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Root and canal morphology of the mesiobuccal and distal roots of permanent first molars in a Kuwait population – a clinical study

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Abstract

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Aim To identify the number of roots and canal configurations in permanent first molars of the indigenous Kuwaiti sub-population and compare them against a similar group of non-Kuwaiti population in different age groups and gender, and to determine the frequency of a second canal in the mesiobuccal root of maxillary first molars and distal root of mandibular first molars that could be located and treated in routine practice without using magnification or special lighting conditions.

Methodology A total of 220 permanent first molar teeth of patients scheduled for root canal treatment over a period of 1 year were included. Patients were identified and grouped according to their nationality as Kuwaiti and non-Kuwaiti (which included Filipinos, Indonesian Indians, Srilankans, Egyptians, Saudi Arabians and Syrians). In both nationality groups, patients were successively distributed into four groups based on their age. The first age group included patients below 20 years, the second 21–30 years, the third 31–40 years and the fourth were over 40 years. The first three groups comprised of 15 male and 15 female patients whilst the fourth group had 10 patients of each gender. Teeth with open apices, resorptions and calcification were excluded from the study. The teeth included were both clinically and radiographically examined for number of roots, the canal configuration and the presence of the additional mesiobuccal and distal canals and recorded. The simplified classification of canal configurations proposed by Weine was utilized.

Results The incidence of a second canal in the mesiobuccal (MB) root of maxillary first molars and the distal root of mandibular first molars was not influenced significantly by nationality and gender. All the 110 maxillary first molars treated had three roots; 58% of MB root had one canal and 42% had two canals. The majority of the mesial roots had Weine type II canal configuration when the second mesiobuccal canal was present. All distobuccal and palatal roots had a single or type I canal configuration. Of the 110 mandibular first molars that were treated, 96% had two roots and 4% had three roots. When present, the third root was located either buccal or lingual to the main distal root. Overall 51% of the single distal roots had one canal whilst 49% had two canals. The mesial root frequently had a Weine type II canal configuration as did the distal root when a second canal was present. Pearson's correlation analysis of both molars revealed a significant ($P < 0.05$) negative correlation ($r = -0.274$, $r = -0.144$) between age and number of canals as well as the type of canal.

Conclusions The incidence of a second canal in distal roots of permanent mandibular first molars was 49% in the Kuwaiti population and this was similar to other Asian ethnic populations. Adopting modified access and troughing procedures revealed a 42% frequency of MB2 canals in maxillary first molars. The incidence of a second canal in both mesiobuccal roots of maxillary molars and distal roots of mandibular molars decreased significantly with age; no differences were noticed amongst the nationalities and gender studied. The possibility of extra roots should be anticipated in mandibular molars.

Keywords: canal anatomy, fourth canal, mandibular molar, maxillary molar, MB2 canal, extra canal, morphology and root canal.

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Introduction

For root canal treatment to be successful, it is necessary to locate all root canals, debride them thoroughly and seal them completely with a root filling. Unfilled canals remain a nidus for infection and can lead to post-treatment disease. A clinician should be aware of the internal morphology of permanent teeth and the possible variations which may be encountered.

Permanent first molar teeth are frequently affected by caries at an early age and may require root canal treatment for long-term retention. The morphology of both permanent first molars has been studied and it is accepted that the mesial root of maxillary first molars and the distal roots of mandibular first molars often have more than one canal. In general, the second canal of the distal roots of mandibular first molars is more easily located and treated than the second canal in the mesiobuccal root of maxillary first molars which tends to be elusive (Hartwell & Bellizzi 1982).

Recent studies reported a higher incidence of second canals in distal roots of mandibular permanent first molar than earlier studies (Table 1). This could be due to better awareness of morphology amongst clinicians and to a change in the shape of access cavities to a more rectangular form as compared with the earlier triangular shape recommended. One other reason could be its inherent higher distribution in certain populations. Studies amongst the Asian populations have shown a greater tendency for a second canal in the distal roots of mandibular first molars compared with other populations. This is also true with in laboratory studies (Table 1).

A second canal in the mesiobuccal root in the permanent maxillary first molar is one of the common variations. However, its reported frequency varies widely. In laboratory studies using clearing techniques (Hess 1925, Vertucci & Williams 1974, Pecora *et al.* 1992, Imura *et al.* 1998, Al Shalabi *et al.* 2000, Wasti *et al.* 2001, Gulabivala *et al.* 2002, Sert *et al.* 2004), by sectioning (Weine *et al.* 1969, Seidberg *et al.* 1973, Ting & Nga 1992) and using radiographic techniques (Pineda & Kuttler 1972, Thomas *et al.* 1993, Weine *et al.* 1999) reported a range of 25–93.5%. Clinical studies (Hartwell & Bellizzi 1982, Neaverth *et al.* 1987, Fogel *et al.* 1994, Zaatar *et al.* 1997, Stropko 1999, Buhrley *et al.* 2002, Wolcott *et al.* 2002, 2005) have reported their prevalence to be in the range of 18.6–80.3%. In short, there are discrepancies in the number of canals identified between laboratory and clinical studies (Tables 2 and 3).

The orifice of the second mesiobuccal canal in maxillary first molars is usually located either mesial to or in the sub pulpal groove connecting the main mesiobuccal and palatal canals, within 3.5 mm palatally and 2 mm mesially from the main mesiobuccal canal (Gorduysus *et al.* 2001). When mesially located, it is often hidden under the shelf of the dentine wall or calcifications in a small groove. The orifice of the second mesiobuccal canal is small and not as easily seen as the orifices of the other main canals in the floor of pulp chamber. It often has to be exposed by selective removal of dentine. Hence, the frequency of it being

Table 1 Incidence of two canals in distal root of mandibular first molar

Author/year	No. of teeth	% of canals	Population group	Method used	Magnification used
Hess (1925)	512	4	Not specified	*In vitro* vulcanite casting	None
Grifffin *et al.* (1969)	203	27.5	Not specified	*In vitro* radiography	None
Skidmore and Bjorndal (1971)	45	28.9	Caucasians	*In vitro* polyester casting	None
Pineda & Kuttler 1972	300	27	Caucasians	*In vitro* radiography	None
Vertucci & Williams (1974)	100	30	Caucasians	*In vitro* clearing	None
Vande Voorde *et al.* (1975)	136	31	Not specified	*In vivo* radiography	No mention
Hartwell & Bellizzi (1982)	846	35.1	Not specified	*In vivo* radiography	No mention
Fabra-Campos (1985)	145	47.6	Spainish	*In vivo* radiography	No mention
Walker (1988)	100	45	Chinese	*In vitro* clearing and radiography	None
Yew & Chan (1993)	832	31.5	Chinese	*In vitro* clearing and radiography	None
Zaatar *et al.* (1997)	147	29.9	Middle east	*In vivo* radiography	None
Al Nazhan (1999)	251	57.76	Saudi Arabians	*In vivo* radiography	No mention
Wasti *et al.* (2001)	30	47	Pakistanis	*In vitro* clearing	None
Gulabivala *et al.* (2001)	139	20	Burmese	*In vitro* clearing	None
Gulabivala *et al.* (2002)	118	33.4	Thai	*In vitro* clearing	None
Sert *et al.* (2004)	200	46	Turkish	*In vitro* clearing	None

Table 2 Incidence of MB2 canal in maxillary first molars in Asian populations

Author/year	Population group	Method used	No. of teeth	% of canal	Magnification used
Zaatar *et al.* (1997)	Kuwaiti	*In vivo* radiography	133	40	None
Imura *et al.* (1998)	Japanese	*In vitro* clearing	42	80.9	None
Weine *et al.* (1999)	Japanese	*In vitro* radiography	293	58	None
Al Nazhan (1999)	Saudi arabians	*In vivo* clinical	352	23.3	None
Wasti *et al.* (2001)	Pakistanis	*In vitro* clearing	30	53	None
Ng *et al.* (2001)	Burmese	*In vitro* clearing	90	68	None
Ting & Nga (1992)	Asian	*In vitro* sectioning	100	50	None
Alavi *et al.* 2002	Thai	*In vitro* clearing	52	65	None

Table 3 Incidence of MB2 canals in maxillary first molar in non-Asian populations

Author/year	Place of study	Method used	No. of teeth	% of canals	Magnification used
Seidberg *et al.* (1973)	USA	*In vivo* clinical RCT	201	33	No mention
Pomeranz & Fishelberg (1974)	USA	*In vivo* clinical RCT	71	28.2	No mention
Slowey (1974)	USA	*In vivo* radiography	103	50.5	No mention
Hartwell & Bellizzi (1982)	USA	*In vivo* radiography	558	18.6	No mention
Neaverth *et al.* (1987)	USA	*In vivo* clinical RCT	228	60.1	No mention
Kulild & Peters (1990)	USA	*In vitro* sectioning	51	96	Yes
Fogel *et al.* (1994)	Canada	*In vivo* clinical RCT	208	72.1	Yes
Ibarrola *et al.* (1997)	USA	*In vitro* sectioning	87	77	Yes
Stropko (1999)	USA	*In vivo* clinical RCT	1906	73.2	Yes
Al Shalabi *et al.* (2000)	Ireland	*In vitro* clearing	83	78	No mention
Sempira & Hartwell (2000)	USA	*In vivo* clinical RCT	130	33.1	Yes

found can vary. Other factors such as sample size, illumination and magnification may also contribute to the varied results reported in the literature.

In Kuwait, there are a large number of expatriate populations with the majority from Far East Asia and other Middle East countries. The Government of Kuwait provides Dental Health Services through the Ministry of Health at various polyclinics and Speciality treatment in Dental Centres.

The purpose of this clinical study was to determine (i) the number of roots and canal configurations in permanent first molars of an indigenous Kuwaiti subpopulation and compare them with a similar group of the non-Kuwaiti population by different age groups and gender (ii) to determine the frequency of a second canal in the mesiobuccal (MB) root of maxillary first molars and distal root of mandibular first molars that could be located in routine practice without using magnification or special lighting equipment.

Material and methods

A total of 220 permanent first molar teeth of patients who were scheduled for root canal treatment over a period of 1 year were included. Patients were identified and grouped according to their nationality as Kuwaiti and non-Kuwaiti (which included Filipinos, Indonesians, Indians, Srilankans, Egyptians, Saudi Arabians and Syrians). In both nationality groups, patients were divided into four groups based on their age. The first age group included patients below 20 years, the second 21–30 years, the third 31–40 years and the fourth group were over 40 years. The first three groups comprised of 15 male and 15 female patients whilst the fourth group included 10 patients of each gender. Routine preoperative bitewing and periapical radiographs were taken. Clinical and radiographic findings were recorded in the patient's case notes. Teeth with open apices, resorptions and calcification were excluded from the study. All patients were treated by two endodontists with more than 10 years experience.

Standard endodontic procedures were carried out after rubber dam isolation. In mandibular first molars, the access cavity outline was modified to a more rectangular shape to expose the location of the second distal canal orifice and in maxillary first molars the outline of the access cavity was modified to a rhomboidal shape to improve visibility of the extra canal

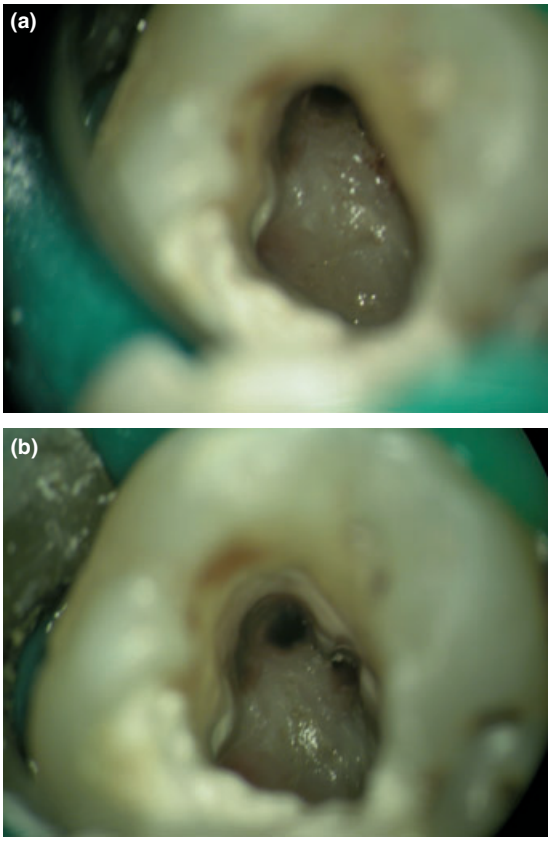

Figure 1 (a) Maxillary first molar with triangular shape access opening shows pulpal floor with only one mesiobuccal canal. (b) Maxillary first molar after modified access opening to rhomboidal shape and toughing procedure shows two mesiobuccal canals.

orifice (Fig. 1). After access cavity preparation, using hand instruments and copious amounts of 2.5% sodium hypochlorite irrigation, an attempt was made to remove the contents of the pulp chamber and locate all canals orifices. After extirpation of pulp tissue from root canals, further debridement of the pulp chamber was enhanced using ultrasonic scalers (Cavitron; Dentsply, York, PA, USA) to dislodge pulpal remnants and calcifications to enhance visibility of the pulp chamber. When pulpal stones were encountered they were carefully dislodged or removed using hand instruments, burs and ultrasonics. In maxillary first molars, after locating the three main canals, the canals were prepared using a crown down technique. Then, assuming the second mesiobuccal canal was always present, a thorough search was made to locate it. At first, the pulp chamber was dried using a cotton pellet, the developmental grooves were carefully observed and then using a sharp endodontic explorer the groove was explored. On a few occasions, the orifice was located on the groove easily, whilst in most teeth a troughing/countersinking procedure (the groove running palatally from the major the mesiobuccal to palatal canals was widened 0.5–1 mm for a length of 2–3 mm at the expense of mesial wall) was used to expose the orifice of MB2 canal. Throughout the procedure, intermittent irrigation with sodium hypochlorite solution was carried out and at all times care was taken not to perforate or weaken the walls. Once the orifice was located, the MB2 canal was negotiated using size 06, 08, 10 K-files. The MB2 canals were considered present only when the canal could be traced and enlarged to a length of at least 1/2 or more of the main mesiobuccal canal.

After locating the main three canals in mandibular first molars, the floor was dried, visualized and then explored for a second distal canal using an endodontic explorer. Wide distal orifices were further explored for a second canal using a small K-file. All the canals were prepared using crowndown technique. Routine diagnostic radiographs with mesial and distal angulations were taken to establish working length of canals and to demonstrate the file in the second canal in MB and distal roots. The canals were filled using the lateral compaction method and postoperative radiographs were taken.

The simplified classification of canal configurations proposed by Weine was used based on clinical observation and radiographic findings. Type I being a single canal from pulp chamber to apex, type II being two canals leaving the pulp chamber and merging to form a single canal short of apex (clinically determined when a file in one canal impeded the placement of another file in another canal to full working length), type III being two separate and distinct canals from chamber to apex (confirmed when separate files could be placed in the canal to working length and seen separated at the apex on the radiograph) and type IV being one canal leaving the pulp chamber and dividing into two separate and distinct canals (here the canal bifurcation was visualized and or by tactile sense a second file was placed and seen on radiograph to diverge from the other file or at times noticed on the postoperative radiograph). The number of roots was evaluated on observations of the radiographs. All radiographs were mounted and evaluated by both clinicians at the same time using magnifying lens. The incidence and configurations of MB2 canals in maxillary first molars and the distal canals of mandibular first molars was recorded in age

groups, gender and nationalities, and were evaluated. The Pearson's correlation was used for statistical comparison.

Results

A total of 220 teeth were studied, distributing them equally amongst the three independent variables, nationality, age and gender.

Maxillary first molars

All the 110 maxillary first molar treated had three roots, 58% had three canals and 42% had four canals. The type of configuration and their percentages are summarized in Table 4. All distobuccal and palatal canals had type I canal configurations. The relationship between the number of MB2 canals and nationality and gender was not significant. Overall the incidence of MB2 canals was 41% in males and 44% in females. The distribution of number and type of canals amongst age groups is shown in the Table 5. A Pearson's correlation analysis between the number of canals and different age groups revealed a negative correlation ($r = -0.274$) between age and number of canals that was statistically significant ($P < 0.01$). This correlation indicates that as the age of patient advances the chances of locating the MB2 canal decreases.

Table 4 Percentage of canal system types in mesobuccal roots of maxillary first molar teeth

	No. of canals (%)		Type of canals (%)		
Nationality	One canal	Two canals	Type I	Type II	Type III
Kuwaitis (55)	58.2	41.8	58.2	33.6	8.2
Non-Kuwaitis (55)	57.3	42.7	57.3	33.6	9.1
Total (110)	57.7	42.3	57.7	33.6	8.7

Values given in brackets indicate number.

Table 5 Distribution of MB2 canals by age groups

	No. of canals (%)		Types of canals (%)		
Age groups	3 canals	4 canals	Type I	Type II	Type III
0–20 (15)	41.7	58.3	41.7	48.3	10
21–30 (15)	51.7	48.3	51.7	36.7	11.6
31–40 (15)	65	35	65	26.7	8.3
>40 (10)	80	30	80	17.5	2.5

Values given in brackets indicate number.

Mandibular first molars

The number of canals and their configuration are summarized in Table 6. The relationship between the number of canals in distal roots and nationality or gender did not reveal any statistical difference. Overall, the incidence of second canals in distal roots was 52% amongst males and 48% in females. The distribution of the number and type of canals amongst different age groups is shown in the Table 7. A Pearson's correlation analysis between the number of canals and the different age group revealed a significant negative correlation ($r = -0.144$) between age and number of canals ($P < 0.05$). This correlation indicates that as the age of the patient advances the frequency of finding the second canal in distal root of mandibular first molars decreases. Four per cent of teeth had three roots amongst all nationalities and the remainder had two roots.

Discussion

The study revealed an overall 49% incidence of a second canal in the distal roots of mandibular first molars with no statistical difference in populations studied. The figure is greater compared with those reported in previous studies of Kuwaiti population (Zaatar *et al.* 1997, 1998) and to previous laboratory studies (Table 1). Studies based in America and Europe, where the majority of population are Caucasians/non-Asians, the incidence of the second canal in distal roots of mandibular first molars canal are reported in a range of 4–35%, except for a clinical study done by Fabra-Campos were the incidence was 48% (Table 1). In short, the review of earlier studies clearly reveals the lack of clinical studies and a lower incidence of two canals in the distal roots of mandibular first molars in the non-Asian populations studied (Table 1).

The incidence of second canal in distal roots of mandibular first molars amongst different age groups has not been studied. The results reveal a statistically significant correlation between the incidence of second canal in distal roots of mandibular first molars and age. The outcome implies that as age advances there is less chances of locating the second canal in distal roots of mandibular first molars. It can be presumed that with age, the tooth is exposed to various insults such as caries, attrition, erosion, etc. leading to calcification of the orifice or canal itself.

The presence of a third root is a typical variation in mandibular first molars. Generally, the additional root is located on the lingual aspect of the distal side of the

Table 6 Percentage of canal system types in mandibular first molars teeth

	No. of canals (%)		Types of distal root (%)				Types of mesial root (%)	
Nationality	3 canals	4 canals	Type I	Type II	Type III	Type IV	Type II	Type III
Kuwaitis (55)	53.6	46.4	55.5	20.9	19.1	4.5	74.5	25.5
Non-Kuwaitis (55)	48.2	51.8	49.1	27.3	19.1	4.5	73.6	26.4
Total (110)	50.9	49.1	52.3	24.1	19.1	4.5	74.5	25.5

Values given in brackets indicate number.

Table 7 Distribution of canals in mandibular first molar by age groups

	No. of canals (%)		Type of distal root (%)				Type of mesial root (%)	
Age groups	3 canals	4 canals	Type I	Type II	Type III	Type IV	Type II	Type III
0–20 (15)	45	55	50	28.3	11.7	10	68.3	31.7
21–30 (15)	48.3	51.7	48.3	21.7	28.3	1.7	80	20
31–40 (15)	48.3	51.7	48.3	25	21.7	5	68.3	31.7
>40 (10)	67.5	22.5	67.5	20	12.5	0	85	15

Values given in brackets indicate number.

tooth (Sperber & Moreau 1998) and can be visualized on preoperative radiograph in most cases (Walker 1988). A third root always indicates the presence of at least two distal canals and they invariably have a type I configuration. In such molars, the two distal canals can result from this additional root. Yew & Chan (1993) studying the prevalence of three roots and four root canals in the mandibular first molars of a Chinese population concluded that more than two-thirds (68.3%) of the cases had the fourth canal arising from an extra distal root with an incidence of 31.5%. It is evident that the prevalence of three-rooted mandibular first molars has racial trends. In this Kuwaiti population, 4% of the molars had three roots. The result reinforces the earlier observation made by Al Nazhan (1999) those East Asian populations have more three rooted teeth than other racial groups.

The MB2 canal is inconspicuous and its orifice is inconsistent in location within the pulp chamber floor. Hence, it can be missed in routine clinical practice unless the clinician is aware of its incidence and adopts steps to rule out its existence. After finding a significant difference in MB2 canal between initial treatment and re-treatments, Wolcott *et al.* (2002, 2005) reported that failure to find and treat MB2 canals would decrease the long-term prognosis. Recently, Cleghorn *et al.* (2006) reviewing data from 34 studies of 8399 teeth in a weighted average of all reported studies found that the incidence of two canals in the mesiobuccal root was 56.8% and of one canal was 43.1%.

Recently, many studies investigated the benefits of magnification and its ability to locate MB2 canals in the mesiobuccal root of maxillary molars. (Baldassari-Cruz *et al.* 2002, Buhrley *et al.* 2002, Yoshioka *et al.* 2005, Tauby *et al.* 2006). Few clinical studies have reported higher percentage of MB2 canals in maxillary first molars without use of magnification (Neaverth *et al.* 1987, Henry 1993).

It is important to be aware that in few maxillary molars, can the MB2 canal be traced to length Fogel *et al.* 1994, Ibarrola *et al.* 1997, Stropko 1999, Gorduysus *et al.* 2001 Yoshioka *et al.* 2005). In this study, although the orifice was located in 10 molar teeth, the canals could not be negotiated even after spending much time. In essence, there are a certain percentage of MB2 canals where the orifice can be located but not necessarily negotiated.

In routine practice, the important factors which help in treating MB2 canal is the clinician's awareness of its presence in maxillary molars, their perseverance and allocating sufficient clinical time to locate and treat these canals.

Conclusion

The frequency of a second canal in the distal roots of permanent mandibular first molar and the mesiobuccal root of maxillary first molar teeth was high in this Kuwaiti population and similar to Asian ethnic population. The incidence of a second canal was

significantly correlated to age, suggesting that as age advances fewer numbers of canals are found. The possibility of extra roots should also be anticipated in mandibular first molars.

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