ORIGINAL ARTICLE

Root and canal morphology of maxillary first premolar teeth in a Ugandan population

Charles Mugisha Rwenyonyi[1], Annet Kutesa[1], Louis Muwazi[1], William Buwembo[2]

[1]Department of Dentistry, [2]Department of Anatomy, College of Health Sciences, Makerere University, Kampala.

Corresponding author
Dr. Charles Mugisha Rwenyonyi
Department of Dentistry
College of Health Sciences,
Makerere University
P.O.Box 7072
Kampala, Uganda
Tel. 256-772-405349
E-mail: mrwenyonyi@chs.mak.ac.ug

Running title: Root and canal morphology of maxillary first premolar teeth

Field: Endodontics

Abstract

Aim : To determine the variations in the root and canal morphology of the maxillary first premolar teeth in a Ugandan population. **Methodology :** Extracted maxillary first premolar teeth (n = 202) were evaluated in this study. The specimens had their pulp chambers de-roofed. They were decalcified in nitric acid and made transparent with methyl salicylate. Indian ink was injected into the root canals to display their configuration. **Results :** One hundred and forty eight (73.3%) of the specimens had two roots, of which 16.9% (n = 25) had fused roots. About 26.7% (n = 54) of the specimens were single rooted. Eleven (20.4%) of the single rooted specimens had one canal of either Vertucci type I, III, V or VII configuration while 79.6% (n = 43) of the specimens had two canals of either Vertucci type II, IV or VI configuration. The two-rooted specimens exhibited Vertucci type IV and VIII canal configuration: 96.6% and 3.4%, respectively. The single rooted teeth had a higher prevalence of lateral canals, canal intercommunications and multiple apical foramina as compared to the two-rooted specimens. **Conclusion :** The maxillary first premolar teeth in this Ugandan population showed a higher prevalence of two-root morphology with majority of the roots having Vertucci type IV canal configuration. There was no three-root anomaly recorded in the present material.

Keywords: clearing technique, maxillary premolars, root canal, Ugandan

Introduction

Anatomical variations of teeth need to be considered in clinical and radiographic evaluations during endodontic treatment [1]. Clinical management involving maxillary first premolar teeth with unpredictable root and canal morphology may pose some challenges [2,3]. Some of the challenges include: the difficulty in extraction and orthodontic movement requiring excessive force, and frequent failures of endodontic treatment resulting from missed canals or because of difficulty to radiographically visualise the apical limit of the multi-rooted premolars.

In previous studies [2-11], the prevalence of one root varied from 15.5% to 60%; two roots, 40% to 80.9%; and three roots, 0 to 9.2% (Table 1). The canal morphology of the maxillary first premolar teeth has been reported with varying prevalence rates: one canal, 0% to 26.2%; two canals, 73.3% to 97% and three canals, 0.5% to 9.2% [3-5,8-14] (Table 2). The majority of these studies were carried out in teeth from populations of Caucasian [4-6,8,9,12,14] and Asian origins [2,7,10]. It is evident that the anatomy of these teeth tends to have racial variations [6,7,13]. Information on the root and canal morphology of maxillary first premolar teeth from populations of indigenous Africans is scarce. The purpose of this study was to assess the root and canal morphology of maxillary first premolar teeth from a Ugandan population using the clearing technique.

Material and methods

The material consisted of 210 extracted maxillary first premolar teeth. They were collected from Ugandan patients of African descent attending dental clinics in Kampala. Fifteen dental clinics were randomly selected from all the five divisions of Kampala metropolitan where each clinic was provided with a 500 ml plastic container having 10% formalin (Akron Healthcare Pvt. Ltd. Delhi, India). The dentists were instructed to put extracted maxillary first premolar teeth into the plastic containers. The teeth were collected with the verbal consent of the patients. However, the age and sex of the patients who donated the teeth were not recorded. The teeth were collected from the clinics and taken to the Department of Dentistry, Makerere University College of Health Sciences, for processing as previously described [15,16]. Hard and soft deposits were removed from the tooth surfaces using hand scaling instruments, and the teeth were scrubbed in running cold tap water. The teeth (n = 8) with less than two-thirds of the crown present, which could not easily be differentiated based on crown morphology as described by Scott and Symons [17] were excluded. The remaining 202 specimens were made transparent following the method of Yang, et al. [18] with modifications.

An endodontic access cavity was prepared in each specimen using a high-speed handpiece and diamond fissure bur. The specimens were placed in a 5% sodium hypochlorite solution (Ameya Chemicals, Mumbai, India) and periodically agitated 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, dried on a wire mesh, and decalcified in 10% nitric acid (MJ Patterson, Dunstable, UK) for 6 days. The nitric acid solution was changed daily and manually agitated once a day during the first 3 days. However, during the last 3 days the acid solution was not changed. The teeth were rinsed in running cold tap water for 4 h and dried on a wire mesh. They were dehydrated in successive solutions of 75% and 95% alcohol; each for 12 h. Transparency was induced by placing the specimens in 99% methyl salicylate (Merck, Poole, UK). To clearly view the root canal

system, India ink (Calder Colours, Ashby-de-la-Zouch, Leicester, UK) was coronally injected into the pulp chambers using a 5 ml plastic disposable syringe with a 23 gauge needle (Sherwood Medical, St. Louis, MO, USA). The ink was withdrawn through the root apical foramen/foramina using a rubber tube with one end inserted up to the cervical third of the root and the other end connected to a suction machine (Ramvac, Spear-fish, SD, USA). The specimens were then viewed in natural light through a lens at 3x magnification, and the number of root canals and their configurations according to Vertucci [6] classification (Table 3), lateral canals, inter-canal communications, and multiple apical foramina (deltas) were recorded.

The number of roots and their morphology was also recorded. Although there is no universally accepted system for classifying root morphology [19], in the present study, roots were considered fused if the union occurred in the apical, middle, or cervical one-third of the roots [20]. Data were entered in a computer and analysed using Statistical Package for Social Sciences Inc. (version 15.0 for windows, Illinois, USA). Frequency distributions were used to describe the material. The Chi-square statistics was used to test any significant differences in the canal configuration based on root morphology. The level of significance was set at 5%.

Results

One hundred and forty eight (73.3%) of the specimens had two roots (Table 1) of which 16.9% (n = 25) had fused roots. About 26.7% (n = 54) of the specimens were single rooted (Table 1). Eleven (20.4%) of the single rooted specimens had one canal of either Vertucci type I, III, V or VII configuration while 79.6% (n = 43) of the specimens had two canals of either type II, IV or VI configuration (Table 4). On the other hand, the two-rooted specimens exhibited Vertucci type IV and VIII canal configurations: 96.6% and 3.4%, respectively (Table 4). The lateral canals were more frequently observed in the apical and cervical thirds as compared to mid third of the roots. The single rooted specimens had a significantly higher frequency of lateral canals as compared to two-rooted teeth ($p<0.05$, Table 4). Multiple apical foramina were the most prevalent in this material (Table 4). Canal intercommunications were more commonly recorded in the single as compared to the two-rooted specimens: 7.4% versus 0.7% (Table 4).

Discussion

Several methods have been employed in studying the root and canal morphology of the different teeth. Recently, spiral computed tomography [21] and micro-computed tomography [22] have been advocated for use in studying root and canal system. Despite their accuracy, these methods involve expensive equipment. In the present study, a modified clearing method was used. It enabled viewing of a three-dimensional morphology of the roots and canals [23]. It is relatively simple, acceptable and inexpensive procedure.

The specimens used in the present study were clearly identified by instructing the dentists to put the extracted maxillary first premolar teeth from patients of African descent in the provided containers. The specimens were further identified before processing by assessing the crown morphology as described by Scott and Symons [17]. About 3.8% (n

= 8) of the specimens, which could not be identified based on their coronal structure were excluded. It is unlikely that there was any misclassification of the specimens.
In the present study, 26.7% of the first maxillary premolar teeth had one root. This value is higher than reported in the Polish [9] and Saudi populations [11] but, much lower than reported from other populations [2-8] (Table 1). A prevalence of 73.3% of two-rooted specimens was recorded in the present study, which is higher than values (41.7% to 60.8%) observed in other populations [2-8,10] (Table 1). However, Lipski, et al. [9] recorded 75.3% of two-rooted specimens in the Polish population while Atieh, et al. [11] recorded 80.9% in the Saudi population (Table 1).
In the present study, 16.9% (n = 25) of the specimens with two roots were fused. This value was much lower as compared to 32.1% of the teeth in the Singaporeans [2], 26% in the Polish [9] and 36.2% in the Saudis [11]. In corroboration to the finding in the Chinese [7] and Singaporean populations [2], the present study showed no three-root anomaly in the maxillary first premolar teeth (Table 1). However, studies in other populations found the anomaly in the range of 0.8% to 9.2% [3-6,8-11] (Table 1).
Apart from assessing the number of roots in the present study, the number of the canals, the canal configuration and the apical foramina were also evaluated, which are more important to the clinicians. We found 5.4% of all the specimens had one canal. This prevalence is considerably lower when compared with those of previous studies [3-5,10-13] but, higher than reported by other workers [8,9,14] (Table 2).
Our finding of 92.1% of the two-canalled specimens (Table 2) corroborates those of previous studies in the Polish [14] and Jordanian populations [10]. However, lower values (73.3% - 89.8%) were previously reported in other populations [3-5,9,11-13]. On the other hand, Chaparro, et al. [8] reported a higher prevalence of specimens with two canals (Table 2). When the analysis was based on root morphology, the predominance of two canals was still evident in the present study (Table 4).
In this Ugandan population, lateral canals were 64.8% and 14.9% in the single and two-rooted specimens (Table 4). Pineda and Kuttler [4] reported a value of 41.2% in the Mexican maxillary first premolars. Multiple apical foramina were the most prevalent in the present study (Table 4), which corroborates a previous finding in the Mexicans [4]. Awawdeh [10] reported a lower value in the Jordanians.

Conclusions

The maxillary first premolar teeth in this Ugandan population showed a higher prevalence of two-root morphology with the majority of the roots having a Vertucci type IV canal configuration and multiple apical foramina. There was no three root anomaly recorded in the present material.

Acknowledgement

The authors are grateful to the dentists who collected the specimens for this study. Musoke David of the Department of Pharmacy, Makerere University College of Health Sciences advised on the handling of chemicals. Sida/SAREC financially supported the study.

References

1. H. D. Arisu and T. Alacam "Diagnosis and treatment of three-rooted maxillary premolars," European Journal of Dentistry, vol. 3, 2009, pp. 62–66.
2. H. S. Loh, "Root morphology of maxillary first premolar in Singaporeans," Australian Dental Journal, vol. 43, 1998, pp. 399-402.
3. J. D. Pécora, P. C. Saquy, M. D. Sousa Neto and J. B. Woelfel, "Root form and canal anatomy of maxillary first premolars," Brazilian Dental Journal, vol. 2, 1991, pp. 87-94.
4. F. Pineda and Y. Kuttler, "Mesiodistal and buccolinqual roentgenographic investigation of 7,275 root canals," Oral Surgery, vol. 33, 1972, pp. 101-110.
5. E. J. Carns and A. E. Skidmore, "Configuration and deviations of root canals of maxillary first premolars," Oral Surgery, Vol. 36, 1973, pp**.** 880-886.
6. F. J. Vertucci, "Root canal anatomy of the human permanent teeth," Oral Surgery Oral Medicine and Oral Pathology, Vol. 58, 1984, pp. 589-599.
7. R. T. Walker, "Root form and canal anatomy of maxillary first premolars in a southern Chinese population," Endodontic Dental Traumatology, vol. 3, 1987, pp. 130-134.
8. J. Chaparro, J. Segura, E. Guerrero, A. Jiménez-Rubio, C. Murillo and J. Feito, "Number of roots and canals in maxillary first premolar: Study of an Andalusian population," Endodontic Dental Traumatology, vol. 5, 1999, pp. 65-76.
9. M. Lipski, K. Woźniak, R. Lagocka and M. Tomasik, "Root and canal morphology of the first human maxillary premolar," Durham Anthropology Journal, vol. 12, 2003, pp. 2-3.
10. L. Awawdeh, H. Abdullah and A. Al-Qudah, "Root form and canal morphology of Jordanian maxillary first premolars," Journal of Endodontics, vol. 34, 2008, pp. 956-961.
11. M. A. Atieh, "Root and Canal Morphology of Maxillary First Premolars in a Saudi Population," Journal of Contemporary Dental Practice, vol. 1, 2008, pp. 46-53.
12. F. J. Vertucci and A. Gegayff, "Root canal morphology of the maxillary first premolars," Journal of American Dental Association, vol. 99, 1979, pp. 194-198.
13. N. Kartal, B. Özçelik and H. Cimilli, "Root canal morphology of maxillary premolars," Journal of Endodontics, vol. 24, 1998, pp. 417-419.
14. T. K. Różyło, M. Miazek, I. Różylo-Kalinowska and F. Burdan, "Morphology of root canals in adult premolars," Folia Morphology, vol. 67, 2008, pp. 280-285.
15. C. M. Rwenyonyi, A. Kutesa, L. Muwazi,and W. Buwembo, "Root and canal morphology of maxillary first and second permanent molar teeth in a Ugandan population," International Endodontic Journal, vol. 40, 2007, pp. 679-683.
16. C. M. Rwenyonyi, A. Kutesa, L. Muwazi and W. Buwembo, "Root and canal morphology of mandibular first and second permanent molar teeth in a Ugandan population," Odontology, vol. 97, pp. 92-96.
17. J. H. Scott and N. B. B. Symons, "Introduction to Dental Anatomy," Longman, 1982.

18. Z. P. Yang, S. F. Yang and G. Lee, “The root and root canal anatomy of maxillary molars in a Chinese population,” Endodontic Dental Traumatology, vol. 4, 1988, pp. 215–218.
19. A. M. Alavi, A. Opasanon, Y.L. Ng and K. Gulabivala, “Root canal morphology of Thai maxillary molars,” International Endodontic Journal, vol. 35, 2002, pp. 478-485.
20. I. E. Ross and P. A. Evanchik, “Root fusion in molars: incidence and sex linkage,” Journal of Periodontology, vol. 52, pp. 663-667.
21. V. Gopikrishna, N. Bhargavi and D. Kandaswamy, “Management of a maxillary first molar with a single root and a single canal diagnosed with the aid of spiral CT: a case report,” Journal of Endodontics, vol. 32, 2006, pp. 687–691.
22. I. Kim, K. Paik and S. Lee, “Quantitative evaluation of the accuracy of micro-computed tomography in tooth measurement,” Clinical Anatomy, vol. 20, 2007, pp. 27-34.
23. S. Sert, V. Aslanalp and J. Tanalp, “Investigation of root canal configurations of mandibular permanent teeth in the Turkish population,” International Endodontic Journal, Vol. 37, 2004, pp. 494–499.

Table 1. Comparison of frequency distribution of root morphology of the maxillary first premolar teeth in the present and previous studies

Study	Population	Number of teeth	Frequency of roots (%)		
			One root	Two roots	Three roots
Pineda and Kuttler [4]	Mexicans	259	43.0	54.6	2.4
Carns and Skidmore [5]	White Americans	100	22.0	72.0	6.0
Vertucci and Gegayff [12]	White Americans	400	39.5	56.5	4.0
Walker [7]	Chinese	100	60.0	40.0	0
Pécora, et al. [3]	Brazilians	240	55.8	41.7	2.5
Chaparro, et al. [8]	Spanish	150	40.0	56.7	3.3
Loh [2]	Singaporeans	957	49.4	50.6	0
Lipski, et al. [9]	Polish	142	15.5	75.3	9.2
Awawdeh, et al. [10]	Jordanians	600	30.8	68.4	0.8
Atieh [11]	Saudis	246	17.9	80.9	1.2
Present study	Ugandans	202	26.7	73.3	0

Table 2. Comparison of frequency distribution of root canal morphology of maxillary first premolar teeth in the present and previous studies

Study	Population	Number. of teeth	Frequency of root canals (%)		
			One canal	Two canals	Three canals
Pineda and Kuttler [4]	Mexicans	259	33.9	65.6	0.5
Carns and Skidmore [5]	White Americans	100	9.0	85.0	6.0
Vertucci and Gegayff [12]	White Americans	400	8.0	87.0	5.0
Kartal, et al. [13]	Turkish	300	8.7	89.6	1.7
Pécora, et al. [3]	Brazilians	240	17.1	80.4	2.5
Chaparro, et al. [8]	Spanish	150	1.4	95.3	3.3
Lipski, et al. [9]	Polish	142	2.1	88.6	9.2
Awawdeh, et al. [10]	Jordanian	600	5.6	92.2	1.5
Różylo, et al. [14]	Polish	55	0	91.0	9.0
Atieh [11]	Saudis	246	8.9	89.8	1.2
Present study	Ugandans	202	5.4	92.1	2.5

Table 3. Root canal configuration according to the Vertucci [6] classification

Root canal configuration	Description
Type I	One root canal extending from the pulp chamber to the apex
Type II	Two separate root canals leave the pulp chamber and join short of the apex to form one canal
Type III	One root canal leaves the pulp chamber before dividing into two within the root, which then merge to exit as a single canal
Type IV	Two separate root canals extend from the pulp chamber to the apex
Type V	One root canal leaves the pulp chamber and divides short of the apex into two separate and distinct canals with separate apical foramina.
Type VI	Two separate root canals leave the pulp chamber, merge in the body of the root, and again divide short of the apex to exit as two separate and distinct canals
Type VII	One root canal leaves the pulp chamber, divides and rejoins within the body of the root, and finally re-divides into two distinct canals short of the apex
Type VIII	Three separate and distinct root canals extend from the pulp chamber to the apex

Table 4. Frequency distribution of root canals and their configuration according to Vertucci [6] classification, lateral canals, canal intercommunication and apical foramina in different root morphologies of the maxillary first premolar teeth (n = 202)

Variable	Two-rooted teeth (n = 148)	Single rooted teeth (n = 54)
Canal configuration		
Type I	0 (0.0)	7 (13.0)
Type II	0 (0.0)	16 (29.6)
Type III	0 (0.0)	1 (1.9)
Type IV*	143 (96.6)	26 (48.1)
Type V	0 (0.0)	1 (1.9)
Type VI	0 (0.0)	1 (1.9)
Type VII	0 (0.0)	2 (3.7)
Type VIII	5 (3.4)	0 (0.0)
Lateral canals*	22 (14.9)	35 (64.8)
Canal intercommunication	1 (0.7)	4 (7.4)
Apical foramina		
Single foramen	0 (0.0)	24 (44.4)
Multiple foramina	148 (100)	9 (55.6)

Percentages are in parentheses; *P-value < 0.05