obturated CBCT was obtained using On-Demand software for scanning under CS 9300 system (Carestream Health, Rochester, NY, USA) using Carestream Dental Imaging Software v.3.5.7 (Carestream Dental, Atlanta, GA, USA). A standardized mix of zinc oxide eugenol (ZOE) (DPI Ltd, Mumbai, Maharashtra, India), 0.400 mL eugenol/gram of zinc oxide was prepared on a dry glass slab at room temperature for 45 seconds as specified by Aylard and Johnson for root canal obturation. In all the groups, when the canal was assumed to be filled, a wet cotton pellet was used to lightly press the material inside the canals and post-intervention analysis was carried out immediately after obturation.

The single operator, after learning and mastering the procedure under the supervision of expert radiologist, had analyzed and performed all the volumetric measurements required (pre- and post-obturation) through CBCT using On-demand software. The scanning protocol was used sagittal plane; 20 seconds scanning time; 84 kv; 5 mA; 5 cm × 5 cm field of view; and 6.07 mGy.cm² radiation. The prepared root canal area was measured from the canal orifice to the root apex by measuring the area of each slice. The thickness of each slice was fixed at 0.045 mm for measuring the area of each slice. The area was marked and finally computed automatically using On-demand software. The volume of each slice was then calculated by multiplying the root canal area by the slice thickness (0.045 mm). The pre-obturated (X) of each canal was calculated by adding the individual volume of each slice of the root canal from the canal orifice to the radiographic apex.

**Criteria for Evaluation** – The comparison among the three techniques was determined by evaluating the following:

1. **Apical seal** was defined as the measurement (mm) between the apical end of the filling material and the radiographic apex (Fig. 1).

   Scoring criteria for apical seal: Score 1 – Obtained apical seal, Score 2 – 1 mm less than the radiographic apex, and Score 3 - >1 mm less than the apical seal.

2. **Quality of filling** was defined as the measurement (mm) of the largest dimension of any voids within the filling material, i.e., number of voids present, types, and location of voids.

Figs 1A and B: CBCT images of (A) Canal preparation; (B) Optimal achievement of apical seal
present at the cervical 1/3, middle 1/3, and the apical 1/3. Size of the voids was measured and standardized, given a score 1 as \( \leq 1 \) mm, score 2 as \( \geq 1–2 \) mm, and score 3 as \( > 2 \) mm (Fig. 2).

3. **Statistical analysis:** Data analysis was done using the Statistical Package for Social Sciences (SPSS) version 15.0. Chi-square test was used to compare the categorical data and post-hoc test was done for intergroup comparison. The significance level for the statistical test utilized in this study was set at \( p < 0.05 \% \).

**Results**

Table 1 shows the scoring of 1, 2, and 3, with score 1 was at the level of apical seal, score 2 was 1 mm less than the radiographic apex, and score 3 was more than 1 mm less than the apical seal. Nine canals were obturated with a disposable syringe in which 2 canals obtained score 1, 2 canals obtained score 2, and 5 canals obtained score 3. Nine canals were obturated with endodontic pressure syringe in which 6 canals obtained score 1, 3 canals obtained score 2, and none of the canals obtained score 3. Nine canals were obturated with a Skinni syringe with NaviTip in which 5 canals obtained score 1, 4 canals obtained score 2, and none of the canals obtained score 3.

The frequency of apical seal with endodontic pressure syringe was better and a statistically significant relation was observed between three groups in respect to apical seal (\( p = 0.013 \)).

Table 2 shows the size, type, and location of voids. The maximum numbers of voids (14) were seen with a disposable syringe in which 5 canals void sizes were \( \leq 1 \) mm (score 1), 9 canals void sizes were \( \geq 1–2 \) mm (score 2), and none of the canals found with score 3. In 6 canals of endodontic pressure syringe, 5 canals obtained void size of \( \leq 1 \) mm (score 1), 1 canal obtained void size with \( > 2 \) mm (score 2), and none of the canals obtained score 3. Five canals were obturated with NaviTip in which 5 canals void sizes were \( \leq 1 \) mm (score 1) and none of the canals found with score 2 and 3. In disposable syringe I-type voids (very common in apical area) were found in 6 of the canals and S-type voids (very common in coronal third area) were found in 8 of the canals. In endodontic pressure
syringe, I-type voids were found in 1 canal and S-type voids were found in 5 canals, whereas in NaviTip I-type voids were present in 1 of the canals and S-type voids were present in 4 of the canals. Location of voids; in a disposable syringe, 3 canals found voids in the cervical third, 7 canals found voids in the middle third, and 4 canals found voids in the apical third. In the endodontic pressure syringe, 1 canal found voids in the cervical third, 4 canals found voids in the middle third, 1 canal found void in the apical third. None of the canal found voids in the cervical third using a Skinni syringe with NaviTip, 4 canals found voids present in the middle third, 1 of the canal found voids in the apical third. Comparing the size of voids it was maximum with disposable syringe (9) which was statistically significant ($p = 0.01$). The “I” and “S” type of voids were maximum with disposable syringe and minimum with Skinni syringe with NaviTip that was statistically significant ($p = 0.04$ and $p = 0.07$). The location of voids at the cervical (1), middle (4), and apical third (1) was minimum seen with endodontic pressure syringe which was statistically significant ($p = 0.016$).

Table 3 shows intergroup comparison of size and type of voids with their location within the canal between disposable syringe, endodontic pressure syringe, and Skinni syringe with NaviTip that was statistically non-significant.

### Discussion

Severely infected primary teeth can be saved successfully by pulpectomy which consists of extirpation of pulp tissue followed by obturation with resorbable biocompatible materials. The success of pulpectomy mainly depends on proper disinfection/debridement of the root canal and with quality of obturation that can be improved with better obturation technique. The quality of obturation can be assessed with the presence of voids, apical seal, and penetration of dye, bacteria or radioisotopes with different radiographic and digital imaging technique.

It has been generally accepted that all of the techniques used in the present study, such as disposable syringe, endodontic pressure syringe, and Skinni syringe with NaviTip, can deliver ZOE. ZOE is most commonly used root canal filling material for primary teeth and many investigators have assessed its clinical performance.\(^6,8,11,12\)

With the introduction of CBCT, 3D volume measurements are possible without sectioning the specimens and thus avoiding the loss of tooth material; therefore, an *in vitro* study was planned to assess the efficacy of different root filling techniques. However, very few scientific studies have been conducted to determine which technique is actually superior in its depth and quality of fill capabilities through 3D imaging system like CBCT.\(^6,8,10\)

Therefore, in the present study, CBCT was chosen as the tool for investigating the efficacy of root canal filling in primary teeth. Aylard and Johnson concluded that all techniques used to fill the canals led to voids in the filling material.\(^10\) The voids may create leakage in the paste, and thus may lead to microorganism regrowth, reinfection, and an increased risk of post-treatment disease, especially if there are several large voids.\(^12\) In the present study, voids are larger in the apical portion, smaller in the middle portion, and fewer voids are seen in the cervical third. Regarding the distribution of voids into root canal, significantly more voids were detected into the middle third, which was similar to the finding of Estrela et al.\(^13\)

The results showed statistically significant difference among the three techniques when apical seal was tested. Better apical seal was achieved by endodontic pressure syringe followed by Skinni syringe with NaviTip and disposable syringe which was similar to the findings of Dandashi et al.\(^14\) Maximum number of voids were seen with the disposable syringe and were present at the middle third area. Comparatively poor results were observed with disposable syringe in the present study as air bubbles might be entrapped in the paste during mixing of thepowder with the liquid.

The Skinni syringe with NaviTip system consists of a highly flexible metal tip that penetrates into curved, narrow canal close to the apex and injects paste rapidly and uniformly. Memarpour and Nezam also concluded that NaviTip system produced the best result in controlling paste extrusion from the apical foramen and having smallest void size and lowest number of voids\(^6,15\), whereas Guellmann and Nezam concluded that NaviTip system offered a more desirable filling quality than the lenturospiral and vitapex syringe techniques.\(^6,16\)

However, in our study, the better results of the endodontic pressure syringe could be due to the greater pressure generated by the screw mechanism leading to the smooth and continuous flow of the filling material into the irregularities of the canal, filling it laterally as well as apically. A lot of operator skill is required to operate and handle the endodontic pressure syringe compared to the other two techniques. The flexibility of the needle of the endodontic pressure syringe allowed it to bend, simulating the curvature of the root canals of posterior primary teeth, which adds to its advantage of filling the canals of primary molars, particularly those with curved root canals, more efficiently and effectively, as also found in the present study. Other than the higher cost of endodontic pressure syringe, difficulty in placing the rubber stop correctly due to refill of the hub several times during procedure may lead to over or under obturation.

According to the results of the present study, there was no statistically significant relationship between disposable syringe, endodontic pressure syringe, and Skinni syringe with NaviTip, hence we cannot consider which one is the best for root filling. The findings of this study were limited to *in vitro* primary molars. We suggest that future studies should involve a larger sample size by including more *in vitro* and *in vivo* primary molars, and conduct longer periods of evaluation. Moreover, frequently encountered *in vivo* clinical factors should be considered carefully—such as the patient’s age and cooperation level, intraoral opening, access to the involved teeth and canals, and facility or approach for the advanced system of imaging (e.g., CBCT)—that can affect the outcome when

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**Table 3:** Post-hoc analysis for intergroup comparison of the size and type of voids with respect to their location within the canal between disposable syringe, endodontic pressure syringe, and Skinni syringe with NaviTip

<table>
<thead>
<tr>
<th>Groups</th>
<th>Groups</th>
<th>Size of voids</th>
<th>p-value</th>
<th>Type of voids</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I (disposable syringe)</td>
<td>Group II (endodontic pressure syringe)</td>
<td>0.100</td>
<td>0.938</td>
<td>−0.100</td>
<td>0.920</td>
</tr>
<tr>
<td>Group II (endodontic pressure syringe)</td>
<td>Group III (Skinni syringe with NaviTip)</td>
<td>0.167</td>
<td>0.873</td>
<td>−0.500</td>
<td>0.230</td>
</tr>
<tr>
<td>Group III (Skinni syringe with NaviTip)</td>
<td>Group III (Skinni syringe with NaviTip)</td>
<td>0.067</td>
<td>0.962</td>
<td>−0.400</td>
<td>0.189</td>
</tr>
</tbody>
</table>
trying to determine the most effective and efficient obturating technique for human primary teeth.

**Conclusion**

Based on this study’s results, all three techniques, disposable syringe, endodontic pressure syringe, and Skinni syringe with NaviTip, can be used for placing ZOE in the root canals of primary molars. The endodontic pressure syringe provided the best root canal obturation of primary molars with the nearest to complete filling of the volumes of prepared root canals. In descending order, the disposable syringe was the least effective in filling the canals of primary teeth when compared to the endodontic pressure syringe and Skinni syringe with NaviTip system.

**References**