Original Article

Three-Dimensional Assessment of Root Canal Morphology of Human Deciduous Molars Using Cone Beam Computed Tomography: An *In vitro* Study

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Abstract

Background: Endodontic treatment involves cleaning, shaping, and obturation of the root canal system which requires knowledge of root canal morphology and its commonly occurring variation. **Aim:** The aim of the present study was to assess the variations in number and morphology of deciduous molar teeth using cone beam computed tomography (CBCT) an auxiliary imaging modality. **Materials and Methods:** A total of ninety recently extracted deciduous molar teeth were collected which are divided into four groups: Group I: mandibular first molars ($n = 22$), Group II: maxillary first molars ($n = 18$), Group III: mandibular second molars ($n = 21$), Group IV: maxillary second molars ($n = 29$). The length of the roots, angulation of the roots, number of the root canals, curvature of the root canals, and the type of root canals were determined using CBCT. **Statistical Analysis:** Descriptive statistics were used to find out the frequency, mean, standard deviation, and range of all the five parameters. **Results:** CBCT showed that the distobuccal root of primary maxillary molars had the greatest angulation, whereas, in deciduous mandibular molars, distal root has the greatest angulation. S-shaped canals were more common in the palatal root of maxillary molars, and curved canals were more common in the mesial root in mandibular molars. **Conclusions:** CBCT was found to be an effective and accurate diagnostic tool which provides an auxiliary imaging technology to assess the root canal morphology of primary teeth.

Keywords: Cone beam computed tomography, primary teeth, root canal morphology

Introduction

Dental caries and dental trauma are the two main etiologic factors responsible for pulp involvement necessitating treatment to maintain the integrity of oral tissues. Endodontic procedures for the treatment of deciduous teeth are indicated if the canals are accessible and there is evidence of essential normal supporting bone.[1]

This knowledge of the anatomy of root canal systems is an essential prerequisite for endodontic treatment. Many of the problems encountered during and after root canal treatment occur because of inadequate understanding of the pulp space anatomy. Studies on the internal and external anatomy of teeth have shown that anatomic variations can occur in all groups of teeth and can be extremely complex.[2]

Pulpectomy of primary teeth is indicated when the dental pulp is nonvital or irreversibly inflamed. However, as the primary teeth may show bizarre internal geometry of the pulp cavity, with features not commonly observed in permanent teeth, such as connections involving furcations and horizontal anastomosis, endodontic treatment of primary teeth is considered highly complicated.[3]

There are numerous reports on the root canal morphologies of different populations, which is extremely important for a pedodontist as well as general dental practitioners. The methods most commonly used in analyzing the root canal morphology are canal staining and tooth clearing, conventional radiographs, digital and contrast medium-enhanced radiographic techniques, radiographic assessment enhanced with contrast media, and more recently computed tomographic techniques.[4]

Access this article online

Quick Response Code:

Website: www.ijpedor.org

DOI: 10.4103/ijpr.ijpr_21_17

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How to cite this article: Reddy NV, Daneswari V, Patil R, Meghana B, Reddy A, Niharika P. Three-dimensional assessment of root canal morphology of human deciduous molars using cone beam computed tomography: An *In vitro* Study. Int J Pedod Rehabil 2018;3:36-41.

However, as root resorption of primary teeth begins, dentin is deposited within the root canal system and may change the number, size, and/or shape of the root canals significantly. The presence of necrotic pulp or the unsuccessful outcome of pulpotomy procedures may make endodontic therapy of the root canal systems desirable if extraction of the tooth is to be avoided.[5]

The purpose of this study was to assess the variations in the length, angulation of the roots, type of canals, number of root canals, and root canal curvature using a cone beam computed tomography (CBCT) which provides a three-dimensional (3D) visualization of the internal and external root canal anatomy.

Materials and Methods

A total of 1000 primary molars were collected from the Department of Pedodontics and Preventive Dentistry, Khammam, and from different private practices in and around Khammam district. Out of the sample procured, only ninety primary molars with at least two-third root length and without any evidence of root fracture were used in the study.

These samples were then divided into four groups:

- Group I: Mandibular first molars (*n* = 22)
- Group II: Maxillary first molars (*n* = 18)
- Group III: Mandibular second molars (*n* = 21)
- Group IV: Maxillary second molars (*n* = 29).

To remove any debris or attached tissue remnants, all teeth were cleaned with soap and washed using vigorous amount of ultrapure water. Hand scalers were used to remove calculus if present on the root surface and stored in individual glass container containing 10% formalin solution while waiting for further experimentation. The teeth were mounted in a straight line on the modeling wax after determining the various aspects of the tooth, i.e., buccal, lingual, mesial and distal, so as to maintain uniformity in the samples [Figure 1].

The mounted teeth were then scanned using CBCT scanner (KODAK-9000 3D, Carestream Dental, USA) and ported to the vision preview screen for 2D and 3D reconstruction images in three planes, i.e., sagittal, axial, and coronal [Figure 2]. An experienced radiologist acquired the images according to the manufacturer's instructions. The whole CBCT imaging protocol was carried by a registered dental radiologist following the as low as reasonably practicable protocol.

Figure 1: Teeth mounted on wax for cone beam computed tomography.

Two examiners evaluated the CBCT images: a senior postgraduate (PG) pedodontist student (Examiner 1) and a certified oral and maxillofacial radiologist (Examiner 2). Before evaluation of the CBCT images, adequate training of the PG student in image processing and reconstruction was conducted. Then, case definitions and criteria for reading and recording data were set.

Once the sample data were acquired or data for a sample were loaded, the software immediately reconstructs the tooth images in sagittal, axial, and coronal planes. The length and the angulation of each root were measured by taking the maximum length from the apex of the tooth to the greatest area of constriction at the cementoenamel junction. The length of the roots, angulation of the roots, number of the root canals, curvature of the root canals, and the type of root canals were determined [Figures 3-7].

Statistical analysis

The readings obtained during the scanning procedure were put to statistical analysis. Descriptive statistics were used to find out the frequency, mean, standard deviation, and range for all the five parameters: (1) Length of roots; (2) angulation of the roots; (3) number of the root canals; (4) type of the root canal (Vertucci's classification); and (5) curvature of root canals

Results

The mean root length of the maxillary molar teeth was considered; it was found that palatal root was found to be longest while distobuccal root was shortest. In mandibular molars, the mesial root is longer than distal root [Table 1]. On comparing the mean root angulation of the teeth, it was found that the distobuccal root of primary maxillary molars had the greatest angulation, whereas in deciduous mandibular molars, distal root had the greatest angulation [Table 2]. When the number of root canals in the teeth was considered, in maxillary molars, single root canals are found in most of the teeth specimens whereas mesial root of all mandibular molars had two canals (100%) whereas distal root showed single canal (77.3%) [Table 3]. Vertucci's classification Type I or Type IV type canals were found in all the primary molar teeth specimens [Table 4]. S-shaped canals were more commonly seen in the palatal root of maxillary molars, and curved canals were seen in the mesial root in mandibular molars [Table 5].

Discussion

Knowledge of the size, morphology, and disparity of the root canals of primary teeth are helpful in visualizing the pulp cavity during treatment. Since primary teeth exhibit morphologic differences from the permanent teeth both in size, external and internal morphology, successful endodontic treatment lies in understanding the complex root canal system. Many of the errors occur during the access cavity preparation or when locating the canal orifices, which is dependent on the dentists' tactile perception and knowledge of the dental anatomy.[6]

Figure 2: Cone beam computed tomography imaging technology.

Table 1: Length of the roots

Group	*n*	Minimum (°)	Maximum (°)	Mean	Median	SD
Group I						
Mesial root	22	82	100	91.91	91.00	5.098
Distal root		79	105	90.64	90.00	5.602
Group II						
Mesiobuccal root	18	69	91	80.89	81.00	6.192
Distobuccal root		71	95	83.11	83.50	6.009
Palatal root		74	96	84.17	85.00	5.404
Group III						
Mesial root	21	78	101	87.29	87.00	6.528
Distal root		78	98	87.57	88.00	5.221
Group IV						
Mesiobuccal root	29	70	92	83.07	84.00	5.849
Distobuccal root		71	93	84.24	86.00	5.926
Palatal root		69	93	83.24	83.00	5.214

SD: Standard deviation

Table 2: Angulation of roots

Group	*n*	Minimum (°)	Maximum (°)	Mean	Median	SD
Group I						
Mesial root	22	82	100	91.91	91.00	5.098
Distal root		79	105	90.64	90.00	5.602
Group II						
Mesiobuccal root	18	69	91	80.89	81.00	6.192
Distobuccal root		71	95	83.11	83.50	6.009
Palatal root		74	96	84.17	85.00	5.404
Group III						
Mesial root	21	78	101	87.29	87.00	6.528
Distal root		78	98	87.57	88.00	5.221
Group IV						
Mesiobuccal root	29	70	92	83.07	84.00	5.849
Distobuccal root		71	93	84.24	86.00	5.926
Palatal root		69	93	83.24	83.00	5.214

SD: Standard deviation

In the present study, CBCT was found to be an effective and accurate diagnostic tool which provides an auxiliary imaging modality to supplement conventional radiography in difficult situations demanding localization and description of root canal systems because of its ability to render 3D information.[7,8]

In Group I and III, the mean length of the mesial root was longer than the distal root. In Group II, the mesiobuccal root showed longest measurement (7.85 mm) followed by palatal root and distobuccal root, which was in accordance with Bagherian *et al*., but in contrast to the findings of Zoremchhingi *et al*.[1,9] This difference might be attributed to the different populations examined. In Group IV, the palatal root showed the longest measurement (8.95 mm) followed by mesiobuccal root and the distobuccal root; these results were in accordance with the study conducted by Gaurav *et al*. on primary molars.[7] Better

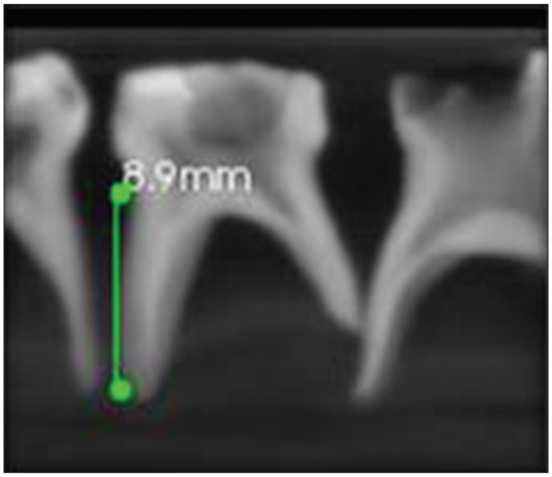

Figure 3: Length of roots.

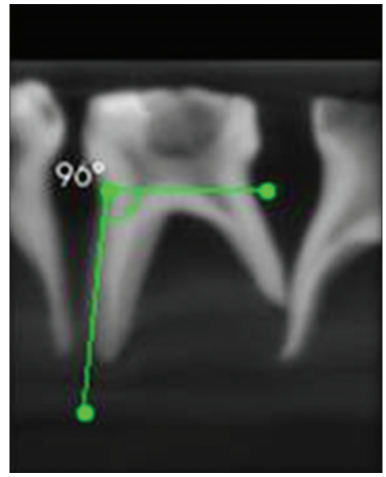

Figure 4: Angulation of roots.

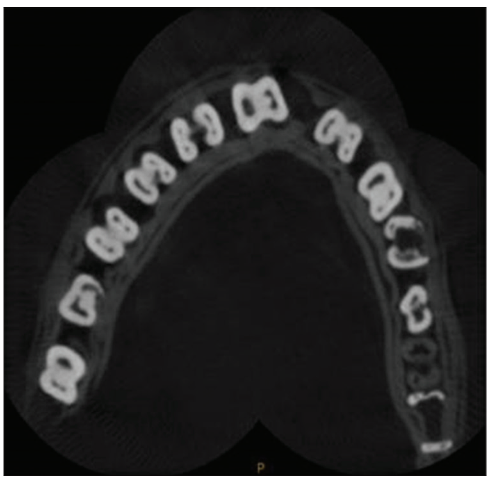

Figure 5: Number of root canals.

Table 3: Number of roots and canals

Group	Number of teeth	1 canal (%)	2 canal (%)
Group I			
Mesial root	22	4 (18.2)	18 (81.8)
Distal root		17 (77.3)	5 (22.7)
Group II			
Mesio buccal root	18	16 (88.9)	2 (11.1)
Distobuccal root		18 (100)	0
Palatal root		18 (100)	0
Group III			
Mesial root	21	0	21 (100)
Distal root		15 (71.4)	6 (28.6)
Group IV			
Mesiobuccal root	29	29 (100)	0
Distobuccal root		29 (100)	0
Palatal root		29 (100)	0

knowledge of root length may be useful for determining the working length which prevents over or under instrumentation wherein debris removal might be hampered.

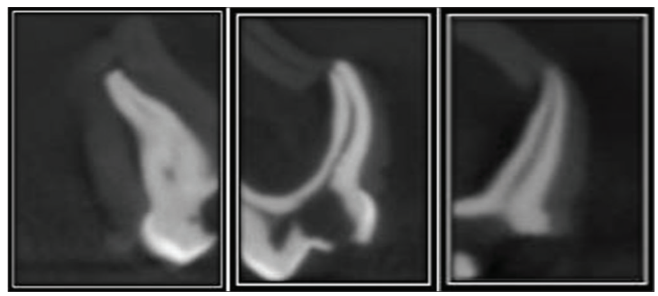

Figure 6: Shape of canals.

In the present study, mean root angulation of the deciduous molars, it was found that the distobuccal root of primary maxillary molars had the greatest angulation (84.24°), whereas in deciduous mandibular molars, distal root had the greatest angulation (90.64°), the present results were slightly varied when compared to the results obtained by Gaurav *et al*. on primary molars.[7] These angulations help in determining the amount of file precurving for easier access to the root canal during pulpectomy procedures so that endodontic mishaps such zipping, transportation can be avoided.

The results of this study indicated that all the deciduous mandibular first molars had two roots (100%) and 2–4 root canals. These results were in agreement with the studies conducted by Gupta and Grewal and Hibbard and Ireland[10,11] Most of the *in vivo* and *in vitro* studies have shown that deciduous mandibular first molars have two or three roots with three or four root canals. A radiographic study of extracted mandibular first molar with three distal canals was noticed which occurs only in 1.7% of cases. Further review of endodontic literature also reveals that the mandibular first molar presenting with three distal canals was a rare phenomenon.[12] A deciduous mandibular first molar with three distal canals was first reported by Berthiaume; however, the three distal canals ended in two apical foramina. Reuben *et al*. using spiral computerized tomography examined 125 mandibular first molars in an Indian population, and none of the teeth had three distal canals.[13,14] Gupta *et al*. reported three case reports where he observed primary bifurcated maxillary left canine, primary three-rooted mandibular right first molar, and a third case having bilaterally primary three-rooted mandibular first and second molars.[15]

All the teeth specimens in this study were of Vertucci classification Type I and Type IV; therefore, if there were two root canals in one root, these two canals were completely separated, which is in agreement with the study conducted by Bagherian *et al*.[1]

In the present study, curved and straight profiles of the root canals were dominant in all classes. S-shaped curvature was observed only in primary maxillary molars, especially in the palatal root of second maxillary molars. Since curvature of the root canal may pose problems such as perforation during the cleaning procedure, more detailed knowledge of the frequency of these curvature types may be beneficial for avoiding this kind of complication.

As there is sparse availability of literature on the study of root and canal morphology of primary molars, it is necessary to conduct further studies with a larger sample size in different groups of population with more advanced techniques such as high-resolution CBCT, microcomputed tomography, and peripheral quantitative computed tomography. These studies will further aid the pedodontist as well as the general dentist in gaining thorough knowledge regarding primary root canal morphology which will lead to success of pulp therapy in primary teeth.

Table 4: Type of canals (Vertucci's classification)

Group	Number of teeth	Type I canal (%)	Type IV canal (%)
Group I			
Mesial root	22	4 (18.2)	18 (81.8)
Distal root		17 (77.3)	5 (22.7)
Group II			
Mesio buccal root	18	16 (88.9)	2 (11.1)
Distobuccal root		18 (100)	0
Palatal root		18 (100)	0
Group III			
Mesial root	21	0	21 (100)
Distal root		15 (71.4)	6 (28.6)
Group IV			
Mesiobuccal root	29	29 (100)	0
Distobuccal root		29 (100)	0
Palatal root		29 (100)	0

Conclusions

CBCT was found to be an effective and accurate diagnostic tool to study the root length, angulation, and root canal morphology

Figure 7: Type of the canals.

Table 5: Shape of canals

Group	Number of teeth	Straight (%)	Curved (%)	S-shaped (%)
Group I	22			
Mesial root canal	4	1 (25)	3 (75)	
Mesiobuccal root canal	18	3 (16.6)	15 (83.4)	
Mesiolingual root canal	18	11 (61.2)	7 (38.8)	
Distal root canal	17	10 (58.8)	7 (41.2)	
Distobuccal root canal	5	3 (60)	2 (40)	
Distolingual root canal	5	4 (75)	1 (25)	
Group II	18			
Mesiobuccal root canal	18	1 (5.6)	16 (88.8)	1 (5.6)
Distobuccal root canal	18	7 (38.8)	11 (61.2)	
Palatal root canal	18	14 (77.7)	2 (11.1)	2 (11.1)
Group III	21			
Mesiobuccal root canal	21	1 (4.8)	20 (95.2)	
Mesiolingual root canal	21	7 (33.4)	14 (66.6)	
Distal root canal	15	6 (40)	9 (60)	
Distobuccal root canal	6	1 (16.7)	5 (83.3)	
Distolingual root canal	6	2 (33.4)	4 (66.6)	
Group IV	29			
Mesiobuccal root canal	29	3 (10.3)	26 (89.7)	
Distobuccal root canal	29	9 (31)	20 (69)	
Palatal root canal	29		21 (72.8)	8 (27.2)

of primary teeth. The distobuccal root of primary maxillary molars had the greatest angulation, whereas, in deciduous mandibular molars, distal root showed the greatest angulation. One or two root canals are found in mesial and distal roots of primary mandibular molars. In maxillary molars, single root canals are found in most of the teeth specimens. Only Type I or Type IV type of canals is found in all the primary molar teeth specimens. Curved canals were more common in the mesial roots in mandibular molars with S-shaped canals more predominantly seen in the palatal roots of maxillary molars.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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