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INTERNAL ROOT MORPHOLOGY IN MAXILLARY FIRST PERMANENT MOLARS IN A KENYAN POPULATION
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N. J. MURIITHI, S. MAINA, J. OKOTH and L. GATHECE

ABSTRACT

***Objective*: To determine the internal root morphology and gender variations in maxillary first permanent molars in a Kenyan population.**
***Design*: *In vitro* descriptive cross-sectional study.**
***Setting*: School of Dental Sciences, University of Nairobi.**
***Subject*: One hundred and eighty seven maxillary first permanent molars were collected from Kenyans of African descent aged between 10 and 40 years attending dental clinics within Nairobi.**
***Results*: Majority of palatal (98.9%), mesiobuccal (70.6%) and all distobuccal roots (100%) had one canal. Two canals were observed in 29.4% of the mesiobuccal roots. The number of canals and canal configurations in the maxillary roots were similar in both genders. The Vertucci type I canal configuration was the most predominant in all roots. The mesiobuccal root presented the most varied canal configurations.**
***Conclusion*: A significant proportion of maxillary first molars have four canals and the type I canal configuration is the most prevalent. More attention should be directed towards locating a second canal in the mesiobuccal root.**

INTRODUCTION

One of the most important aspects of clinical dentistry is a thorough knowledge of dental anatomy which is a foundation subject. However, it is not only critical to know the normal or the usual root morphology but it is also equally important to be aware of the variations. While racial differences in crown morphology have long been recognised, the diverse aspects of root form and canal anatomy of human teeth have not received the same attention in different populations. Majority of books on dental anatomy fail to provide detailed information of the features of root and root canal morphology that may be unique to African population. These features have neither been systematically reported nor their implications upon clinical endodontics studied (1-6). The success of endodontic treatment is attributed to correct chemo-mechanical preparation, achievement of a hermetic seal in obturation and a timely coronal restoration. The knowledge of internal root morphology is vital in the elimination of all infected debris, toxic materials and pulpal remnants. The complexity of pulpal pathways and varied root angulations presents a great challenge in endodontics.

In a Dutch population, 52.2% of endodontically treated teeth were found to have had persistent periapical radiolucencies during post-operative follow-up (7). In a study carried out in the Lodz region in Poland, 86.8% of root canal retreatment was due to inadequately filled root canals (8). The studies concluded that molars were frequently treated and improvement in the quality of root canal treatment may reduce patients' needs for retreatment (7-9). There seems to be a relationship between the presence of ramifications, the knowledge of their existence and the prognosis of root canal treatment. Clearly, the number of roots, canals and canal configurations can vary and the literature demonstrates an extensive number of anatomical variations (10, 11, 12). Studies on root and canal morphology, which predominantly have been carried out on different tooth types of Caucasian and Asian populations have indicated these variations (2, 13, 14).

The few research studies done in African populations have demonstrated significant variations too. Root and canal morphology of maxillary first permanent molars in a Ugandan population was reported to have been different from that in previous studies Table 1 (6). The study reported a low frequency of the second mesiobucccal canals compared to that reported in various other studies (13, 15-17). In Kenya, there is scarcity of published data on root morphology in permanent molars necessitating the execution of the present study.

Table 1

Canal configuration in maxillary first molars based on the Vertucci classification

Percentage for types I-VIII (Vertucci 1984) Investigator	No. of teeth	Roots	I	II	III	IV	V	VI	VII	VIII
Ameen[16] (2007)	100	MB	22.7	27.8	2.1	35.1	1.0	7.2	3.1	-
Vertucci[13] (1984)	100	MB	45.0	37.0		18.0	-	-	-	-
Rwenyoyi[6] (2007)	221	MB	75.1	4.1	0.9	-	-	-	-	-
		DB	97.7	0.5		11.3	5.8	1.4	0.9	
		P	100	-	-	-	1.8	-	-	-
Ng and Alavi[17] (2001)	90	MB	30	25.6	1.1	-	-	-	-	-
		DB	100	-	-	33.3	6.7	-	-	
		P	94.5	2.2	1.1	-	-	-	-	
		MB	54.5	13	4	-	-	-	-	
Alavi[22] (2002)	77	DB	100	-	-	13	9.1	2.6	2.6	-
		P	100	-	-	-	-	-	-	

MATERIAL AND METHOD

This was an *in vitro* and cross-sectional descriptive study conducted at the University of Nairobi, School of Dental Sciences. One hundred and eighty seven maxillary first permanent molars extracted from Kenyans of African descent aged between 10 and 40 years were collected in four oral health care facilities within Nairobi (Kenyatta National Hospital, Social services league Dental clinic, St. Mary's mission Hospital Dental clinic, Mbagathi District Hospital Dental Clinic and University of Nairobi Dental Hospital). Nairobi is a cosmopolitan city whose residents are migrants from various parts of the country. Only patients who had a treatment plan involving extraction of maxillary first permanent molars and satisfied the inclusion criteria were selected. The study was approved by the Kenyatta National Hospital and University of Nairobi Ethics and Research Committee (P219.8.2008). In addition, consent to collect the teeth was obtained from the patients and the institutional heads of the various dental clinics. The teeth were grouped into two at the collection point based on gender. The extracted teeth were washed in tap water immediately after extraction before being immersed in 3.85%m/v sodium hypochlorite solution (Reckitt Benckiser E. A. Nairobi, Kenya) for a minimum of thirty minutes to remove adherent soft tissue and disinfection. Subsequently, the teeth were washed with plain water. Calculus and organic debris were removed using an ultrasonic scaler (Parkell,inc.,Edgewood, USA). Subsequent storage was done in 10% formalin (ART-M3 Bonart, Taiwan) till all the teeth were collected.

The collected teeth were verified as first maxillary molars according to their anatomical characteristics distinct from the second and third molars by examining the crown morphology as per the description by Ngassapa *et al*. (18). The teeth were further sorted using the inclusion criteria as follows:

- First molars with fully formed roots
- First molars with well defined roots and crown morphology
- First molars non-root treated
- First molars extracted without root fractures

After evaluating the external root morphology, a standard clearing technique was applied with adapted modifications from previous studies to determine the number and types of root canal configurations (1-4, 6).

Access cavities were prepared in the teeth using a high speed hand piece and diamond fissure burs and the coronal pulp tissues extirpated until the canal orifices. They were then immersed in 5.25% sodium hypochlorite solution (Chlorex-5, Synerchemie, Nairobi, Kenya) and agitated for 24 hours then washed in running water for two hours. This was followed by drying for 12 hours. An endodontic irrigation syringe with a 27 gauge needle (BU Kwang Medical Inc., Seoul, Korea) was used to inject Indian ink (Sanford rotring GmbH, Hamburg, Germany) into the root canal system. The root apex was then

immediately connected to a central suction system, until the ink exited through the apical foramina.

After another 12 hours of drying, the teeth were decalcified in 10% nitric acid (Ridel Thaen.Germany) for five days. The acid was agitated daily and the process was monitored periodically by radiography to avoid over-decalcification. Decalcified teeth were then washed in running tap water for four hours, dried and dehydrated in ascending concentrations (70, 95, 100%) of ethyl alcohol (Scharlab S.L. Sentmenat, Spain) for three days. They were then rendered transparent by immersing in methyl salicylate (RANKEM RFCL Limited Okhla-India) for six hours. The observations for the number of canals per root and canal configurations were done under a lens with a magnification power of 3X. The Vertucci[19] classification of canal configurations was taken as the main reference (Fig.1). The data collected were entered into a computer and analysed using the Statistical Package for Social Sciences (SPSS) 12.1(SPSS Inc, Chicago, Ilinois, USA).

Figure 1
Diagramatic representation of root canal types according to Vertucci classification

Type I Type II

Type III Type IV

Type V Type VI

Type VII Type VIII

RESULTS

All the maxillary first molars had three roots, some of which were fused. Of the fused roots, 28.6% were mesiobuccal and distobuccal root fusions while 71.4% were distobuccal and palatal root fusion. No root fusion was observed between the mesiobuccal and palatal roots. The frequency of root fusion was higher among males (57.1%) compared to females (42.9%) though the variation was not statistically significant.

Number of canals in maxillary first molars: Majority of maxillary first molars had three canals (70.1%). Four canals were observed in 29.4% maxillary first molars (Fig. 2). All distobuccal roots and 98.9% of the palatal roots had one canal. In the mesiobuccal root, 70.6% had one canal while 29.4% had two canals. The frequency of canals in the maxillary roots was similar in both genders. However, the male palatal root had two canals in 2.3% of the cases. In the mesiobuccal root, two canals were more frequent in males (31.8%) compared to females (27.3%). Gender variations in the number of canals in the mesiobuccal root was not statistically significant (Table 2).

Canal configurations in the maxillary first molars: Table 3 shows the frequencies of canal configurations in the palatal, mesiobuccal and distobuccal roots in maxillary first molars. The Vertucci type I canal configuration was the most predominant in the palatal root at 97.9%, mesiobuccal root at 70.5% and was the only canal configuration in the distobuccal root. In the maxillary roots, the mesiobuccal root presented the most varied canal types with 12.8% type II, 14.4% type IV, 4.3% type V, 2.7% type VI and 0.5% type VII configurations.

Overall, majority of the roots had type I canal configuration in the maxillary first molar mesiobuccal, distobuccal and palatal roots in both genders. There were differences in canal configuration between males at 31.8% and females at 27.3% in the maxillary mesiobuccal roots. However, the observed differences in canal configurations between the genders in reference to types I, II and IV was not statistically significant (χ^2=1.84, d.f. 2 and p-value =0.17).The distobuccal root had Vertuccci type I canal configuration in all the teeth studied in males

and females. In the palatal root, all canals had type I configuration in females while males had 95.5% type I, 1.1% type II, 1.1% type IV and 2.3% type V configurations. Canal configurations observed in mesiobuccal root (Fig.3).

Figure 2
Canals configurations observed in maxillary first molars

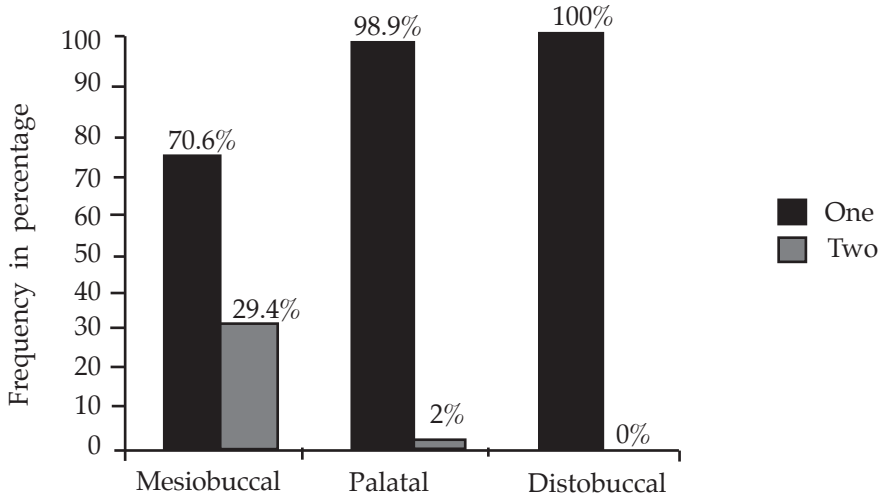


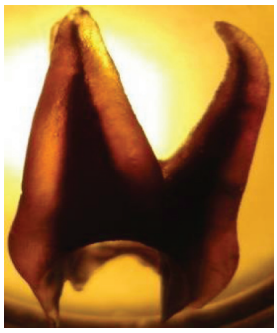
Table 2
Proportions of the number of canals in first molars as they exit pulp chamber among male and female tooth specimens

Number of canals per root	Gender		Test statistics
Maxillary	Male(n=88) %	Female(n=99) %	Fisher's exact test
Palatal root			
1 canal	97.7	100	P=0.22
2 canals	2.3	0	(>0.05)
Mesiobuccal root			
1 canal	68.2	72.7	X^2=0.46, d.f 1,
2 canals	31.8	27.3	P=0.50
			(>0.05)
Distobuccal root			
1 canal	100	100	0

Table 3
Distribution of root canal configurations in maxillary first molars among male and female tooth specimens based on the Vertucci classification

		Canals types I-VIII in percentage(%)								
Maxillary molars										
Root	M-male F-female	I	II	III	IV	V	VI	VII	VIII	Test
P	M(n=88)	95.5	1.1	0.0	1.1	2.3	0.0	0.0	0.0	*
	F(n=99)	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Total	97.9	0.5	0.0	0.5	1.1	0.0	0.0	0.0	
MB	M(n=88)	60.2	16.0	0.0	14.8	6.8	1.0	1.0	0.0	χ^2 =1.84
	F(n=99)	69.7	10.1	0.0	14.1	2.0	4.1	0.0	0.0	p=0.17
	Total	65.2	12.8	0.0	14.4	4.3	2.7	0.5	0.0	(I,II&IV)
DB	M(n=88)	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*
	F(n=99)	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Total	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Figure 3
Number of canals at the floor of the pulp chamber in maxillary first molars.



Type 1

Type IV

Type VI

Types I

Type II

Type IV

Type VI

DISCUSSION

The maxillary first molars had three roots similar to the pevious studies, (6, 14, 20). Majority had separate roots while 3.9% had roots fused. In a previous study on maxillary first permanent molar root fusion, Rwenyonyi *et al* (6) reported a 4.1% frequency of root fusion in a Ugandan population in a sample of 221 teeth. Pecora *et al* (14) reported 13.6% frequency of root fusion among Brazillians in a sample of 140 first molars. The differences in the frequencies between the current study and previous studies can be attributed to sample variation. Males had a higher frequency of root fusion compared to females. However, the variation was not statistically significant. Evanchick *et al* (29) reported the proportion of females with molar root fusion to have been 5% higher than among males. The difference in the study findings may be attributed to the variation in methodology and study population. The previous study was carried out among Caucasian patients while the current study was on extracted teeth from patients of African origin. Therefore, teeth with fractured roots were excluded in the current study which may have influenced the study findings. The results on maxillary first molar root fusion contrast with previous studies among the Burmese (17) and Thai (22) populations where the maxillary teeth were reported to have had three separate roots by Ng *et al*. (17) and Alavi *et al* (22) respectively. This difference can be attributed to racial variation.

Radiography, microscopy, photography and clearing techniques have been used to study internal tooth anatomy. A standard clearing technique has been shown to have been an effective method of studying the internal morphology (23). Unlike radiographic images, it provides a three dimensional view of the pulp cavity in relation to the exterior of the teeth and allows a comprehensive examination of the pulp chamber and root canal system (1,2,13,19, 25). Most of the maxillary first permanent molars had three canals; a single canal in the mesiobuccal, distobuccal and palatal roots. Two canals were more prevalent in the mesiobuccal root compared to the distobuccal and palatal roots.

These results are in agreement with those reported by Rwenyonyi *et al* (6) and Pecora *et al* 1991 (14) . Rwenyonyi *et al* (6) using a clearing technique reported a 16.8% prevalence of mesiopalatal canals in a Ugandan population. The differences between the Ugandan findings and the current study may be attributed to sample variations. Wasti *et al*. (4) reported a 53% frequency of four canals in three-rooted maxillary first molars among Pakistanis which was higher than the 29.4% observed in this study. The frequency of two canals in the mesiobuccal root among the Pakistanis was higher (53.3%) than the one observed in this study which may be attributed to racial variations.

In a weighted average of 34 studies, Blaine *et al*. (24) reported 60.5% frequency of two canals in the mesiobuccal root. The differences between the Blaine *et al*. (24) findings and this study may be attributed to high variability of complexity of maxillary molar morphology based on ethnic background, author's definition of a canal and the study methodology used as noted by Ahmed *et al* (1) and Giuseppe *et al* (21). In this study, only types II, IV and VI were considered as two canals since they extended as such from the pulp chamber. A second canal in the mesiobuccal root is of particular significance since unfavorable endodontic treatment outcomes in maxillary first molars have been attributed mainly to difficulties in cleaning, shaping and adequately filling the canals in the mesiobuccal root.

The Vertucci type I canal configuration was the most prevalent in all the three maxillary first molar roots (100% for distobuccal, 97.9% for palatal and 65.2% for mesiobuccal roots). The mesiobuccal root with two canals had the greatest variability in canal configurations with canals types II (12.8%) and IV (14.4%) having been the most frequent. Rwenyonyi *et al* (6) reported the Vertucci type I canal configuration in 97.7% of distobuccal roots, 100% of the palatal roots and 75.1% of the mesiobuccal roots in a sample of 221 teeth in Ugandan population. Wasti *et al* (4) reported 33.3%, 83.3% and 66.7% frequencies of the Vertucci type I canal configuration in the mesiobuccal, distobuccal and palatal roots among Pakistanis respectively. Pecora *et al* (26) reported 75, 100 and 100% frequencies of Vertucci type I canal configurations in the mesiobuccal, distobuccal and palatal root among Brazillians. Vertucci *et al* (19) reported 100% frequencies of type I canals in the palatal and distobuccal roots and a 45% frequency of type I canal configuration in the mesiobuccal root among Caucasians. The differences between this study and that reported by Wasti *et al* (4), Pecora *et al* and Vertucci *et al* (19) may be attributed to racial and intrapopulation variations.

There are conflicting results with regard to gender and number of canals and canal configurations. The gender differences in canal configurations in the mesiobuccal root were not statistically significant in this study. Semih *et al* (27) reported a frequency of 3% compared to 10% type I, 19% compared to 10% type II and 1% compared to 10% type VII in the mesiobuccal root among males and females respectively. However, Semih *et al* (27) did not demonstrate any statistical significance in the difference. The gender differences in canal configurations between this study and a previous study may be attributed to the difference in sampling and racial variations or a combination of these factors. The previous study was done among an Asian population while this study was among Africans. The age which is reported to influence the number of canals and canal configurations was not specified in the previous study (28).

Inconclusion, all maxillary first permanent molars had three roots with root fusion occurring in 3.9% of the teeth. The pattern of root fusion was not influenced by gender. Most (70.1%) of the maxillary first molars had three canals while 29.4% had four canals whence the Vertucci type I canal configuration was the most prevalent in all roots. More attention should be directed towards searching for and locating the second canal in the mesiobuccal root.

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