Evaluation of Different Root Canal Obturation Methods in Primary Teeth Using Cone Beam Computerized Tomography

Singh R*/ Chaudhary S**/ Manuja N***/ Chaitra TR****/ Sinha AA*****

Objective: *To evaluate the efficiency of 3 different obturation techniques; motor driven lentulospiral, hand held lentulospiral and reamer in primary anterior teeth and presence of voids by analyzing with CBCT.* ***Study Design:*** *60 single rooted extracted primary teeth were prepared and obturated with ZOE paste. Obturation methods were divided into three groups.* ***GROUP I-*** *motor driven lentulo spiral,* ***II-*** *hand held lentulo spiral and* ***III-*** *reamer. Obturated samples were scanned in CBCT machine and images were analysed for the evaluation of their quality of fill comprising presence, location and size of voids.* ***Results :*** *At all the locations, Group II had maximum number of sites with voids when compared to other two groups. However, statistically significant intergroup differences were observed only at coronal third location (p=0.001) and overall assessment (p=0.003). Number of affected sites revealed the difference between Groups I and II be significant statistically (p=0.002) while the difference between Groups I and III and between Groups II and III was not significant statistically (p>0.05). At all the locations as well as for combined assessment, Group I had minimum mean size of the void.* ***Conclusion :*** *Motor driven lentulo spiral technique demonstrated more number of optimal fills with fewer voids when compared to hand held lentulo spiral technique and reamer.*

Key Words: *CBCT, ZOE, FOV, obturation, lentulospiral, voids. Cone beam, Zinc Oxide and eugenol.*

INTRODUCTION

Pediatric dentistry is the specialized branch in dentistry which cares for prevention and maintainence of oral health care needs in children. Despite significant advances in preventive dentistry, dental caries continues to be one of the most common infectious oral health diseases in mankind.[1]

Retention of pulpally involved primary tooth facilitates mastication, esthetics, and phonetics, prevents aberrant oral habits and above all acts as a natural space maintainer.[2,3] Root canal therapy was advocated as early as 1932 as a method of retaining those primary teeth which would be otherwise lost. Zinc oxide and eugenol paste was the first root canal filling material to be recommended for primary teeth, as described by Sweet in 1930.[4]

From the Department of Pediatric and Preventive Dentistry Kothiwal Dental College and Research Centre

*Rishav Singh, MDS

**** Seema Chaudhary , MDS,**Professor and Head.

*****Naveen Manuja, MDS,** Professor.

******Chaitra T.R., MDS**,Reader

*******Ashish Amit Sinha, MDS,**Reader

Send all correspondence to

Naveen Manuja,
Department of Pediatric and Preventive Dentistry
Kothiwal Dental College and Research Centre
Moradabad-244001, Uttar Pradesh, India
Phone: +91-9997048380
Email: naveenmanuja@gmail.com, naveenmanuja@yahoo.com

Root canal obturation of primary teeth is dependent on the variables such as unpredictable root canal anatomy of primary teeth, deposition of secondary dentin, physiological resorption causing changes in anatomical forms of root canals and tortuosity of the root canals.[5] To circumvent these problems, numerous root canal obturating techniques have been introduced for primary teeth like using hand held lentulospiral paste filler, engine driven lentulo spiral paste filler, endodontic plugger, endodontic pressure syringe, reamers, tuberculin syringes, paper points and Navi Tip.[6-10]

Radiography has an important place in dentistry. Since Roentgen discovered X-rays in 1895 and Kels promoted their use in dentistry, diagnosis from radiographic images has been widely used. In most treatments, however, two dimensional evaluation using conventional radiographs of the teeth and jaws may not always be sufficient to make a diagnosis.[11] Cone-beam technology has existed since the 1980's. However, the convergence of technology and its applications has only recently made cone-beam volumetric tomography (CBVT) or cone-beam computed tomography (CBCT) a viable option for the dental office.[12]

Imaging systems in CBCT utilizes two main innovations- one is the change from analog to digital imaging and other advances in imaging theory and volume-acquisition data which have allowed for increasingly detailed 3-D imaging. A cone-shaped beam of radiation to acquire a volume in a single 360-degree rotation is used in Cone-beam technology, similar to panoramic radiography. The volume acquired by a CBVT is composed of voxels same as a digital picture is subdivided into pixels. A voxel is a 3-D pixel and as the data are captured in a volume as opposed to slices, all the voxels are isotropic, which enables objects within the volume to be accurately measured in different directions.[12]

The CBCT hardware consists of an X-ray source and detector, or sensor, mounted on a rotating gantry. During imaging, a cone-shaped X-ray beam is emitted from the X-ray source and is directed through the area of interest in the patient's maxillofacial skeleton. Having passed through the area of interest, the beam is projected on to the X-ray detector, as both it and the X-ray source rotate synchronously 180°-360° around the patient's head, in a single sweep. The scan time typically ranges from 10-40 s, depending on the equipment and exposure parameters employed. However, many CBCT systems employ a pulsatile X-ray beam and with these systems the actual patient exposure time can be as low as 2-5 s. Reconstructed CBCT images can be displayed in a variety of ways. A commonly used option is for the images of the area of interest to be displayed, simultaneously, in the three orthogonal planes (axial, sagittal and coronal), affording the clinician a truly three-dimensional view of the area of interest.[13]

In addition, CBVT offers significant scan-time reduction, radiation dose reduction, reduced cost for the patient, increase accuracy and higher resolution when compared to traditional or medical CT.[14]

Therefore the purpose of this study is to compare and evaluate the different obturation techniques used in primary dentition by a newer advanced Cone Beam Computerised Tomography.

MATERIALS AND METHOD

The present in-vitro study was carried out in the Department of Pedodontics & Preventive Dentistry, Kothiwal Dental College & Research Centre, Moradabad in association with Mahajan Imaging Centre, New Delhi. The present study was approved by the ethical committee of Kothiwal Dental College & Research Centre, Moradabad.

Sixty primary anterior teeth having at least two-thirds remaining root were collected and placed in 0.9% normal saline. Then the teeth were thoroughly cleaned with pumice slurry, rinsed with water and stored in normal saline.

The collected teeth were then divided into three groups as-

Group I- Obturation using motor driven lentulospiral. (21 mm, Mani, Japan)

Group II- Obturation using hand held lentulo spiral. (21 mm, Dentsply Maillefer, Switzerland)

Group III- Obturation using reamer. (21 mm, size 15-40, Mani, Japan)

Teeth were taken from saline and placed on paper to air dry. Then the access was gained using #4 round carbide bur. Coronal pulp remnants were removed with the round carbide bur itself and the radicular pulp remnants were removed using barbed broaches. The chamber was then irrigated with normal saline. A size 15 K- file was inserted into the root canal and radiograph was taken. Working length was established by subtracting 1mm from the total canal length. The root canal was then sequentially enlarged starting with size 15 K-file and finished with a 35 size file. Final finishing was done using an H-file of the corresponding last K-file used. The canals were dried using sterile paper points and obturation was performed using three delivery systems; a) motor driven lentulospiral paste carrier, b) handheld lentulospiral paste carrier and c) reamer.

Before obturation the tooth was randomly selected for any one of the three obturating techniques. The teeth were divided into three groups as:

Group I: 20 teeth obturated using motor driven lentulospiral.

Group II: 20 teeth obturated using hand-held lentulospiral.

Group III: 20 teeth obturated using reamer.

The obturating material used was Zinc Oxide Eugenol cement. A standardized mix of zinc oxide eugenol, 0.400 ml eugenol/gram of zinc oxide was prepared for each test group according to the technique specified by Aylard & Johnson.[8] A triple beam balance was used to measure each gram of zinc oxide powder. A tuberculin syringe was used to dispense the corresponding amount of eugenol liquid. The mixture was then spatulated on a dry glass slab at room temperature for 45 seconds.

Obturation techniques

Group I: Lentulospiral mounted in a slow speed handpiece

A 21mm lentulospiral of size 30 mounted in a slow speed contra-angle handpiece (1,000 rpm) was used to deliver the zinc oxide eugenol into root canals. A rubber stopper was used to keep lentulospiral 1mm short of the working length, based on the pre-operative radiograph. The lentulospiral was smeared with cement, inserted into the canal and rotated in clockwise direction and withdrawn from the canal while still rotating. The process was repeated until the canal orifice appeared to be filled with the cement. The motor driven lentulospirals were changed after every 5 samples.

Group II: Handheld lentulospiral

A 21mm handheld lentulo spiral of varying sizes i.e; from 25-40 was used for obturation. When the lentulo spiral was held by hand, it was inserted into the canal with clockwise rotation, accompanied by a vibratory motion to allow the material to reach the apex, and then withdrawn from the canal, while simultaneously continuing the clockwise rotary motion. The handheld lentulospirals were changed after obturating every 5 samples.

Group III: Reamer

A 21mm reamer of size 30 was used to deliver the zinc oxide eugenol into root canals. A rubber stopper was used to keep the reamer 1mm short of the apex based on pre-operative radiograph. The reamer was smeared with fresh mix of zinc oxide eugenol, inserted into the canal and rotated in counter clockwise direction. Then it was pumped up and down, with a wiping motion against the canal walls. It was then withdrawn from the canal. This process was repeated until the canal orifice appeared to be filled with the cement.

Once the root canals in all the groups were obturated, the access cavity was sealed with a thick mix of zinc oxide eugenol, carried and condensed into the cavity with a plastic instrument without applying any apical pressure.

Assesment of obturating techniques done using CBCT

Effectiveness of the three obturation techniques was assessed by viewing the samples under **i-CAT** Cone Beam Computerized Tomographic scanner (Imaging Sciences International, Hatfield, Pennsylvania) by placing ten teeth on a modeling wax sheet and a total of twenty teeth belonging to a particular group was scanned. So, finally three individual scans were made for the teeth samples belonging to three selected groups and the software used for the volumetric analysis of the obturated samples was done by using AW Volumeshare 5, Version 4.6. The plane which was used to measure the voids was sagittal.

The scanning protocol which was used to measure the voids are as follows:

Plane: sagittal.Scanning time: 7 seconds.kV: 120. mA: 5Radiation delivery type: pulsed.Size of FOV: 4.8 cm for group I, 6.0 cm for group II & group III..Resolution: 0.2 mm for group I, 0.25 mm for group II and group III.

Statistical analysis

Data analysis was done using SPSS (Statistical Package for Social Sciences) Version 15.0. Chi-square test was used to compare the categorical data. Wherever expected frequency of one cell was less than five, Fisher exact test was used. As the sample size was small, hence quantitative data was assessed for normality and was found to be asymmetric and non-normal, hence a non-parametric analysis plan was followed. Intergroup comparisons were done using Kruskall Wallis test (non-parametric ANOVA) (for more than two groups) and Mann-Whitney U test (non-parametric Independent samples test). The confidence level of the study was kept at 95%, hence a "p" value less than 0.05 indicated a statistically significant association.

RESULTS

After obturation of 60 teeth samples, an evaluation of each tooth was done at four different locations in each teeth : A) Coronal third, B) Middle third, C) Apical third, D) Coronal middle third. The evaluation was done for the presence of voids (Fig. 1-3), both quantitatively as well as categorically. Categorical comparison was done in terms of presence or absence of voids while quantitative assessment was done for number of affected sites and size of voids.

Table 1 shows evaluation of different groups for presence of voids at different locations. At all the locations as well as for overall assessment, Group II had maximum number of sites with voids. However, statistically significant intergroup differences were observed only at coronal third location (p=0.001) and overall assessment (p=0.003).

Table 2 shows between group comparisons for the presence of voids at different locations. Between groups comparison revealed no statistically significant difference for any of the comparisons at middle third, apical third and coronal middle third locations. At coronal third location, Group II had significantly higher proportion of teeth with presence of voids as compared to Group I (p<0.05). Statistical significance was also achieved between Group II & Group III (p<0.05). However, no significant difference was observed between Groups I and III at similar location (p=1.000). For overall assessment too, Group II showed significantly higher number of locations with voids as compared to the other two groups i.e; Group I & Group III (p<0.05). Group III had relatively higher number of locations with voids as compared to Group I but the difference was not significant statistically (p=0.168). Thus on the basis of categorical assessment, the following order of groups with presence of voids was observed: Group I $\simeq$ Group III < Group II.

Comparison of different groups for number of affected sites in a tooth has been shown in Table 3. In Group I, more than two third (70%) specimen had no affected site, 4 (20%) had one affected site and 2 (10%) had two affected sites. Mean number of affected sites in Group I was 0.40±0.68. In Group II, majority of specimen (55%) had one affected site, 4 (20%) had two affected sites while 2 (10%) specimen had three affected sites. A total of 3 (15%) specimen had no affected site. Mean number of affected sites in Group II was 1.25±0.85 sites. In Group III, a slight less than half (45%) specimen had no affected site, 6 (30%) had one affected site while remaining 5 (25%) had two affected sites. Mean number of affected sites was 0.80±0.83.On evaluating the data statistically, the difference among groups was found to be significant (p=0.005).

Table 1: Evaluation of different groups for presence of voids at different locations

SN	Location	Group I (n=20)		Group II (n=20)		Group III (n=20)		Significance of difference	
		No.	%	No.	%	No.	%	2	p
1.	Coronal third	3	15	13	65	4	20	13.65	0.001
2.	Middle third	2	10	4	20	6	30	2.500	0.287
3.	Apical third	3	15	4	20	3	15	0.240	0.887
4.	Coronal middle third	0	0	4	20	1	5	5.673	0.059
5.	Total (n=80 each group)	8	10	25	31.25	14	17.5	11.80	0.003

Table 2: Between Group comparison for presence of voids at different locations

SN	Location	Group I vs Group II		Group I vs Group III		Group II vs Group III	
		2	p	2	p	2	p
1.	Coronal third	10.42	0.001	0.173	1.000*	8.29	0.004
2.	Middle third	0.784	0.661*	2.500	0.235*	0.533	0.716
3.	Apical third	0.173	1.00*	0.000	1.000	0.173	1.00*
4.	Coronal middle third	4.444	0.106*	1.026	1.000*	2.057	0.342*
5.	Total(n=80 each group)	11.03	0.001	1.897	0.168	4.103	0.043

*Fisher exact test'

Table 4 shows between group comparisons of different groups for number of affected sites. Between group comparison for number of affected sites revealed the difference between Groups I and II be significant statistically (p=0.002) while the difference between Groups I and III and between Groups II and III was not significant statistically (p>0.05). Thus, the order of groups on the basis of number of affected sites in each group was as follows: Group II > Group I ~ Group III.

Comparison of mean area of voids in different groups for different locations as well as for overall assessment (Table 5) shows at all the locations as well as for combined assessment, Group I had minimum mean size of the void. It was found to be maximum in Group II for coronal third, coronal middle third and combined assessment and in Group III for middle and apical third locations. On evaluation for inter group differences, the differences were found to be significant statistically only at coronal third and combined assessment ($p \leq 0.001$).

Table 6 shows between group comparison of size of void in different groups at different locations and for overall combined assessment. Between group assessment of area covered revealed statistically significant differences between Groups I and II and Groups II and III at coronal third location (p<0.05) and between Groups I and II for combined assessment (p<0.001). None of the other comparisons were significant statistically (p>0.05).

DISCUSSION

Pulpectomy can be one option in the treatment of severely infected primary teeth.[15,16] It consists of extirpation/debridement of the pulp tissue to remove organic debris and filling of a canal, and obturation with an antibacterial, resorbable filling paste which restores the tooth to function and free from disease.[17]

The methods selected by practitioners to fill the pulpectomized canals of primary teeth are numerous and varied. This can be achieved by using lentulo spiral, or an endodontic pressure syringe, a reamer, Navi Tip syringe or pastinject. [18, 19]

The ultimate goals of root filling are to adequately adapt the paste to the canal walls, completely fill the root throughout its length (apical sealing without overfilling), and avoid the creation of voids or gaps in the paste.[7] Different laboratory approaches have been used to evaluate root canal filling quality, such as the penetration of dye, bacteria, or radioisotopes, clearing techniques following tooth sectioning, radiographic assessment, Digital Imaging with Photo-stimulated Phosphor plate and Spiral CT Scans.[18,20]

But these techniques do not assess obturation in 3 dimensions. With the introduction of Cone Beam Computerized Tomography (CBCT), 3-dimensional volume measurements were possible without sectioning the specimens and, thus, avoiding the loss of tooth material, which would mimic voids. The specimens also can be used for further research.[21] Literature shows there is no study that evaluated the efficiency of various primary root canal filling techniques using CBCT. So, an in- vitro study was planned to assess the efficacy of different root filling techniques.

In CBCT images the specific location of voids can also be determined accurately. A recent study by Sogur E et al.[22] have proved that CBCT provides a great detail into the evaluation of length and homogeneity of root fillings in permanent teeth.

In our study, we did not encounter any noise or streaking artifacts associated with CBCT devices because we used a limited FOV. Also the noise reduction algorithm was optimal and the voxel resolution used was adequate.

Further, CBCT has also been used in the assessment of morphology of the tooth in permanent dentition [23,24] and more recently in primary dentition.[25] Studies regarding CBCT to assess the obturation in primary dentition are sparse. Hence, CBCT was chosen as the tool for investigating the efficacy of root canal fillings in primary teeth in our study because the management of endodontic problems is reliant on radiographs to assess the anatomy of the tooth and its surrounding anatomy.

Many investigations have evaluated and compared the success rate of different root canal filling techniques used for primary teeth. The present study, compared the efficiency of the lentulo spiral mounted in a slow-speed handpiece, hand-held lentulo spiral and reamer—at providing optimal filling for the root canal of primary anterior teeth. At the same time, the study compared the quality of the root canal filling.

Table 3: Comparison of different groups for number of affected sites in a tooth

SN	Number of Affected sites	Group I (n=20)		Group II (n=20)		Group III (n=20)	
		No.	%	No.	%	No.	%
1.	None	14	70	3	15	9	45
2.	1 site	4	20	11	55	6	30
3.	2 sites	2	10	4	20	5	25
4.	3 sites	0	0	2	10	0	0
5.	4 sites	0	0	0	0	0	0
6.	Mean affected sites±SD	0.40±0.68		1.25±0.85		0.80±0.83	

^{2}=10.608 (df=2); p=0.005 (Kruskall Wallis test)

Table 4: Between group comparison of different groups for number of affected sites (Mann-Whitney U test)

SN	Comparison	z-value	"p"
1.	Group I vs Group II	3.282	0.002
2.	Group I vs Group III	1.644	0.149
3.	Group II vs Group III	1.596	0.134

Table 5: Comparison of Mean area covered by voids in different groups at different sites (cu units)

SN	Group	No. of specimen	Mean	SD	Min	Max
Coronal Third						
1.	I	20	0.20	0.52	0	2
2.	II	20	1.90	2.40	0	10
3.	III	20	0.55	1.43	0	6
^{2}= 14.613 (df=2); p=0.001 (Kruskall Wallis test)						
Middle Third						
1.	I	20	0.15	0.49	0	2
2.	II	20	0.50	1.28	0	5
3.	III	20	2.05	5.27	0	20
^{2}=2.778 (df=2); p=0.249 (Kruskall Wallis test)						
Apical Third						
1.	I	20	0.20	0.52	0	2
2.	II	19*	0.16	0.37	0	1
3.	III	20	0.40	1.10	0	4
^{2}=0.011 (df=2); p=0.995 (Kruskall Wallis test)						
Coronal Middle Third						
1.	I	20	0.00	0.00	0	0
2.	II	20	0.40	1.79	0	8
3.	III	20	0.30	1.34	0	6
^{2}=1.018 (df=2); p=0.601 (Kruskall Wallis test)						
Overall (Combined area in a specimen)						
1.	I	20	0.30	0.47	0	1
2.	II	20*	2.95	2.72	0	10
3.	III	20	2.75	5.28	0	20

^{2}=17.361 (df=2); p<0.001 (Kruskall Wallis test)

*One case had void area 1003 cu units at apical third, which was an extreme value and hence it was excluded from the analysis.

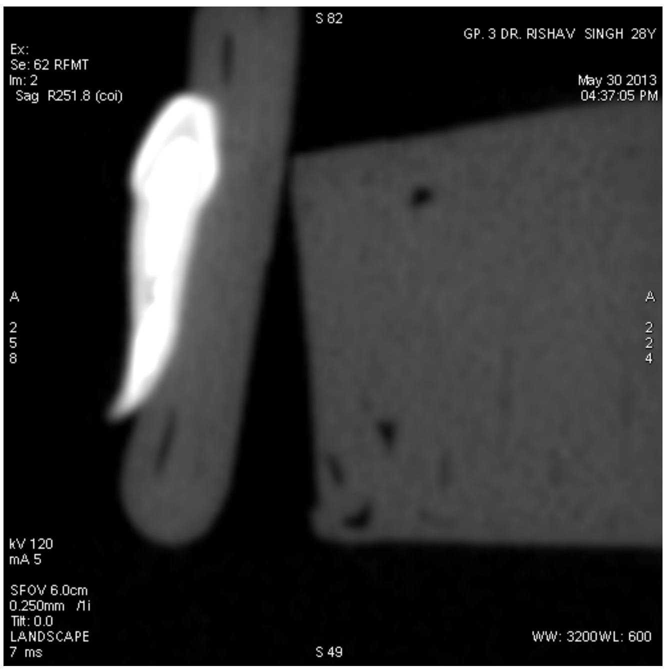
Table 6: Between group comparison of size of void in different groups at different locations and for overall combined assessment (Mann Whitney U test)

SN	Location	Group I vs Group II		Group I vs Group III		Group II vs Group III	
		z	p	z	p	z	p
1.	Coronal third	3.387	0.002	0.531	0.738	2.773	0.012
2.	Middle third	0.915	0.583	1.646	0.253	0.801	0.547
3.	Apical third	0	1.000	0.109	0.947	0.067	0.967
4.	Coronal middle third	1.000	0.799	1.000	0.799	0.036	0.989
5.	Combined assessment	4.429	<0.001	1.595	0.174	1.967	0.056

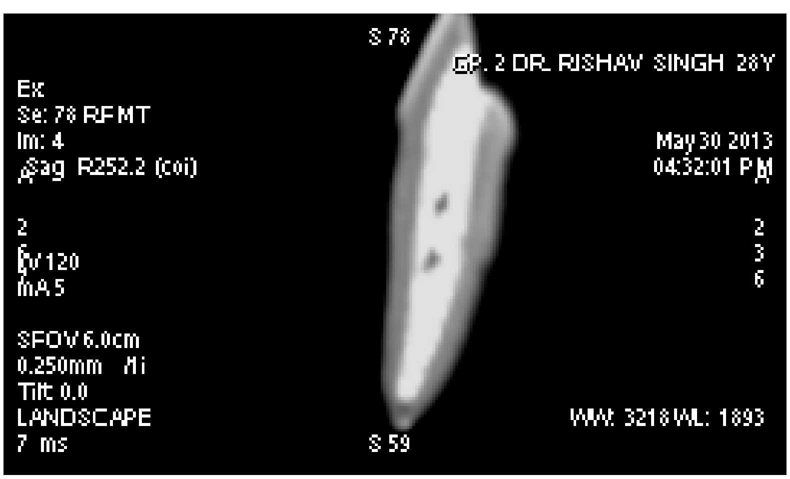
Various techniques for the endodontic treatment of primary teeth have been described in the literature by Holan *et al* [26], Takushige *et al* [27], Barr *et al* [28], and Moskovitz *et al* [29]In our study, the lentulo spiral, smaller by 2 sizes from the last Hedstroem file and kept 1 mm short of the working length, was used to transport ZOE to the root canal of primary teeth as suggested by Bawazir and Salama.[16] By applying this role, there were no broken lentulo spirals and each were used several times in this study. This is considered a key for safe use of the lentulo spiral

In the third technique, an endodontic reamer, corresponding to the size of the canal, with rubber stopper was used to place a thick mix of zinc oxide-eugenol paste into the canal as suggested by Dandashi et al.[10] The thick mix was prepared and rolled into a flame shape, corresponding to the size and shape of the canal. A ZOE block measuring approximately 2 mm, starting from the tapered part of the rolled mix was carried into the canal, and tapped gently into the apical area. Additional increments of 2-mm blocks were added until the canal was filled to the cervical area.

(Fig 1. CBCT image showing voids in group I after obturation with motor driven lentulospiral)



(Fig 2. CBCT image showing voids in group II after obturation with hand held lentulospiral)



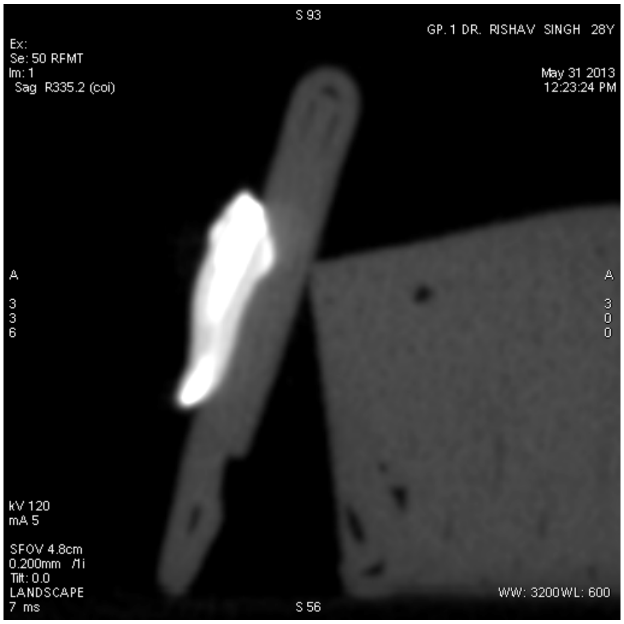
In the present study, all techniques used to fill the canals led to voids in the filling material—a finding consistent with earlier reports by Aylard and Johnson,[8] Bawazir and Salama, [16] and Sigurdsson.[30] The voids may create leakage in the paste, and thus may lead to micro-organism regrowth, reinfection, and an increased risk of post-treatment disease, especially if there are several large voids.

In the present study the motor driven Lentulo spiral led to the best filling technique. This is consistent with the study by Torres *et al* [31] who found that the Lentulo spiral delivered paste into the canals better than injection systems such as the Ultradent Navi Tip system. This finding is also reported by other authors like Aylard [8] and Kahn [32] in their study. As in our study, Dandashi *et al*[10] found no significant difference between the motor driven Lentulo instrument, pressure syringe, and packing technique. The motor driven Lentulo spiral is one of the most effective and straightforward techniques for applying sealers and calcium hydroxide into permanent tooth root canals or pastes into primary tooth canals.

Our comparison of the mean sizes of voids in each third of the root canal showed that, in general, the voids were larger in the coronal third portion (p=0.001) and smaller in the apical part (p=0.995). Peters [33] also found fewer voids in the canal's apical third. The author found that $Ca(OH)_2$ when placed in a simulated canal using mortor driven lentulo spiral had significantly fewer voids than injection technique. Regarding the distribution of voids into root canal thirds, significantly more voids were detected coronally than in the middle and apical third which is consistent with our findings. The voids were analysed using digital radiography.

In an another study, conducted by Kahn [32] the authors found that motor driven lentulo spiral carried the root canal sealer most effectively near the apical part of the tested samples. The authors concluded that motor driven lentulo spiral is the most effective methods of sealer placement along the canal walls. The higher void formation in the coronal third may be related to the finishing procedure we used in all groups. As in the actual clinical procedure, after the canal was filled, we did not packed the ZOE paste into the access cavity with a cotton pellet as suggested by Memarpour et al.[18] This may have increased the void formation in the root's coronal third portion. But various studies have reported that void formation is mostly seen in the middle portion of the root canal which was also confirmed by Estrela et al.[34]

(Fig 3. CBCT image showing voids in group III after obturation with a reamer)



CONCLUSIONS

Based on this study's results, the following conclusion can be made.

- All of the three obturating techniques showed presence of voids.
- CBCT can be an efficient radiographic modality for assessment of the quality of root canal obturation in primary teeth.

REFERENCES

1. V Law, WK Seow, G Townsend. Factors influencing oral colonization of mutans streptococci in young children. Aust Dent J, 52: 93-100, 2007.
2. Ingle JI, Bakland LK. Endodontics. 5th ed. BC Decker Inc, Hamilton; 861, 2002.
3. Finn SB. Clinical Pedodontics. 4th ed. W.B. Saunders Company, Philadelphia; 201, 1991.
4. Mortazavi M, Mesbahi, M. Comparison of zinc oxide and eugenol, and Vitapex for root canal treatment of necrotic primary teeth. Int J Pediatr Dent, 14: 417-424, 2004.
5. Salama FS, Anderson RW, Hanes MC , Barenie JT, Myers DR. Anatomy of primary incisor and molar root canals. Pediatr Dent, 14: 117-118, 1992.
6. Bhandari SK, Prajapati U. Root canal obturation of primary teeth: Disposable injection technique. J Indian Soc Pedod Prev Dent, 30: 13-18, 2012.
7. Guelmann M, Mc Eachern M, Turner C. Pulpectomies in primary incisors using three delivery systems: An in vitro study. J Clin Pediatr Dent, 28: 323-326, 2004.
8. Aylard SR, Johnson R. Assesment of filling techniques for primary teeth. Pediatr Dent, 9: 195-198, 1987.
9. Staehle HJ, Thoma C, Muller HP. Comparative in vitro investigation of different methods for temporary root canal filling with aqueous suspensions of calcium hydroxide. Endod Dent Traumatol, 13: 106-112, 1997.
10. Dandashi MB, Nazif MM, Zullo T, Elliot MA, Schneider LG, Czonstkowsky M. An in vitro comparison of three endodontic techniques for primary incisors. Pediatr Dent, 15: 244-256, 1993.
11. Palomo JM, Kau CH, Bahl L, Hans MG. Three-Dimensional Computerised Tomography in Dentistry. Int Dent SA, 9: 40-49, 2007.
12. Cotton TP, Geisler TM, Holden DT, Schwartz SA, Schindler WG. Endodontic applications of Cone-Beam Volumetric Tomography. J Endod, 33: 1121-1132, 2007.
13. Durack C, Patel S. Cone Beam Computed Tomography in Endodontics. Braz Dent J, 23: 179-191, 2012.
14. Mozzo P, Procacci C, Tacconi A, Tinnazi MP, Bergamo IA. A new volumetric CT machine for dental imaging based on the cone beam technique: preliminary results. Eur Radiol, 8: 1558-1564, 1998.
15. Nedley MP. The pulpectomy in primary teeth. J Mich Dent Assoc, 84: 38-42, 2002.
16. Bawazir OA, Salama FS. Clinical evaluation of root canal obturation methods in primary teeth. Pediatr Dent, 28: 39-47, 2006.
17. Chawla HS, Setia S, Gupta N, Gauba K, Goyal A. Evaluation of a mixture of zinc oxide, calcium hydroxide and sodium fluoride as a new root canal filling material for primary teeth. J Indian Soc Pedod Prevent Dent, 26: 53-58, 2008.
18. Memarpour M, Shahidi S, Meshki R. Comparison of different obturation techniques for primary molars by digital radiography. Pediatr Dent, 35: 236-240, 2013.
19. Grover R, Mehra M, Pandit IK, 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: 104-108, 2013.
20. Asokan S, Sooriaprakas C, Raghu V, Bairavi R. Volumetric analysis of root canal fillings in primary teeth using spiral computed tomography. An in-vitro study. J Dent Child, 79: 46-48, 2012.
21. Scarfe WC, Levin MD, Gane D, Farman AG. Use of Cone Beam Computed Tomography in Endodontics. Int J Dent 2009.
22. Sogur E, Baksi BG, Grondahl HG. Imaging of root canal fillings: a comparison of subjective image quality between limited cone beam CT, storage phosphor and film radiography. International Endodontic Journal, 40: 179-185, 2007.
23. Aminsobhani M, Sadegh M, Meraji N, Razmi H, Kharazifard MJ, Evaluation of root and canal morphology of mandibular permanent anterior teeth in an Iranian population by Cone-Beam Computed Tomography. J Dent (Tehran), 10: 358-366, 2013.
24. Liu J, Luo J, Dou L, Yang D. CBCT study of root and canal morphology of permanent mandibular incisors in a Chinese population. Acta Odontol Scand, 72: 26-30, 2014.
25. Gaurav V, Srivastava N, Rana V, Adlakha VK. A study of root canal morphology of human primary incisors and molars using cone beam computerized tomography: An in vitro study. J Indian Soc Pedo Prev Dent, 31: 254-259, 2013.

26. Holan G, Fuks AB. A comparison of pulpectomies using ZOE and KRI paste in primary molars. Pediatr Dent, 15: 403-407, 1993.
27. Takushige T, Cruz EV, Moral AA, Hoshino E. Endodontic treatment of primary teeth using a combination of antibacterial drugs. Int Endod J, 37: 132-138, 2004.
28. Barr ES, Flaitz CM, Hicks MJ. A retrospective radiographic evaluation of primary molar pulpectomies. Pediatr Dent, 13: 4-9, 1991.
29. Moskovitz M, Sammara E, Holan G. Success rate of root canal treatment in primary molars. J Dent, 33: 41-47, 2005.
30. Sigurdsson A, Stancill R, Madison S. Intracanal placement of $Ca(OH)_2$: A comparison of techniques. J Endod, 18: 367-370, 1992.
31. Torres CP, Apicella MJ, Yancich PP, Parker MH. Intracanal placement of calcium hydroxide: A comparison of techniques, revisited. J Endod, 30: 225-227, 2004.
32. Kahn FH, Rosenberg PA, Schertzer L, Korthals G, Nguyen PNT. An in-vitro evaluation of sealer placement methods. Int Endod J, 30: 181-186, 1997.
33. Peters CI, Koka RS, Highsmith H, Peters OA. Calcium hydroxide dressings using different preparation and application modes: density and dissolution by simulated tissue pressure. Int Endod J, 38: 889-895, 2005.
34. Estrela C, Neto IM, Lopes HP, Estrela CRA, Pecora JD. Root canal filling with calcium hydroxide: Using different techniques. Braz Dent J, 53-56, 2002.