Journal of Oral Science, Vol. 52, No. 3, 397-403, 2010

Original

An *in vitro* study of root and canal morphology of human deciduous molars in an Iranian population

Ali Bagherian[1], Katayoun A. M. Kalhori[2], Mostafa Sadeghi[3], Farzaneh Mirhosseini[4] and Iman Parisay[5]

[1]Department of Pediatric Dentistry, School of Dentistry, Rafsanjan University of Medical Sciences, Rafsanjan, Iran
[2]Department of Pathology, School of Dentistry, Rafsanjan University of Medical Sciences, Rafsanjan, Iran
[3]Department of Restorative Dentistry, School of Dentistry, Rafsanjan University of Medical Sciences, Rafsanjan, Iran
[4]Rafsanjan School of Dentistry, Rafsanjan University of Medical Sciences, Rafsanjan, Iran
[5]Department of Pediatric Dentistry, School of Dentistry, Yazd University of Medical Sciences, Yazd, Iran

(Received 28 November 2009 and accepted 27 May 2010)

Abstract: Dental caries is the most common chronic childhood disease. Deep caries and dental trauma are the two main etiologic factors responsible for pulp involvement. Better knowledge of the morphology of the root canals of deciduous teeth can improve the outcome of pulp treatment. In this study, 90 deciduous molar teeth (27 first mandibular molars, 27 first maxillary molars, 22 second mandibular molars and 14 second maxillary molars) were prepared using the clearing technique, and then dye was injected into the pulp cavity of each tooth. The roots of the teeth were examined under a stereomicroscope at ×10 magnification from different aspects. Measurements of root length and angulation were also recorded, and the data were analyzed using SPSS-16 software. Deciduous molar teeth in all four classes showed variability in the number of roots and root canals, and also differed in mean root length and angulation. Type I and IV root canal configurations were observed in the samples, and different types of curvature were recorded for the root canals in all four classes. As deciduous molar teeth exhibit morphologic differences from permanent teeth, a thorough knowledge of the root canals in the former can improve the outcome of pulp treatment. (J Oral Sci 52, 397-403, 2010)

Keywords: root canal morphology; deciduous teeth; clearing technique; Iranian population.

Correspondence to Dr. Ali Bagherian, Department of Pediatric Dentistry, School of Dentistry, Rafsanjan University of Medical Sciences, Rafsanjan, Iran
Tel: +98-391-8220013
Fax: +98-391-8220008
E-mail: drbagherian@yahoo.com

Introduction

Dental caries is the most common chronic childhood disease (1,2). Despite modern advances in the prevention of dental caries and an increased understanding of the importance of maintaining natural dentition, many teeth are still lost prematurely because of dental caries, and this can lead to malocclusion, and esthetic, phonetic or functional problems (3,4).

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. The deposition of secondary dentine throughout the life of deciduous teeth causes a change in the morphologic pattern of the root canal, making pulpectomy a difficult procedure in deciduous teeth (5). Since the main purpose of filing in the pulpectomy procedure (3,6) is the removal of organic contents from the canal, more detailed knowledge of root

and canal morphology is certainly helpful for achieving this goal.

A few previous studies have investigated the root and canal morphology of deciduous teeth using different techniques, including radiography (7), computed tomography (4) and clearing (7). Zoremchhingi et al. (4) investigated the root and canal morphology of primary molars in an Indian population using a CT scan technique and reported that it was highly variable and complex. They also observed that the prevalence of fused palatal and distobuccal roots in primary maxillary molars was not uncommon in Indians (4). Gupta and Grewal (8) investigated the root canal configuration of deciduous mandibular first molars in another Indian poulation using roentgenographic and clearing methods, and reported major variability in the root canal morphology of these teeth. In their samples, they observed a maximum of five root canals in a single specimen, but on average, the majority of the specimens had four root canals (8).

Because of the small number of known studies of root canal morphology in deciduous teeth, and the differences in the races investigated, study methods and sample sizes, the results have been debatable. To our knowledge, no previous study has investigated the deciduous molars in an Iranian population. Therefore, to add further data for a different racial group, the present study focused on the root and canal morphology of the deciduous molar teeth in an Iranian population using a clearing technique.

Materials and Methods

Ninety extracted deciduous molar teeth with no evidence of macroscopic root resorption or fracture were collected from the Department of Pedodontics of Rafsanjan Dental School. Since these teeth were not extracted for the purpose of this study, accurate data pertaining to the age and sex of the source individuals were unnecessary. The collected teeth were divided into four classes:

Class I: Mandibular first molars (n = 27)

Class II: Maxillary first molars (n = 27)

Class III: Mandibular second molars (n = 22)

Class IV: Maxillary second molars (n = 14)

The samples were cleaned with soap and washed in running water. Hand scalers were used to remove any soft tissue present on the root surfaces, and the teeth were then stored at room temperature in individual glass containers containing distilled water. The number, length and angulation of the roots were determined.

The length of the roots was measured after tracing the cervical and apical reference point on tracing paper to the nearest 1 mm using a ruler. The greatest area of constriction was considered a cervical point (4) and the apical end of the root was considered as an apical reference point. Coronal root angulation was assessed using a protractor by measuring the angle between a line perpendicular to the cervical line (4) and the tangent to the outer surface of the coronal part of each root on tracing paper.

Access cavities were prepared using a #836 cylinder diamond bur (Diatech, Heerbrugg, Switzerland). For removal of soft pulp tissue and disinfection, the teeth were stored for 24 h in 5.25% sodium hypochlorite solution (Golrang, Tehran, Iran).

Since no specific decalcification or clearing technique has been reported for deciduous teeth, we employed a modification of a technique devised previously for permanent teeth (9,10). The optimal concentration and duration of treatment for each material were determined in a pilot study using 12 deciduous molar teeth.

For decalcification, the teeth were soaked in 6% hydrochloric acid (Merck KGaA, Darmstadt, Germany) for 24 h, and then washed under running water for one hour, followed by passage through different concentrations of ethanol (Taghtir Khorasan, Mashhad, Iran) for dehydration. The sequence of ethanol concentrations employed was 70%, 80%, 90%, and absolute ethanol, and the teeth were kept in each concentration for 5 h.

Clearing of the teeth was done by immersing them in a mixed solution of methyl salicylate and absolute ethanol for 5 h, followed by immersion in methyl salicylate (Merck KGaA) until the beginning of the next stage. Methylene blue (Merck KGaA) dye was injected into the coronal end of the canal. Suction, if needed, was applied at the apical end of the root to facilitate the flow of the dye. After injecting the dye, the roots of the teeth were examined under a stereomicroscope (Olympus, Tokyo, Japan) at ×10 magnification (Fig. 1).

The number of root canals, root canal curvature (straight, curved, S-shaped) (Fig. 2), and root canal type (according to Vertucci's classification) (11) were determined. All the above measurements and root and canal morphology were recorded by two independent precalibrated examiners, and consensus was required in the event of disagreement. Descriptive statistics were used to determine the frequency, mean, standard deviation and range for all four groups using the SPSS-16 software package.

Results

Class I:

All the samples of this class had two roots (mesial and distal). The number, curvature and type of the root canals are shown in Table 1. The mean length of the mesial root was 9.66 mm and the mean angulation of this root was 12.96°. The mean length of the distal root was 7.22 mm

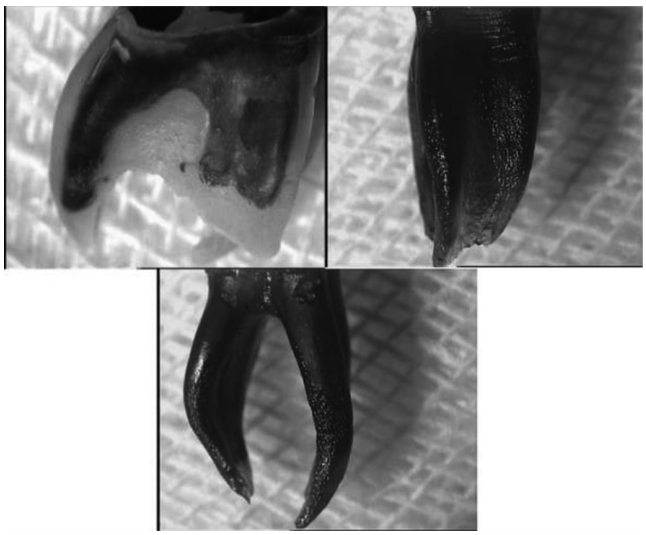

Fig. 1 Stereomicroscopy view of some decalcified and cleared teeth after injection of methylene blue.

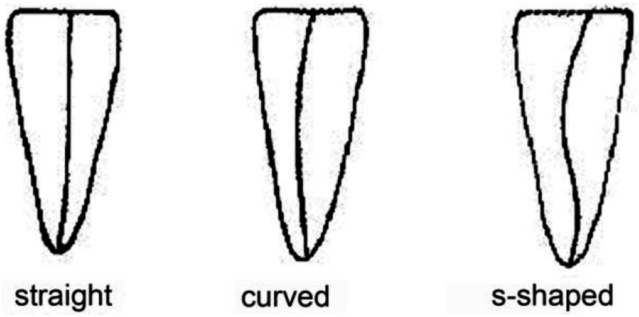

Fig. 2 Different types of root canal curvature.

and the mean angulation was 8.92° (Table 2).

Class II:

All the teeth of this class had three roots (mesiobuccal, distobuccal, palatal). The palatal and distobuccal roots were fused in 77.7% of the samples, and in the others the roots were completely separated. The number, curvature and type of the root canals are shown in Table 3. In this class, the mesiobuccal (MB) root showed the maximum root length, with a mean of 8.11 mm, and the distobuccal (DB) root showed the minimum length with a mean of 6.77 mm. The mesiobuccal root also showed the maximum angulation (18.66°), followed by the distobuccal root (15.40°). The palatal root (12.29°) showed the least angulation (Table 4).

Class III:

In this class, 95.5% of the samples had two roots (mesial and distal) and only one of 22 samples had three roots (mesiobuccal, mesiolingual, distal). The number, curvature and type of the root canals are shown in Table 5. The mean length of the mesial root was 9.40 mm and the mean

Table 1 Frequency of number, curvature and type of root canals in deciduous mandibular first molars

Variables	Number (Percent)
N. of root canals	
Mesial root:	
2	22 (81.5)
1	5 (18.5)
Distal root:	
2	6 (22.2)
1	21 (77.8)
Curvature of canals	
Mesial root	
MB canal	
Straight	2 (9.1)
Curved	20 (90.9)
ML canal	
Straight	18 (81.8)
Curved	4 (18.2)
Mesial canal	
Straight	1 (20)
Curved	4 (80)
Distal root	
DB canal	
Straight	4 (66.6)
Curved	2 (33.4)
DL canal	
Straight	5 (83.3)
Curved	1 (16.7)
Distal canal	
Straight	14 (66.6)
Curved	7 (33.4)
Type of root canals	
Mesial root:	
IV	22 (81.5)
I	5 (18.5)
Distal root:	
IV	6 (22.2)
I	21 (77.8)

Table 2 Descriptive distribution of root length and angulation in deciduous madibular first molars

Variables	Min-Max	Mean ± SD
Root length		
Mesial root	8 - 11 mm	9.66 ± 1.03
Distal root	6 - 10 mm	7.22 ± 0.89
Root angulation		
Mesial root	3° - 20°	12.96° ± 3.79°
Distal root	3° - 20°	8.92° ± 3.67°

Table 3 Frequency of number, curvature and type of root canals in deciduous maxillary first molars

Variables	Number (Percent)
N. of root canals	
MB root	
2	2 (7.4)
1	25 (92.6)
DB root	
2	1 (3.7)
1	26 (96.3)
Palatal root	
1	27 (100)
Curvature of canals	
-MB canal	
Curved	25 (92.6)
Straight	1 (3.7)
S-shaped	1 (3.7)
-DB canal	
Curved	13 (48.1)
Straight	14 (51.9)
-Palatal canal	
Curved	2 (7.4)
Straight	25 (92.6)
Type of root canals	
MB root	
IV	2 (7.4)
I	25 (92.6)
DB root	
IV	1 (3.7)
I	26 (96.3)
Palatal root	
I	27 (100)

Table 4 Descriptive distribution of root length and angulation in deciduous maxillary first molars

Variables	Min-Max	Mean ± SD
Root length		
MB root	6 - 10 mm	8.11 ± 0.89
DB root	5 - 9 mm	6.77 ± 1.01
Palatal root	5 - 9 mm	7.14 ± 0.94
Root angulation		
MB root	5° - 27°	18.66° ± 4.93°
DB root	5° - 27°	15.40° ± 5.07°
Palatal root	3° - 28°	12.29° ± 5.22°

Table 5 Frequency of number, curvature and type of root canals in deciduous mandibular second molars

Variables	Number (Percent)
N. of root canals	
Mesial root	
2	22 (100)
Distal root	
2	8 (36.4)
1	14 (63.6)
Curvature of canals	
Mesial root	
MB canal	
Curved	21 (95.5)
Straight	1 (4.5)
ML canal	
Curved	12 (54.5)
Straight	10 (45.5)
Distal root	
With one canal	
Curved	9 (62.3)
Straight	5 (37.7)
With two canals	
DB canal	
Curved	6 (75)
Straight	2 (25)
DL canal	
Curved	4 (50)
Straight	4 (50)
Type of root canals	
Mesial root	
IV	22 (100)
Distal root	
IV	8 (36.4)
I	14 (63.6)

Table 6 Descriptive distribution of root length and angulation in deciduous mandibular second molars

Variables	Min-Max	Mean ± SD
Root length		
Mesial root	8 - 12 mm	9.40 ± 1.18
Distal root	7 - 12 mm	8.27 ± 1.31
Root angulation		
Mesial root	5° - 27°	15.25° ± 5.76°
Distal root	3° - 25°	11.79° ± 5.24°

angulation was 15.25°. The mean length of the distal root was 8.27 mm and the mean angulation was 11.79° (Table 6).

Class IV:

All the samples of this class had three roots (mesiobuccal, distobuccal, and palatal). In four out of 14 samples, the distobuccal and palatal roots were fused, but those in the other samples were completely separated. The number, curvature and type of the root canals are shown in Table 7. In this class, the palatal root showed the maximum root length, with a mean of 9.92 mm, and the distobuccal root showed the minimum length with a mean of 7.21 mm. The palatal root also showed the maximum angulation (16.14°),

Table 7 Frequency of number, curvature and type of root canals in deciduous maxillary second molars

Variables	Number (Percent)
N. of root canals	
Mesiobuccal root	
1	14 (100)
Distobuccal root	
1	14 (100)
Palatal root	
1	14 (100)
Curvature of canals	
MB canal	
Curved	14 (100)
DB canal	
Curved	8 (57.1)
Straight	6 (42.9)
Palatal canal	
Curved	11 (78.6)
S-Shaped	3 (21.4)
Type of root canals	
Mesiobuccal root	
I	14 (100)
Distobuccal root	
I	14 (100)
Palatal root	
I	14 (100)

Table 8 Descriptive distribution of root length and angulation in deciduous maxillary second molars

Variables	Min-Max	Mean ± SD
Root length		
MB Root	7 - 13 mm	9.57 ± 1.69
DB root	6 - 9 mm	7.21 ± 0.97
Palatal root	8 - 12 mm	9.92 ± 1.54
Root angulation		
MB root	5° - 16°	10.71° ± 3.12°
DB root	4° - 16°	8.78° ± 3.68°
Palatal root	10° - 30°	16.14° ± 5.44°

followed by the mesiobuccal root (10.71°). The distobuccal root (8.78°) showed the least angulation (Table 8).

Discussion

Maintenance of pediatric dental integrity is important for ensuring correct tooth spacing, mastication, phonation, esthetics, and prevention of psychological effects due to tooth loss (3,4,12). The main goal of root canal therapy for deciduous teeth is to clean the root canals of infected tissues (3,6); therefore, detailed knowledge of the root and canal morphology of deciduous teeth can greatly improve the effectiveness and outcome of treatment.

Several methods have been used to investigate the morphology of root canals in extracted teeth, including conventional radiography (12), computed tomography (4), and filling of canals with epoxy resin followed by decalcification (13). However, all have been shown to have limitations in previous studies.

In the conventional radiographic method, in order to study the buccolingual aspect of the roots, the tooth should be sectioned into two or three parts, which leads to loss of the overall tooth structure. Although computed tomography is a good method for studying the morphology of root canals, it requires an expensive special device and trained personnel. The main problem associated with filling canals with inert materials and subsequent tooth decalcification with strong acid is loss of structures external to the pulp during sample preparation.

In the present study, we used an inexpensive clearing technique that allowed observation of the teeth in three dimensions. However, this method also destroyed the enamel structure during decalcification, and could not completely preserve the tooth structure. Another limitation of this technique was the distribution of methylene blue in all areas of the tooth structure after about 30 min, making study of the root canal morphology beyond this period more difficult, and thus affecting the repeatability of canal morphological study. Injection of the dye under high pressure into the root canals before decalcification and clearing may help to solve this problem in future studies.

The results of this study indicated that all the deciduous mandibular first molars had two roots and 2-4 root canals, in agreement with the studies conducted by Gupta and Grewal (8) and Hibbard and Ireland (14). The numbers of roots and root canals in classes II, III and IV were very similar to those reported by Zoremchhingi et al. (4).

The specimens investigated in this study included type I, where roots have one canal, and type IV, where the roots have two canals; therefore if there were two root canals in one root, these two canals were completely separated. 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 (Fig. 3). Since curvature of the root canal may pose problems (15) 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.

The results of this study also showed some fusion between the palatal and distobuccal roots of deciduous maxillary molars, being more frequent in first maxillary molars, although the canals were completely separated. This

Fig. 3 S-shaped root and root canals in the palatal root of a deciduous maxillary second molar.

fusion may increase the likelihood of superimposition of these two separate canals in diagnostic radiographs. The clinician must keep in mind that changing the inclination of the X-ray tube may aid better detection of the root canals of each tooth.

Another finding of interest was the presence of one broad root canal in deciduous mandibular molars, especially in the distal root. This feature may be helpful for clinicians when they are looking for the orifices of root canals at the floor of the pulp chamber during the pulpectomy procedure.

In the deciduous mandibular molar samples we examined, the mesial root was longer than the distal root, and in the maxillary first molar group the mesiobuccal root showed the longest measurement, in contrast to the findings of Zoremchhingi et al. (4). Also, the angulation of the roots in this study was lower in all the deciduous molar groups than was the case in the latter study (4). This difference may have been due to the different populations examined, and also inter-observer variation.

Knowledge of the coronal angulation of the root (the angle formed by the coronal part of the root with the crown at the cervical line) may be of help for determining the amount of file precurving for easier access to the root canals during pulpectomy. Also, knowledge of root length may be useful for determining the working length.

More comprehensive investigation of this issue will be needed in the future to overcome all the shortcomings of the present study design. The following conclusions can be drawn from the present results:

- One broad buccolingual canal was common in the distal root of deciduous mandibular molars, being more frequent in the first molars.
- It was uncommon to have two well developed and separated mesial roots in the primary mandibular molars (only one example being found in the second molar group), but all the samples in the second molar group had two separated canals and only a few in the first molar group had one broad fused root canal.
- Fusion of the distobuccal and palatal roots in the maxillary molars was common, especially in the first molars, although the canals were not also fused.
- Better knowledge of root length and angulation would help to achieve better outcomes of pulpectomy in deciduous teeth.

Acknowledgments

The authors would like to thank the Research Center of Rafsanjan University of Medical Sciences for funding this research.

References

1. Krol DM, Nedley MP (2007) Dental caries: state of the science for the most common chronic disease of childhood. Adv Pediatr 54, 215-239.
2. Bagherian A, Nematollahi H, Afshari JT, Moheghi N (2008) Comparison of allele frequency for HLA-DR and HLA-DQ between patients with ECC and caries-free children. J Indian Soc Pedod Prev Dent 26, 18-21.
3. Fuks AB (2005) Pulp therapy for primary dentition. In: Pediatric dentistry: infancy through adolescence, 4th ed, Pinkham JR, Casamassimo PS, McTigue DJ, Fields HW, Nowak AJ eds, Elsevier Saunders, St Louis, 375-393.
4. Zoremchhingi, Joseph T, Varma B, Mungara J (2005) A study of root canal morphology of human primary molars using computerized tomography: an in vitro study. J Indian Soc Pedod Prev Dent 23, 7-12.
5. McDonald RE, Avery DR, Dean JA (2004) Dentistry for the child and adolescent, 8th ed, Mosby, St

Louis, 388-412.
6. Guelmann M, McEachern M, Turner C (2004) Pulpectomies in primary incisors using three delivery systems: an in vitro study. J Clin Pediatr Dent 28, 323-326.
7. Omer OE, Al Shalabi RM, Jennings M, Glennon J, Claffey NM (2004) A comparison between clearing and radiographic techniques in the study of root-canal anatomy of maxillary first and second molars. Int Endod J 37, 291-296.
8. Gupta D, Grewal N (2005) Root canal configuration of deciduous mandibular first molars – an in vitro study. J Indian Soc Pedod Prev Dent 23, 134-137.
9. Vatanpour M, Javidi M (2007) Evaluation of different clearing techniques: an auxiliary method for studying root canal anatomy. J Islamic Dent Assoc Iran 19, 28-33. (in Persian)
10. Robertson D, Leeb IJ, Mckee M, Brewer E (1980) A clearing technique for the study of root canal systems. J Endod 6, 421-424.
11. Cleghorn BM, Christie WH, Dong CC (2006) Root and root canal morphology of the human permanent maxillary first molar: a literature review. J Endod 32, 813-821.
12. Laing E, Ashley P, Naini FB, Gill DS (2009) Space maintenance. Int J Paediatr Dent 19, 155-162.
13. Barker BC, Parsons KC, Williams GL, Mills PR (1975) Anatomy of root canals. IV deciduous teeth. Aust Dent J 20, 101-106.
14. Hibbard ED, Ireland RL (1957) Morphology of the root canals of the primary molar teeth. J Dent Child 24, 250-257.
15. Vertucci FJ, Haddix JE, Britto LR (2006) Tooth morphology and access cavity preparation. In: Pathways of the pulp, 9th ed, Cohen S, Hargreaves KM, Keiser K eds, Mosby Elsevier, St Louis, 148-232.