Volumetric Evaluation of Different Obturation Techniques in Primary Teeth Using Spiral Computed Tomography

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Background: *Various obturation techniques have been evaluated for better filling of the root canals in primary teeth using different methods. Spiral Computed Tomography (SCT) is a new revolution in the pediatric endodontics for assessment of quality of the obturation from 3 dimensions.* ***Objectives:*** *To evaluate the efficiency of 5 different obturation methods in delivering the filling material into the canals of primary teeth using Spiral Computed Tomography scan.* ***Study design:*** *A total of 50 canals of primary teeth were prepared, divided into 5 groups with 10 canals in each group and obturated with Zinc Oxide Eugenol cement using 5 different obturation techniques such as Local anesthetic syringe, Tuberculin syringe, Endodontic plugger, hand held Lentulo-spiral, and Lentulo-spiral mounted on slow speed hand piece. The pre and post obturation volume and finally the Percentage of Obturated Volume (POV) were calculated using SCT scan for each group. The data obtained was statistically analyzed using One-way Analysis of Variance (ANOVA) and Tukey's post-hoc test.* ***Results:*** *Lentulo-spiral hand held showed highest POV value followed by Lentulo-spiral mounted to hand piece, Tuberculin syringe and Endodontic plugger; whereas Anesthetic syringe had least POV ($P < 0.05$).* ***Conclusion:*** *Lentulo-spiral hand held is the best obturating technique among the 5 groups evaluated as the canals of this group showed maximum percentage of filled material. However, a further study with large sample size is highly essential.*

Key words: *primary teeth, obturation , Spiral CT, volumetric analysis*

INTRODUCTION

Preservation of primary teeth with normal function and in a healthy state as a natural space maintainer till their exfoliation is the primary goal of Pediatric Dentistry. Pulpectomy is the treatment of choice for primary teeth with inflamed pulp resulting from caries or trauma.[1] Essential steps of this therapy consists of removal of pulp tissue infected with micro-organisms followed by obturation of the root canal with suitable resorbable filling material and to create a three dimensional hermetic seal to prevent recurrence of infection.[2]

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Various techniques have been used to obturate primary teeth root canals like endodontic plugger,[3] tuberculin syringe,[4] disposable local anesthetic syringe,[5] endodontic pressure syringe,[6] lentulo-spiral[7] and Navi tip system.[8] However, due to the varied morphology of primary teeth like thin ribbon shaped canals, lateral branching, apical ramifications, connecting fibrils and sometimes fusion of canals, it is very difficult to provide complete obturation of the canal with a hermetic seal.[1,2]

As a result, several investigators studied the quality of different filling techniques both in vivo and in vitro methods including radiographs,[9] dye penetration,[10] radio isotopes, fluid filtration,[11] bacterial leakage,[12] and digital radiography.[4] But no technique currently available meets all the criteria of ideal method and moreover, does not assess the obturation from 3 dimensions. Therefore, still there is an ongoing quest for better technique in the field of pulpectomy.

Spiral Computed Tomography (SCT) also known as 3D image analysis is a new revolution in the Dental science which provides a 3-dimensional interpretation of the specimen without sectioning the study material.[13] So the specimen can be used for further research. SCT has been extensively employed in endodontic research but its use in pediatric endodontic research is limited. Recent studies have shown that SCT provides volumetric analysis of root canal fillings

like gutta percha as well as evaluated efficacy of various retreatment systems for gutta percha removal in the permanent teeth.[13,14] Moreover; this advanced diagnostic aid has been used in determining the complex morphology of roots, canals and various anomalies of the teeth.[15,16] Therefore, the present *in vitro* pilot study was designed to evaluate the efficacy of total 5 different obturation methods such as Local anesthetic syringe, Tuberculin syringe, Endodontic plugger, hand held Lentulo-spiral and Lentulo-spiral mounted on slow speed hand piece in primary teeth using Spiral Computed Tomography. The 5 methods were selected based on their cost, common daily usage in clinical practice, easy availability and easy to perform.

MATERIALS AND METHOD

Extracted primary teeth were collected from the Outpatient Department of Pedodontics and Preventive Dentistry. The teeth were extracted as they were over retained, when failure of pulp therapy occurred, and in those patients where parents were not willing for the pulp treatment for diseased teeth. Some teeth were also collected from the private dental clinics which run by only BDS doctors, not a pediatric dentist and where pulpectomy is not carried out. The purpose of research using children's teeth was explained to the parents before using their teeth for the study and consent was obtained. Both maxillary and mandibular first as well as second molars were considered for the study. In maxillary molars we considered only the palatal root as the mesial and distal roots are thinner. From these teeth, fifty canals with minimum three-fourth of the original root length of the root were selected for the study. Teeth with incompletely calcified apices, fractures or severe resorption (internal or external resorption) were excluded. The soft tissue remnants and calculus adhered to the tooth were removed. Collection, storage, sterilization and handling of extracted teeth was done according to the Occupational Safety and Health Administration (OSHA) guidelines and regulations given by Reuben *et al*[17]

A standard coronal access cavity preparation with diamond fissure bur was done. Patency of the canals was checked using a 10 K-file. Working length was recorded as length of initial file at the apical foramen minus one millimeter. Root canals were instrumented till file number 30-35. Saline and 1% sodium hypochlorite were used as an irrigant while enlarging the canals. All canals were finally dried using size 30 paper points. Canals were numbered from 1 to 25. Specimens were then mounted on a sheet of modelling wax and scanned using SCT Scan (Toshiba Medical System, Tochigi- KEN, Japan) for assessment of volume of the canal. Scanned specimens were viewed under high resolution, both cross–sectionally and longitudinally with a constant thickness of 0.5mm/slice and a constant spiral or table speed of 0.5 and 140 KVP. The scanned data was then transferred to Advantage window work station image analysis software (OsiriX imagaing software, Geneva, Switzerland) and evaluated. The area of prepared root canal in each slice was measured from cemento-enamel junction (CEJ) to the root apex. The volume of each slice was calculated by multiplying the measured area of root canal by the slice thickness (0.5mm). Using this data the volume of each canal was calculated (X).

The canals were randomly divided into five groups consisting of teeth with 10 canals in each group. The canals were obturated with slow setting Zinc Oxide Eugenol cement (ZOE) using different methods. ZOE was selected as an obturation material based on the easy availability, cost factor, most routinely used material, and mainly to maintain the standardization of one material as well as obturation among all groups. One volume unit of powder was mixed with two volumes of liquid to achieve acceptable creamy consistency of ZOE in all the groups for obturation.

For Group 1, creamy consistency of ZOE was obtained as described earlier. The cement was filled in a local anesthetic syringe with a 27-gauge needle. 10 canals were obturated by injecting the cement into the canal using this syringe. Canals were considered obturated when the canal orifice appeared filled with the cement.

In Group 2, ZOE was mixed as described earlier and used to fill a Tuberculin Syringe (needle-29 gauge and length-11mm). The paste was injected into the 10 canals. Canals were filled till the backflow of cement was observed in the orifice.

In Group 3, ZOE was mixed to a thick consistency. The cement was pushed into 10 canals using endodontic plugger. Cement was filled in 3-4 increment to fill the canal.

In Group 4, ZOE mixed in creamy consistency was obtained by the above mentioned method. This cement was filled in the canal using hand held lentulo spiral. Lentulo spiral with the cement was inserted into the canal with clockwise rotation, accompanied by vibratory motion to allow the material to reach the apex and was withdrawn in the same fashion.

In Group 5, ZOE was mixed in the same manner. 10 canals were filled using lentulo-spiral mounted on slow speed hand piece. Lentulo-spiral was inserted into the canal in clockwise rotation direction and was withdrawn from the canal while still rotating.

After completion of the obturation in respective groups, a second SCT Scan was done to determine the volume of filling material in all the groups (Y) (Figure 1 and 2). Percentage of obturated volume (POV) was calculated using the formula POV=Y/X x 100 for all 5 groups**.** The data obtained from 5 groups was statistically analyzed using one way analysis of variance (among 5 groups) and a Tukey's post-hoc test (within the same group).

RESULTS

In this pilot study, pre and post obturation volumes were obtained using SCT scan which was then used to calculate the POV for each group. The volume (mean and standard deviation) of the root canals analyzed before the obturation (X) and after the obturation (Y) along with the POV obtained for each group is illustrated in Table 1. According to One-way Analysis of Variance test (ANOVA), statistically highly significant difference was found in the POV values among the groups ($P < 0.05$). On comparing the values of POV, between the

Figure 1. Spiral computed tomography scan picture showing post obturation volume of the canal in 5 groups obturated using different techniques. A – Group 1 (Local anesthetic syringe), B – Group 2 (Tuberculin syringe), C – Group 3 (Endodontic plugger).

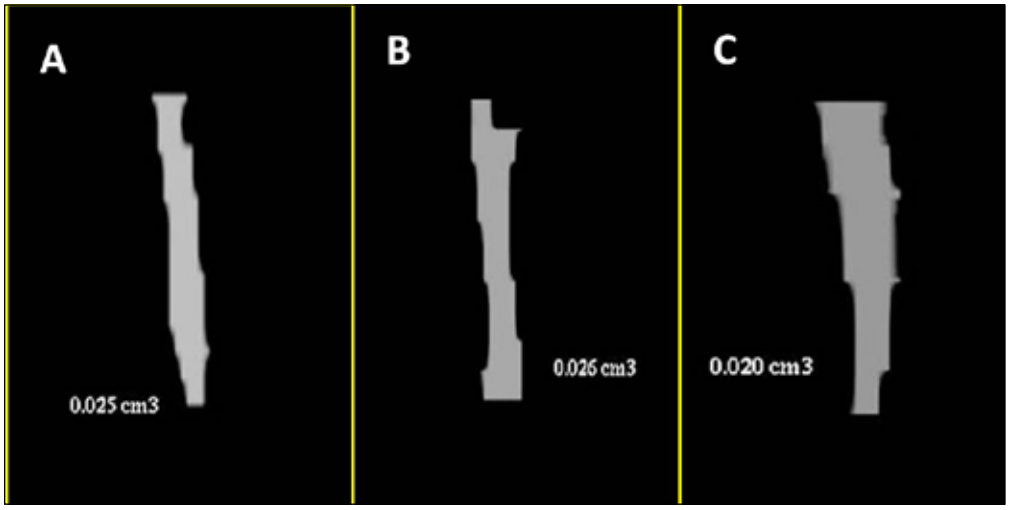

Figure 2. Spiral computed tomography scan picture showing post obturation volume of the canal in 5 groups obturated using different techniques. D – Group 4 (Lentulospiral –hand held), E – Group 5 (Lentulospiral – mounted to hand piece).

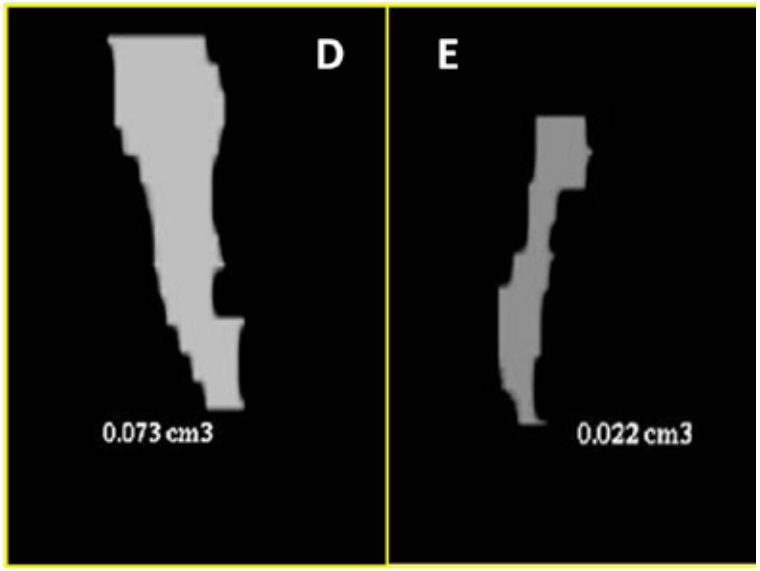

Table 1: Pre and post obturation volume (cm^3) and POV among groups studied using 5 different obturation techniques

Groups	Number (N)	Pre obturation volume (X) Mean ±(SD)	Post obturation volume (Y) Mean ± (SD)	Percentage of obturated volume (POV)
Local anesthetic syringe	10	2.02±1.20	1.24±0.76	61.60± 4.49 (a)
Tuberculin syringe	10	1.79±0.87	1.39±0.64	74.60 ±5.03 (b)
Endodontic plugger	10	4.08±2.13	3.03±1.61	±5.40 (b)
Lentulo spiral-hand held	10	4.57±2.63	4.16±2.45	90.70± 2.37 (c)
Lentulo spiral-mounted to hand piece	10	5.54±3.02	4.92±2.64	89.21± 3.28 (c)

Cells with same letter denote no statistical significance between them (p>0.05)

groups, Tukey's Post-hoc test showed that the fourth Group (Lentulo-spiral hand held) showed maximum POV followed by Group 5 (Lentulo-spiral mounted to hand piece), Group 2 (Tuberculin syringe) and Group 3 (Endodontic plugger); whereas Local anesthetic syringe (Group 1) showed least POV. However, no statistical significant difference in POV was seen between Group 2 (Tuberculin syringe) and Group 3 (Endodontic plugger) as well as Group 4 (Lentulo-spiral hand held) and Group 5 (Lentulo-spiral mounted to hand piece).

DISCUSSION

The purpose of root canal obturation after pulpectomy procedure in primary teeth is to create a complete, 3-dimensional tight seal of the root canal system, with the aim of preventing recurrence of bacterial infection.[1,2] Numerous techniques have been used for filling root canals.[3-8] Among these, most studies have compared only two or three techniques.[5-7] Although investigators demonstrated various methods to evaluate the quality of obturation of the primary root canal, each one have their own disadvantages. Like, radiographic method (including both conventional and digital) gives only 2-dimensional interpretation of the obturation.[4,9] Whereas, sectioning the root canal results in loss of tooth material, which could mimic voids. The fluid filtration and clearing techniques are time consuming procedures.[11] Dye penetration studies do not correlate clinically whereas dye extraction methods evaluate only the apical part of the tooth.[10] Bacterial leakage experiments do not simulate exact clinical conditions, need longer observation period and do not allow quantification of the number of penetrating bacteria.[12]

A recent innovation in science technology is the use of SCT; a noninvasive technique provides a 3-dimensional interpretation of the specimen. It is also associated with other advantages like avoids the loss of material, gives reproducible results, and moreover, the specimen can be used for further research.[13] Recent studies have shown that SCT provides volumetric analysis of root canal fillings like gutta percha in permanent teeth.[13,14,18] It also aids in the removal of old, failed fillings from the root canal in permanent tooth.[14,18] Therefore, in the present pilot study SCT technology was employed to evaluate the efficacy of 5 different obturation techniques to deliver the paste into the root canals of primary teeth.

Although many materials like ZOE, idoform based paste, and calcium hydroxide have been assayed for filling root canals in primary teeth, currently ZOE paste is one of the most widely used obturation material in the primary teeth.[2,3,7] Therefore, we used this paste in our study. However, this material is a slowly resorbable and when overfilling occurs, can cause foreign body reaction.[1,2]

In the present study, the Group 4 (Lentulo-spiral hand held) gave highest overall POV. The explanation for this could be that the design and flexibility of the Lentulo-spiral allow file to carry the paste uniformly throughout the curved, narrow canals of primary molars and better control in hand than the mounted to hand piece. This result is in accordance to the studies reported by Memarpour *et al*,[4] and Torres *et al*[19] In contrast to this, Dandashi[20] found no significant difference between the lentulo-spiral, pressure syringe and packing with plugger technique. In addition to this, Asokan *et al*,[21] and Guelman [22] also showed that vitapex syringe system and Navitip system were more superior than lentulo-spiral in obturation. Memarpour *et al* [4] stated that the lentulo-spiral is one of the most effective and straight forward technique for applying sealers, and calcium hydroxide into permanent teeth root canals, and in canals of primary teeth. However, some of the disadvantages like instrument fracture, difficulties with filling the rubber stop, tendency for extrusion of paste beyond the apex should be considered in children. In addition to this, studies done by Memarpour,[4] Bawazir and Salama *et al* [7] showed that the frequency of overfilling with lentulo-spiral group (mounted to hand piece) was higher compared to other groups. This may be related to the reduction in operator "feel" and displacement of the rubber stop during the filling procedure which results in overfilling.[4] A study done by Asokan [21] showed less dense filling with hand held lentulo-spiral compared to syringe system. This is in contrary to the present study result. The differences between the current study results and those of previous studies shows variations in type of teeth used, sample size evaluated, tip thickness, technique used to evaluate the quality of obturation and finally the operator experience in delivering the paste into the canals.

In the current study, the canals obturated with a local anesthetic syringe showed inferior quality to that of lentulo-spiral and endodontic plugger. This result was consistent with the findings of Hamarpour [4] and Peter *et al*.[23] The reason could be the limited flexibility and thicker tip of the needle used with the anesthetic syringe which make more difficult to reach the apex of the narrow, curved canals in primary teeth. Therefore, an Iranian study[4] has stated that formation of voids seems to be more with this technique if air engages the canal wall, or the needle is displaced while injecting the material. However, an Indian study done by Bhandari et al[5] has shown superior results using local anesthetic syringe.

There was a significant difference between the lentulo-spiral and tuberculin syringe in the POV obtained after obturation. This was in agreement with the results of Aylard *et al*,[24] Subba Reddy and Shakunthala,[6] and Memarpour [4] This could be due to the non flexibility of the tuberculin syringe which does not penetrate close to the apex in curved, thin canals of primary teeth.

In group 3, the obturation done using plugger revealed less POV compared to lentulo-spiral group. In agreement with our study results, other previous studies also found that highest voids were seen in the packing with plugger technique than the lentulo-spiral group. This is attributed to the fact that as the flexibility of endodontic plugger is limited, the paste cannot be obturated properly in the apical part of narrow curved canals.[4] Along with this movement of the plugger during paste application may increase the risk of large voids.

According to author's best knowledge, the present study is the first study which shows efficacy of more number of different obturation delivery techniques using SCT scan in

primary teeth. Although Memarpour [4] analyzed the 5 techniques mentioned in our study; he used radiographic method for evaluation of quality of the obturation which gives only 2 dimensional picture of the canal space. Apart from this, there are only few studies which show the quality of different obturation techniques using gutta-percha in permanent teeth.[13,18] Therefore from this view, we can strongly suggest that the current pilot study will be a boon for further research in evaluation of obturation quality in primary teeth using large sample size.

CONCLUSION

Based on the results obtained from the current pilot study, the following conclusion was made.

Primary teeth root canal's filling using Lentulo-spiral hand held is the best obturation technique among the 5 groups studied as the canals of this group showed maximum percentage of filled material. However, a further study with large sample size is highly essential.

REFERENCES

1. Pinkham JR, Casamassimo PS, Mctigue DJ, Fields HW, Nowak AJ. Pediatric Dentistry: infancy through adolescence. 4th ed. Phildelphia, Pa: WB Saunders Co; 375-90, 2005.
2. Rodd HD, Waterhouse PJ, Fuks AB, Fayle SA, Moffat MA. British Society of Pediatric Dentistry. UK National Guidelines in Paediatric Dentistry. Pulp therapy for primary molars. Int J Paediatr Dent, 16: 15-23, 2006.
3. Fuks AB. Pulp therapy for the primary and young permanent dentition. Dent Clin North Am 44: 571-96, 2000.
4. Memarpour M, Shahidi S, Meshki R. Comparison of different obturation techniques for primary molars by Digital Radiography. Pediatr Dent 35: 236-40, 2013.
5. Bhandari SK, Anita, Prajapati U. Root canal obturation of primary teeth: Disposable injection technique. J Indian Soc Pedod Prev Dent 30: 13-8, 2012.
6. Subba Reddy VV, Shakunthala B. Comparative assessment of three obturating techniques in primary molars: An in-vivo study. Endodontol, 9: 13-6, 1997.
7. Bawazir OA, Salama FS. Clinical evaluation of root canal obturation methods in primary teeth. Pediatr Dent, 28: 39-47, 2006.
8. Guelman M, McEachern M, Turner C. Pulpectomies in primary incisors using three delivery systems. An in vitro study. J Clin Pediatr Dent, 28: 323-6, 2004.
9. Kositbowornchai S, Hnwachirapong D, Somsopon R, Pirmsinthavee S, Sooksuntisakoonchai N. Ex vivo comparison of digital images with conventional radiographs for detection of simulated voids in root canal filling material. Int Endod J, 39: 287-92, 2006.
10. Oliver CM, Abbott PV. Correlation between clinical success and apical dye penetration. Int Endod J, 34: 637-44, 2001.
11. Pommel L, Camps J. Effect of pressure and measurement time on the fluid filtration method in endodontics. J Endod, 27: 256-8, 2001.
12. Siqueira JF Jr, Rocas IN, Favieri A, Abad EC, Castro AJR, Gahyva SM. Bacterial leakage in coronally unsealed root canals obturated with 3 different techniques. Oral Surg Oral Med Oral Pathol, 90: 647-50, 2000.
13. Anbu R, Nandini S, Velmurugan N. Volumetric analysis of root canal fillings using spiral computed tomography: An in vitro study. Int Endod J 43: 64-8, 2010.
14. Mittal N, Jain J. Spiral computed tomography assessment of the efficacy of different rotary versus hand retreatment system. J Conserv Dent 17: 8-12, 2014.
15. Saxena A, Singh A, Ikhar A, Chandak M. A rare case of maxillary first molar with single root and single canal diagnosed using spiral computed tomographic scan. J Indian Soc Pedod Prev Dent 32: 242-5, 2014.
16. Gopikrishna V, Bhargavi N, Kandaswamy D. Endodontic management of a maxillary first molar with a single root and a single canal diagnosed with the aid of spiral CT: A case report. J Endod, 32: 687-91, 2006.
17. Reuben J, Velmurugan N, Kandaswamy D. The evaluation of root canal morphology of the mandibular first molar in an Indian population using spiral computed tomography scan: an in vitro study. J Endod, 34: 212-5, 2008.
18. Hammad M, Qualtrough A, Silikas N. Three dimensional evaluation of effectiveness of hand and rotary instrumentation for retreatment of canals filled with different materials. J Endod 34:1370-3, 2008.
19. Torres CP, Apicella MJ, Yancich PP, Parker MH. Intracanal placement of calcium hydroxide: A comparison of techniques, revisited. J Endod, 30: 225-7, 2004.
20. Dandashi MB, Nazif MM, Zullo TT, Elliot MA, Schneider LG, Czonskowsky M. An in vitro comparison of three endodontic techniques in primary incisors. Pediatr Dent 15: 254-6, 1999.
21. Asokan S, Sooriaprakas, Radhu V, Bairavi R. Volumetric analysis of root canal fillings in primary teeth using Spiral computed tomography: An in vitro study. J Dent Child 79: 46-8, 2012.
22. Guelman M, McEachern M, Turner C. Pulpectomies in primary incisors using three delivery systems: An in vitro study. J Clin Pediatr Dent, 28: 323-6, 2004.
23. Peters CI, Koka RS, Highsmith S, Peters OA. Calcium hydroxide dressings using different preparation and application modes: Density and dissolution by simulated tissue pressure. Int Endod J, 38; 889-95, 2005.
24. Aylard SR, Johnson R. Assessment of filling techniques for primary teeth. Pediatr Dent, 9: 195-8, 1987.
25. Grover R, Mehta M, Pandit K, Srivastava N, Gugnani N, Gupta M. Clinical efficacy of various root canal obturating methods in primary teeth: a comparative study. Eur J Paediatr Dent, 14(2): 104-8, 2013.