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Root and canal morphology of maxillary first and second permanent molar teeth in a Ugandan population

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Abstract

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Aim To investigate the root and canal morphology of permanent maxillary molar teeth from a Ugandan population.

Methodology Maxillary first ($n = 221$) and second molar ($n = 221$) teeth were collected from patients attending dental clinics in Kampala. Teeth were prepared using a clearing technique: the pulp chambers were accessed and the teeth placed consecutively into 5% sodium hypochlorite, 10% nitric acid, then methyl salicylate. Indian ink was injected into the pulp chambers to demonstrate the canal system.

Results In the first molars, 95.9% of the teeth had separate roots. The mesiobuccal root was fused with the palatal root in 3% of specimens and with the distobuccal root in 0.5% of teeth. In the second molars, 86% of the teeth had separate roots. The mesiobuccal root was fused with the palatal root in 6.3% of specimens and with the distobuccal root in 6.8% of teeth. Apical deltas were more frequent in the mesiobuccal root when compared with distobuccal and palatal roots of both the first and second molars. A type I canal configuration (>75%) was the most frequent in all the roots of both the first and second molars. Canal intercommunications and lateral canals were more frequent in the mesiobuccal root when compared with other roots.

Conclusions The mesiobuccal root tended to have more variations in the canal system followed by the distobuccal root, whereas the palatal root had the least. The findings in root and canal morphology of this Ugandan population were different from previous studies, which may partly be attributed to racial differences.

Keywords: clearing technique, maxillary molars, morphology, root canal.

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Introduction

Knowledge of root canal anatomy during root canal treatment is essential. It is not only critical to know the normal or the usual configuration of the pulp, but it is equally important to be aware of the variations (Walton & Vertucci 1996). Previous studies on root and canal anatomy, which predominantly have been carried out on different tooth types of Caucasians and Asians have indicated variations in configuration (Thews *et al.* 1979, Harris 1980, Ross & Evanchik 1981, Cecic *et al.* 1982, Yang *et al.* 1988). These findings suggest that variations in the root canal systems may be attributed to racial differences (Amos 1955, Trope *et al.* 1986, Ng *et al.* 2001).

However, information on these variations in Africans is scarce. The aim of this study was to investigate variations in root and canal morphology within maxillary first and second permanent molar teeth in a Ugandan population.

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Material and methods

The material comprised of 500 teeth collected from Ugandan patients of African descent attending dental clinics in Kampala from December 2003 to May 2004. The gender and age of the patients were not known. The teeth were extracted for reasons other than for this study. They were stored in tap water at room temperature during the period of collection and transported to the Department of Dentistry, Makerere University for processing. Hard and soft deposits were removed using hand-scaling instruments and scrubbed under tap water. Teeth with root fractures ($n = 3$), root resorption ($n = 7$), root abrasion ($n = 9$), hypoplastic defects ($n = 2$) or previously root canal treated ($n = 11$) were excluded. Teeth with less than two-thirds of the crown present were excluded ($n = 26$). The remaining teeth were sorted according to tooth type (first or second molars) based on the crown morphology as described by Scott & Symonds (1982). The final study material comprised of maxillary first ($n = 221$) and second molar teeth ($n = 221$).

Tooth preparation followed the method of Yang *et al.* (1988) with modifications. The pulp chambers were accessed using a diamond fissure bur and high speed handpiece. The teeth were then placed in 5% sodium hypochlorite solution for 24 h to dissolve the organic tissue from the root surface and the root canal system. They were then washed in running water for 2 h. In order to decalcify the teeth, they were then placed in 10% nitric acid at room temperature for 6 days. The acid was changed daily for the first 3 days while agitating manually once a day. However, for the subsequent 3 days the acid was not changed to avoid over decalcification. The teeth were then washed in running water for 4 h and dehydrated in successive solutions of 75% and 95% alcohol for 24 h. The specimens were placed in methyl salicylate to enhance translucence. To demonstrate the canal systems, Indian ink was injected into the pulp chamber using a hypodermic syringe with a 23 gauge needle and drawn through the canals by means of suction. The teeth were then viewed under a lens with magnification power of 3×. The following observations were recorded: root fusion/separation, number of canals and their configurations, lateral canals, canal intercommunications and apical foramina. Canal configuration was based on the classification of Vertucci (1984). The samples that were not included in that classification were categorized according to Sert *et al.* (2004).

Frequency distributions were used to describe the material. The student *t*-test for independent samples was used to assess significant differences in the morphologic variations in roots and root canals. The significance level was set at 5%. The analyses were completed using Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA, version 11.5, 2002).

Results

Variations in root fusion occurred significantly more often in the maxillary second when compared with the first molar tooth ($P < 0.05$, *t*-test; Table 1). Separate roots were found in 95.9% and 86% of the maxillary first and second molar teeth, respectively, whereas 0.5% of each tooth type was found to have all roots fused. The mesiobucal root, especially of the second molar tooth was the most frequently fused to other roots (Table 1).

Type I canal configuration was the most frequent in all roots: 75.1–100% (Table 2). Type VIII canal configuration was not recorded in any root. The mesiobuccal root had significantly more variations in canal configuration when compared with other roots in both the first and second molar teeth ($P < 0.05$, *t*-test; Table 2).

A single apical canal foramen was more frequent in the first when compared with the second molar tooth: 91.8% vs. 89.6%. Multiple apical canal foramina (deltas) were more frequently found in the mesiobuccal root of the first and second molar teeth: 5% and 8.1%, respectively, when compared with other roots ($P < 0.05$, *t*-test; Table 1). Canal intercommunications were mainly observed in the mesiobuccal canals of both

Table 1 The frequency distribution of root morphology and apical foramina of the root canals in maxillary first and second molar teeth

Variables	First molar ($n = 221$)	Second molar ($n = 221$)
Root morphology		
All roots separate	212 (95.9)	190 (86.0)
Palatal + mesiobuccal	7 (3.1)	14 (6.2)
Palatal + distobuccal	0 (0.0)	1 (0.5)
Mesiobuccal + distobuccal	1 (0.5)	15 (6.8)
All roots fused	1 (0.5)	1 (0.5)
Apical foramina		
Single foramen (all roots)	203 (91.8)	198 (89.6)
Multiple foramina		
Mesiobuccal root	11 (5.0)	18 (8.1)
Distobuccal root	5 (2.2)	3 (1.4)
Palatal root	1 (0.5)	0 (0.0)
All roots	1 (0.5)	2 (0.9)

Values are expressed as *n* (%).

Table 2 Frequency distribution of root canal configurations, lateral canals and canal intercommunications in maxillary first and second molar teeth

	First molar (n = 221)			Second molar (n = 221)		
Variable	P	MB	DB	P	MB	DB
Canal configuration						
Type I[a]	100	75.1	97.7	99	86.9	99.5
Type II[a]	0	4.1	0.5	0	1.8	0
Type III[a]	0	0.9	0	0.5	0	0
Type IV[a]	0	11.3	0	0	6.7	0
Type V[a]	0	5.8	1.8	0.5	3.2	0.5
Type VI[a]	0	1.4	0	0	1.8	0
Type VII[a]	0	0.9	0	0	0	0
Type VIII[a]	0	0	0	0	0	0
Type IX[b]	0	0.5	0	0	0	0
Lateral canals	0	2.3	0.9	3	1.8	0.5
Canal intercommunication	0	4.1	0	0	3.2	0.5

[a]Vertucci (1984); [b]Sert *et al.* (2004).
P, palatal root; MB, mesiobuccal root; DB, distobuccal root.

the first and second molar teeth: 4.1% vs. 3.2% (Table 2). Similarly, lateral canals were more frequent in the mesiobuccal root of the first and second molar teeth when compared with other roots. The palatal roots of the first molar tooth neither had lateral canals nor canal intercommunications (Table 2).

Discussion

Different methods have been advocated for use in visualizing root canal systems in extracted teeth. Cross (Green 1958) and longitudinal (Weine *et al.* 1969) sectioning of roots, as well as scanning electron microscopy are some of the methods used to view the canal shape, but have the disadvantage of visualizing only a limited area of tooth structure. Clearing (Yang *et al.* 1988, Giles & Reader 1990, Pecora *et al.* 1992, Singh *et al.* 1994, Çaliskan *et al.* 1995, Imura *et al.* 1998, Ng *et al.* 2001, Wasti *et al.* 2001, Alavi *et al.* 2002, Yoshioka *et al.* 2005) and radiographic techniques (Pineda & Kuttler 1972, Walker 1988) are other commonly used methods. The radiographic technique employs radiographs of extracted teeth with or without rendering them transparent.

Recently, spiral computed tomography (Gopikrishna *et al.* 2006) has been advocated for use in studying root canal system. In this study, a modified clearing method was used. It enabled viewing of a three-dimensional morphology of the roots and canals (Sert *et al.* 2004), and was a simple, acceptable and inexpensive procedure.

The teeth were pooled during the collection exercise and later sorted according to tooth type before processing. Since the differences in crown morphology between the maxillary first and second molar teeth are so distinct (Scott & Symonds 1982), the method of tooth selection according to tooth type did not influence the findings.

While Yang *et al.* (1988) used 5% nitric acid for 3 days to decalcify the teeth, in this study; a 10% solution was used for 6 days because a 5% dilution of the acid did not show adequate decalcification even after 6 days. It should be noted that within the available facilities, it was not possible to standardize the end point of decalcification. However, based on personal judgement, when the enamel became chalky white after 3 days of 10% nitric acid application, fresh acid was added and left without agitation for a further 3 days.

Fifty-eight (11.6%) of the collected teeth were excluded either for having less than two-thirds of the crown that could hinder proper identification, root fractures to avoid leakage of ink through fracture lines, root resorption not to miss the apical foramina, root abrasion to avoid obliterated canals due to secondary dentine deposition, hypoplastic teeth, as they are likely to decalcify more rapidly than their normal counterparts or root filled teeth.

The mesiobuccal root was generally found to have a higher frequency of fusion with other roots and more so in the maxillary second molar when compared with the first molar tooth, this corroborates findings from the Chinese population (Yang *et al.* 1988). However, the frequency of root fusion particularly in the second molar tooth was lower in this study (Table 1) when compared with the Chinese population. On the other hand, previous studies on Burmese (Ng *et al.* 2001) and Thai (Alavi *et al.* 2002) populations demonstrated all roots of both the maxillary first and second molar teeth to be separate.

In the present study, multiple foramina (Table 1), lateral canals and canal intercommunications (Table 2) as well as variations in canal configuration (Table 2) were more frequent in the mesiobuccal root when compared with other roots. All types of canal configuration in the present study fitted Vertucci (1984) classification (Table 2), except one mesio-buccal root of a maxillary first molar tooth that had one canal dividing into three described as type IX (Sert *et al.* 2004).

Consistent with the findings of the present study, but to a lesser extent, Pecora *et al.* (1992), Ng *et al.* (2001) and Yoshioka *et al.* (2005) reported the simplest Vertucci type I canal configuration to be more frequent

Study	Teeth	Race	Types of canal configuration			
			I	II	IV	V
First molar						
Giles & Reader (1990)	21	Americans	9.5	52.4	33.3	4.8
Pecora *et al.* (1992)	120	Brazilians	75.0	17.5	7.5	0
Çaliskan *et al.* (1995)	100	Turkish	34.4	41.0	11.5	1.7
Imura *et al.* (1998)	42	Non-specific	19.1	9.5	71.4	0
Present study	221	Ugandans	75.1	4.1	11.3	5.8
Second molar						
Pecora *et al.* (1992)	200	Brazilians	58.0	22.0	20.0	0.0
Singh *et al.* (1994)	50	Indians	34.0	34.0	0.0	4.0
Çaliskan *et al.* (1995)	100	Turkish	27.1	23.6	14.7	4.2
Ng *et al.* (2001)	77	Burmese	49.3	18.2	15.6	0.0
Yoshioka *et al.* (2005)	110	Non specific	56.4	29.1	0.0	0.9
Present study	221	Ugandans	86.9	1.8	6.7	3.2

Table 3 Comparison of frequency distribution of types of canal configuration in the mesiobuccal root of maxillary first and second molar teeth in the present and previous studies

in the mesio-buccal root (Table 3). However, Giles & Reader (1990), Singh *et al.* (1994), Çaliskan *et al.* (1995) and Imura *et al.* (1998) found other types predominating (Table 3). Generally, the frequency distribution of canal configurations in the mesiobuccal root of the Ugandan maxillary first and second molar teeth were found to vary from those in other races when using a clearing technique (Table 3).

Conclusions

Maxillary second molars had a higher occurrence of root fusion than first molar teeth. The mesiobuccal root tended to have more variations in the canal system followed by the distobuccal root, the palatal root had the least. Root and canal morphology of maxillary first and second molar teeth in this Ugandan population were different from previous studies, which may partly be attributed to racial differences.

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