

ORIGINAL RESEARCH

Canal configuration in the mesio-buccal root of maxillary first molar teeth of a Jordanian population

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Abstract

The purpose of this study was to investigate the canal configuration in the mesio-buccal root of maxillary first molar teeth of a Jordanian population using a clearing technique. One hundred extracted maxillary first molars were collected from Jordanian patients. After a standard access preparation, canals were stained, decalcified, dehydrated, and then rendered clear. The prevalence of a second canal in the mesio-buccal root was 77.32%. Types IV and II canal systems were the most common types with prevalence of 35.05% and 27.83%, respectively. Additionally, 28.86% showed lateral canals mostly located in the apical third and 37.11% had intercanal communications, mainly in the middle third of the root. It was concluded that the prevalence of mesio-palatal canals was high and Types IV and II canal systems were the most prevalent.

Introduction

The failure of endodontic treatment on the maxillary first molar tooth might be related to the presence of an undetected mesio-palatal (MP) canal in the mesio-buccal (MB) root (1–3). Different study methods have been used to illustrate the anatomy of the MB root of the maxillary first molar, including canal staining and clearing techniques (4–10), transverse cross-sectioning (11,12), radiographic examination (2), dentine troughing under magnification (10), examination under clinical operating microscope (13) and examination with scanning electron microscope (5,12) (Table 1).

Investigators who have attempted both laboratory and clinical methods have reported a higher chance of finding two canals in MB roots in the laboratory, highlighting the difficulty of finding the MP canal clinically (6). However, clinical studies using the dental operating microscope, modified access preparation and removal of calcifications with a bur or ultrasonic tip (troughing) have obtained similar results to those reported in laboratory studies (10,11,14–18).

Specific types of root canal morphology appear to occur in different racial groups (1,2,8,9). The aim of this study was to investigate the anatomy and canal configuration of

MB roots in maxillary first molar teeth in a Jordanian population using a canal staining and root clearing technique.

Materials and methods

One hundred extracted mature maxillary first molars from Jordanian patients were obtained from general practitioners' private clinics. Age and gender were not considered in tooth selection. Teeth that were not extracted intact or had incompletely formed apices were discarded.

Teeth were stored in 10% formalin solution until the collection was complete. Thereafter, the teeth were thoroughly washed under tap water. An ultrasonic scaler (SONICflex, KaVo Dental corp., Biberach, Germany) was used for the removal of gross tissue and calculus (8,9). Standard access cavities were prepared; the teeth were then immersed in 3% sodium hypochlorite solution for 5–10 days to dissolve any pulp tissue (2,8). Next, the teeth were rinsed under running tap water and dried overnight.

Canal orifices were located by placing a size 8 file (FlexoFile, Dentsply-Maillefer, Ballaigues, Switzerland) into the visible orifice. In case of locating the orifice but no file penetration, a long shank round bur (ISO # 006, Rosenthal, Miami, FL, USA) was used to remove dentine from the pulp chamber floor (troughing). If no

Table 1 Prevalence of MP canal in previous published studies

Study, year	No. of teeth	Racial origin of samples	Study method	MP (%)
<i>In vitro</i> studies using staining and clearing technique				
Vertucci, 1984 (4)	100	Not specified	Clearing technique	55.0
Alavi <i>et al.</i> , 2002 (9)	52	Thai	Clearing technique	61.5
Ng <i>et al.</i> , 2001 (8)	90	Burmese	Clearing technique	67.8
al Shalabi <i>et al.</i> , 2000 (7)	83	Irish	Clearing technique	78.0
Gilles and Reader, 1990 (5)	21		Clearing technique	90.0
Imura <i>et al.</i> , 1998 (6)	42		Clearing technique	80.9
Yoshioka <i>et al.</i> , 2005 (10)	98		Clearing technique	66.3
<i>In vitro</i> studies not using staining and clearing technique				
Schwarze <i>et al.</i> , 2002 (12)	50		Cross-section SEM	78.0
Kulild <i>et al.</i> , 1990 (11)	51		Cross-section under microscope	95.2
Yoshioka <i>et al.</i> , 2005 (10)	208		Troughing under magnification	51.0
Weine <i>et al.</i> , 1999 (2)		Japan		58.0
<i>In vivo</i> studies				
Wolcott <i>et al.</i> , 2005 (3)	3578		Root canal treatment	58.0
Wolcott <i>et al.</i> , 2005 (3)	3578		Root canal retreatments	66.0
Sempira and Hartwell, 2000 (13)	100		OPM	33.1
Imura <i>et al.</i> , 1998 (6)	42		Root canal treatment	52.3
Stropko, 1999 (14)	802		Root canal treatment	93.0
Schwarze <i>et al.</i> , 2002 (12)	50		Dental loupes ×2	41.3
Schwarze <i>et al.</i> , 2002 (12)	50		OPM	93.7

MP, mesio-palatal; OPM, operating microscope; SEM, scanning electron microscope.

penetration was possible into at least one canal in the MB root, the tooth was discarded.

The clearing and staining protocol used in this study was similar to those used in previous studies (4,8,9). Injection of Indian ink (Daler-Rowney Ltd., Bracknell, UK) into the root canal system was achieved using an endodontic irrigating syringe assisted by vacuum suction apically. After the teeth were air-dried, they were decalcified by immersing in 10% nitric acid (TEDIA Company Inc., Fairfield, OH, USA) for 10–15 days. The acid solution was changed daily. Decalcification was confirmed by radiographs that revealed complete radiolucency. The teeth were subsequently rinsed under running tap water for 4 h and later dried and dehydrated using ethanol (Sharlau Chemie, Barcelona, Spain) in three increasing concentrations (70%, 95%, 100%) for 24 h each. The teeth were then made transparent by submersion in methyl salicylate (ACROS Organics, Morris Plains, NJ, USA) for 48 h.

Upon completion of clearing, the MB root canal configuration was examined under good lighting with ×3.5 magnifying dental loupes (SuperVu Galilean system (XL Advantage), Keeler, Berks, UK). Root canal configurations were classified into eight categories following Vertucci's classification (Fig. 1) (4).

The present study observations were made on the following aspects: (i) the number of roots and their morphology; (ii) the presence of MP canal in MB root and root canal configurations; and (iii) the presence of lateral canals and transverse anastomoses.

Results

Three tooth specimens were discarded because of pulpal calcification; thus, a total of 97 specimens went for further investigations. The final number of specimens (97) was used to calculate the percentages and other values reported in the present study.

All teeth had three separated roots, except for three specimens among which two had MB roots fused with their palatal roots, while the third one had the disto-buccal and palatal roots fused. In one tooth, the MB root had a division in the apical third into two apices.

The prevalence of MP canal was 77.32% and single canal (Type I) was observed in only 22.68% of maxillary molars (Fig. 2). Of the MB roots with two canals, Types IV (35.05%) and II (27.83%) were the most common root canal configurations (Table 2). The canal type in the MB root that showed a division in the apical third was considered additional.

Twenty-eight of the investigated MB roots showed lateral canals located mostly in the apical third of the roots. The incidence of transverse anastomoses was 37.11% and this was mainly in the middle third of MB roots (Table 3).

Discussion

Root number and morphology of Jordanian maxillary first molars were different to those in Burmese (8) and Thai (9) populations, where all molars had completely separate

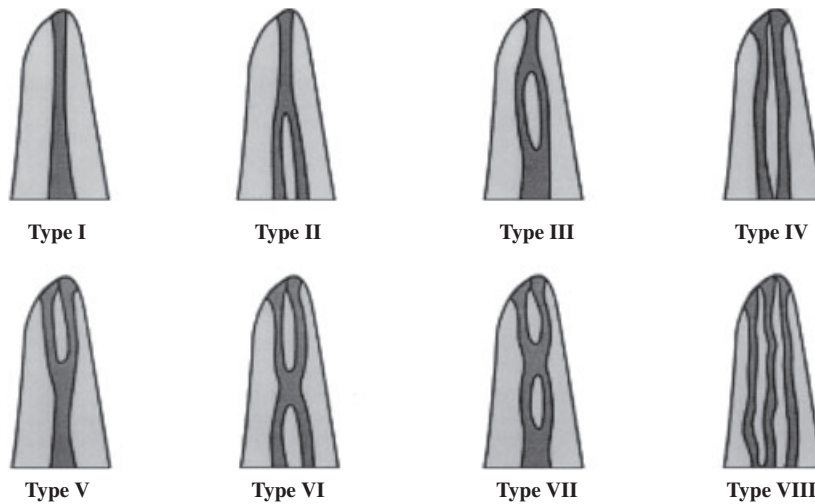


Figure 1 Diagrammatic representation of Vertucci's root canal configurations (4).



Figure 2 Cleared maxillary first molar teeth. (Left) Type I canal configuration. (Right) Type IV with an apical transverse anastomosis indicated by an arrow.

roots; in this study, fused root were observed in 3.09% of teeth. The results of this study showed similarities to those reported in Caucasian populations (19).

The clearing technique used in this study showed a high prevalence of MP canal in the MB root of maxillary first molars (77.32%). This finding is in agreement with the findings of previous studies that used similar techniques (6,7), but higher than in the studies that used dentine troughing under magnification (10), radiographic techniques (2) or a dental operating microscope (13), and

lower than the findings of other groups of investigators who used a sectioning technique (11) (Table 1).

The MB roots of Jordanian maxillary first molars with two canals showed a variety of canal types, with Types II and IV being the most common. The higher prevalence of two canals with two separate foramina (Type IV) in the present study disagrees with the findings of Vertucci and conforms to those studies in Burmese, Thai and Japanese maxillary first molar teeth (2,4,8,9) (Table 4). Those specific configurations might have an implication for failure

Table 2 Number and percentage of canal configuration type in mesio-buccal roots

Canal type	No. of specimens	%
I (1)	22	22.68
II (2-1)	27	27.83
III (1-2-1)	2	2.06
IV (2)	34	35.05
V (1-2)	1	1.03
VI (2-1-2)	7	7.23
VII (1-2-1-2)	3	3.09
VIII (3)	—	
Additional type	1	1.03
Total	97	100

Numbers in parentheses describe the Vertucci's root canal configurations.

Table 3 Number, percentage and location of lateral canal and transverse anastomoses in mesio-buccal roots

	Lateral canal		Transverse anastomosis	
	No. of teeth	%	No. of teeth	%
Coronal	3	33.09	12	12.37
Middle	3	33.09	16	16.49
Apical	22	222.68	8	8.25
Total	28	288.86	36	37.11

Table 4 Percentages of the most common canal configurations in the present study and previous studies

Study	Root canal configuration		
	Type I (1)	Type II (2-1)	Type IV (2)
Present study	22.68	27.83	35.05
Vertucci (1984) (4)	45.00	37.00	18.00
Alavi <i>et al.</i> (2002) (9)	32.70	17.30	44.20
Ng <i>et al.</i> (2001) (8)	30.00	25.60	33.30
Weine <i>et al.</i> (1999) (2)	42.00	24.20	30.40

rates where a competent treatment of only one canal might lead to success in Type II configuration (confluent system), whereas the same treatment might lead to failure in Type IV configuration. Apically dividing systems (Types V, VI, VII) may also occur in MB roots. Those systems are the most difficult to prepare and fill (2).

Among the examined teeth, 28.86% and 37.11% showed lateral canals and transverse anastomoses, respectively. These figures are much higher than those of other studies (1,8,9). The presence of transverse anastomoses might facilitate the penetration of irrigants and medications from the main canal into the undetected MP canal resulting in lower failure rates (8).

The differences in prevalence of MP or canal configurations may be due to the study design, method of canal

identification or to true differences in the samples under investigation according to racial origin (1,2,8,9).

Location and negotiation of the MP canal is often difficult because of a ledge of dentine that covers orifices, the MB inclination of its orifices on the pulpal floor and the canal's pathway, which often takes one or two abrupt curves in the coronal part of the root (1). It is extremely important that clinicians make every effort to locate and negotiate the MP canals by allocating more time for the treatment, dentine troughing and enhanced illumination and magnification (14). Failure of MP detection might lead to treatment failure and a subsequent need for surgical retreatment (2).

Conclusions

Within the limits of this *in vitro* investigation, it was concluded that the first maxillary molar teeth usually had three separate roots, but a low prevalence of root fusion was observed. The prevalence of MP canal in this Jordanian population was high (77.32%) with Types IV and II canal systems being the most prevalent. Lateral canals in MB roots were mostly located in the apical third and transverse anastomoses in the middle third.

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