Volumetric Analysis of Root Canal Fillings in Primary Teeth Using Spiral Computed Tomography: An In Vitro Study

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ABSTRACT

Purpose: The purpose of this study was to volumetrically analyze the efficacy of root canal fillings in primary teeth using spiral computed tomography (CT).

Methods: Root canals in 30 primary maxillary and mandibular molars were instrumented with K files to size 30, and the volumes of the canals were then measured using spiral CT. The teeth were randomly divided into 3 groups of 10 each, and 18 of the canals in each group were evaluated with spiral CT after obturation with zinc oxide eugenol paste, Metapex and Vitapex. The filled volume in each canal was measured using spiral CT, and the percentage of obturated volume (POV) was calculated. The pre- and post-mean canal volume values within each group and the POV of the 3 groups were statistically analyzed using one-way analysis of variance and paired *t* tests.

Results: Filler voids were seen in all groups, but there was a statistically significant difference ($P<.001$) in the calculated POV. Vitapex showed 95% POV compared to Metapex (88%) and ZOE (84%).

Conclusion: Voids were seen in all 3 filling materials. Vitapex showed the maximum percentage of obturated volume among the 3 groups. (J Dent Child 2012;79(2):46-8)

Received May 4, 2011; Last Revision March 14, 2011; Revision Accepted April 11, 2011.

KEYWORDS: PRIMARY TOOTH PULPECTOMY, OBTURATION, BIOMATERIALS

It is unwise to maintain untreated infected primary teeth in the oral cavity. Infected teeth should be treated and maintained in the dental arch as a natural space maintainer, provided they can be restored to function and remain free from disease. The morphology of the root canals, including variations like lateral branching, connecting fibrils, apical ramifications, and partial fusion of canals, in primary teeth make endodontic treatment difficult. These developmental, anatomic, and physiologic differences call for an examination of the differences in the criteria for root canal filling materials in primary teeth.[1,2] No material currently available meets all the criteria for an ideal root canal filling material. In India, the most commonly used filling materials are zinc oxide eugenol (**ZOE**), calcium hydroxide, and iodoform pastes like Metapex and Vitapex.

Traditional experimental methods used to assess the quality of obturation of the root canals include the use of radiographs, radioisotopes, dye penetration, fluid filtration, bacterial leakage, microscopic analysis, and clearing techniques. But these techniques do not assess obturation in 3 dimensions. With the invention of spiral computerized tomography (**CT**), 3-dimensional volume measurements were possible without sectioning the specimens and, thus, avoiding the loss of material.[3] A review of the literature resulted in no studies that evaluated the efficiency of various primary root canal fillings using spiral CT. An in vitro study was planned to assess the efficacy of different root filling techniques by calculating the percentage of obturated volume (**POV**) using spiral CT.

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METHODS

Thirty primary molars with a minimum of 8 mm root length were selected for the study. Maxillary first primary molars were excluded from the study for 2 reasons: (1) resorption and calcifications in the roots in the collected samples; and (2) difficulty in the obturation of its canals. These teeth were obtained from peripheral dental clinics run by the government of Tamil Nadu, India, where procedures like pulpectomies are not carried out. The study design was analyzed and approved by the Institutional Review Board of Meenakshi Ammal Dental College, Meenakshi University, Tamil Nadu, India. Collection, storage, sterilization, and handling of extracted teeth followed Occupational Safety and Health Administration guidelines and regulations.[4] Radiographs were taken to identify the number of canals in each tooth. Thirty teeth were numbered and randomly divided into 3 groups of 10 each using the table of random numbers by an independent examiner.

An access cavity was prepared in all 30 teeth, and a 10-size K file was inserted into the chosen canals until its tip was just visible at the root's foramen. The working length was adjusted to 1 mm short of the apex. All canals were enlarged to size 30, and an examiner verified the biomechanical preparation. Saline and 1% sodium hypochlorite were used as irrigants while enlarging the canals. All canals were dried using size 30 paper points before obturation. All teeth were scanned using a Light Speed VCT Scanner (GE Electricals, Milwaukee, Wis). They were then viewed under high resolution, both cross-sectionally and longitudinally, with a constant thickness of 0.62 mm/slice and a constant spiral or table speed of 0.5 and 140 KVP. The scanned data were transferred to Advantage work station software for Windows (GE System, Milwaukee) for image analysis and evaluated.

The prepared root canal area in each slice was measured from the cementoenamel junction to the root's apex. The volume of root canal in each slice was calculated by multiplying the root canal area by the slice thickness (0.625 mm). Finally, the volume of each canal (X) was calculated. Fifty-four unresorbed complete canals were chosen. Canals with resorption, calcifications, or fractures were excluded from the study. Eighteen root canals were randomly allotted to each filler group in such a way that the similar canal types (eg, palatal roots of maxillary molars) were not allotted to the same filler group. Six root canals each from the maxillary second and mandibular first and second molars were allotted to each filler group.

In Group 1, the 18 canals were obturated with ZOE (Septodont Healthcare India Pvt Ltd, Raigad, Maharashtra, India) using hand lentulospirals. Group 2 was obturated with Metapex (Meta Biomed Co, Ltd, Cheongju City, Korea), and Group 3 was obturated with Vitapex (Neo Dental Chemical Products Co, Tokyo, Japan). When backfill into the pulp chamber occurred, the canals were assumed to be filled, and a wet cotton pellet was used to lightly press the material inside the canals. A second spiral CT scan was performed to determine the volume of the filling materials (Y) inside the canal. Figure 1 shows the obturated root canals with the 3 different materials. The POV in each canal was calculated using the formula Y/X x 100.

The proportions were statistically analyzed using one-way analysis of variance (among the 3 groups) and a paired *t* test (within the same group). In the present study, a $P<.05$ level of significance was observed. The statistical analysis was conducted using SPSS 15 software (SPSS Inc, Chicago, Ill., USA).

RESULTS

The volume (mean and standard deviation) of the root canals before (X) and after (Y) obturation, along with the POV for each group, is provided in Table 1. There was a statistically significant difference ($P<.001$) between the pre- and post-mean values in all the 3 groups. Among the 3 groups, there was a significant difference ($P<.001$) in the mean POV values. Post-hoc tests show that Vitapex was the best among the 3 root canal filling materials followed by Metapex and ZOE.

DISCUSSION

The success of endodontic treatment in permanent teeth depends on the total debridement of pulpal space, the development of a fluid tight seal at the apical foramen, and complete obliteration of the root canals. In primary teeth, a tight apical seal is not always possible after a pulpectomy, and complete debridement of the canals and obliteration of the canal space is not always possible, even in pulpectomies that succeed.[5] Traditional

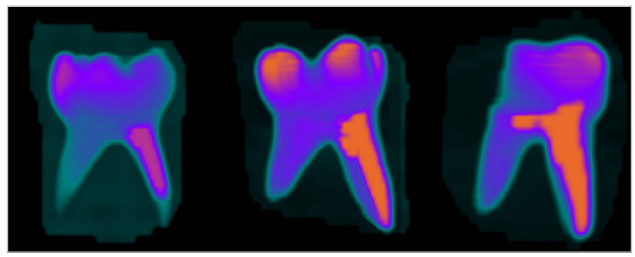

Figure 1. Spiral computed tomography slice showing 3 primary molar root canals obturated with zinc oxide eugenol, Metapex, and Vitapex, respectively (from left to right).

Table 1. Pre- and Post-obturation Volume of Root Canals (cm^3) Filled With 3 Root Canal Fillers and Percentage of Obturated Volume (POV) for Each Group

Groups	N	Pre (X)* mean±(SD)	Post (Y)† mean±(SD)	POV‡
Zinc oxide eugenol	18	0.014±0.005	0.011±0.005	84.405
Metapex	18	0.013±0.005	0.011±0.005	88.311
Vitapex	18	0.013±0.005	0.012±0.005	95.183

** Pre (X): volume (mean and standard deviation) of the root canals after filing, before obturation.*

† Post (Y): volume (mean and standard deviation) of the root canals after obturation.

‡ Calculated using the formula Y/X x 100.

methods of evaluating root fillings in primary teeth have their own disadvantages. Radiographs give a 2-dimensional interpretation only. Sectioning the root could result in loss of tooth material, which could mimic voids.[3]

Spiral CT, a noninvasive technique, gives a 3-dimensional interpretation, avoids loss of material, and yields reproducible results; the specimens also can be used for further research. The specific location of voids can also be determined accurately.[4] CT scans have been used to study the root canal morphology of primary teeth,[6] locate the vital anatomic structures, and image the morbidity of submerged primary molars.[7] CT completely eliminates the superimposition of the images of superficial and deep structures and limits the view to the area of interest. Recent studies have proved that spiral CT provides volumetric analysis of root fillings and aids in the removal of root canal fillings in permanent teeth.[8-10] Hence, spiral CT was chosen as the tool for investigating the efficacy of root canal fillings in primary teeth for the first time, in our study.

In the present study, 3 root canal fillings were assessed. The 3 materials were chosen for the study based on their: (1) common usage in day-to-day practice; (2) cost; and (3) ease in usage. Voids were seen in all 3 materials. There was a highly statistically significant difference ($P<.001$) between the pre- and post-mean values in all 3 groups, clearly indicating that none of the 3 root canal filling materials completely fills the entire canal space. Dandashi et al., showed that voids are common in all the materials used, but were fewer when pressure syringes were used.[11] This agrees with our results, which showed that the Vitapex syringe system delivered the material better than the Metapex system and the lentulospiral-driven ZOE. Good operator skills are required to master the use of any delivery system. Though lentulospiral is a widely accepted successful technique for delivery of endodontic sealers, even experienced operators need to reinsert material to ensure better filling quality.[12,13] Hand-used lentulo procedures produce a much less dense fill than a handpiece-placed lentulo when using ZOE. This could be one of the reasons why ZOE had the least POV in this study.

Coll and Sadrian stated that the amount of preoperative root resorption seemed to be the most important radiographic criterion in determining whether a pulpectomy will likely succeed.[5] But from a 3-dimensional point of view, considering the material's obturating quality alone, Vitapex showed 95% POV obturation vs Metapex (88%) and ZOE (84%). The limitations of the study include the small sample size of unresorbed canals and the difficulty in random allotment of these canals to different filler groups.

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. None of the 3 root canal filling materials was free of voids.
2. Vitapex showed the greatest percentage of obturated canal volume of the 3 canal fillers tested, while ZOE showed the least.

REFERENCES

1. McDonald RE, Avery DR, Dean JA. Treatment of deep caries, vital pulp exposure, and pulpless teeth. In: Dentistry for the Child and Adolescent. 8th ed. New Delhi, India: Mosby; 2004.
2. Pinkham JR. Pulp therapy for the primary dentition. In: Pediatric Dentistry: Infancy Through Adolescence. 2nd ed. New Delhi, India: WB Saunders Co; 2001.
3. Anbu R, Nandini S, Velmurugan N. Volumetric analysis of root canal fillings using spiral computed tomography: An in vitro study. Int Endod J 2010; 43:64-8.
4. Reuben J, Velmurugan N, Kandaswamy D. The evaluation of root canal morphology of the mandibular first molar in an Indian population using a spiral-computed tomography scan: An in vitro study. J Endod 2008;34:212-5.
5. Coll JA, Sadrian R. Predicting pulpectomy success and its relationship to exfoliation and succedaneous dentition. Pediatr Dent 1996;18:57-63.
6. Joseph T, Varma B, Mungara J, Zoremchhingi. A study of root canal morphology of human primary molars using computerized tomography: An in vitro study. J Indian Soc Pedod Prev Dent 2005;23:7-12.
7. Kırzıolu Z, Karayılmaz H, Baykal B. Value of computed tomography (CT) in imaging the morbidity of submerged molars: A case report. Eur J Dent 2007;1:246-50.
8. Bartletta F, Reis M, Wagner M, Borges J, Dall' Agnol C. Computed tomography assessment of three techniques for removal of filling material. Aust Endod J 2008;34:102-5.
9. 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 2008;34: 1370-3.
10. Hammad M, Qualtrough A, Silikas N. Evaluation of root canal obturation: A three-dimensional in vitro study. J Endod 2009;35:541-4.
11. 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 1999;15:254-6.
12. Guelmann M, McEachern M, Turner C. Pulpectomies in primary incisors using three delivery systems: An in vitro study. J Clin Pediatr Dent 2004; 28:323-6.
13. Holan G, Fuks A. A comparison of pulpectomies using ZOE and KRI paste in primary molars: A retrospective study. Pediatr Dent 1993;15:403-7.