AN EVALUATION OF ROOT AND CANAL MORPHOLOGY OF MAXILLARY PREMOLARS IN A NIGERIAN TERTIARY HOSPITAL: AN IN-VIVO STUDY

Agholor C.N[1], Sede M.A[2]

[1]Department of Restorative Dentistry, University of Benin Teaching Hospital, Benin City, Edo State, Nigeria.
[2]Department of Restorative Dentistry, University of Benin, Benin City, Edo State, Nigeria.

Corresponding Author: Matthew A. Sede, Email: sedematt@uniben.eduTel: +234-802-333-2446.

ABSTRACT

AIM: To evaluate the root morphology of maxillary first and second premolars and identify any gender variation in a Nigerian population using direct digital radiography.

MATERIALS AND METHODS: Twenty-four maxillary first premolars and 29 maxillary second premolars from 53 consenting Nigerian adults indicated for root canal treatment were studied. All teeth received pre-treatment evaluation before endodontic treatment. Digital radiographs obtained during treatment and follow-up reviews were stored and evaluated using the Kodak Dental smart software.

RESULTS: The majority of the treated participants were young adults with a mean age ± SD of 34.1 ± 12 years. Maxillary first premolars were mostly two rooted (66.7%), while the maxillary second premolars predominantly had one root (72.4%) (p=0.004) in the studied population. However, two-rooted second premolar teeth occurred more frequently among males in this study. Most of the maxillary first (87.5%) and second (79.3%) premolar teeth had two root canals with a mean working length of 21.85mm and 21.75mm, respectively. The proportion of two canals in male participants was higher in the first than in the second premolars but the difference was not significant (p≥ 0.05). The Vertucci type IV canal configuration was predominantly seen in both genders' maxillary first and second premolars.

CONCLUSION: Maxillary first premolars mainly were two rooted while the second premolars predominantly had single root with a high prevalence of two canals in the studied population. Gender difference in the studied maxillary premolars was not statistically significant.

KEY WORDS: Maxillary premolars, root canal, configuration, gender, Nigerian

INTRODUCTION

The practice of modern endodontics emphasizes a comprehensive antimicrobial approach of effective cleaning, adequate shaping, and complete filling of the root canal space.[1] The dental practitioner must be fully aware of the various pathways root canals take to the apex.[2] Hence, the practitioner must anticipate complex tooth anatomy in every treated case.

Maxillary premolar teeth are essential in the dental arch and often undergo endodontic treatment.[3, 4] They are reported to be amongst teeth with the highest treatment failure rate.[5] Studies have shown that the internal anatomy of maxillary premolars is particularly complex due to variations in the number of roots and canal configuration[6,7] which have been associated with age, sex, race and study designs.[6,8-9] These variations often deviate from the widely known anatomy of maxillary premolars typically described in textbooks of endodontics; which are predominantly based on studies of populations of Caucasoid origin in North America and Europe.[10] These descriptions may not be wholly applicable to Blacks and other mixed populations.[7,10-13] Only a few studies have been documented in African populations [10,14]Unfortunately, practitioners remain fixated on the concept of a root canal as opposed to a complex root canal system during endodontic treatment, resulting in poor outcomes.[15]

Beyond variations in the number of roots and canal configuration occasioned by age, race, and study designs; gender needs careful consideration during non-surgical endodontic treatment.[9] A comprehensive in-vivo study of teeth in a Saudi population[16] observed a significant difference in the number of canals and canal configuration of maxillary roots in both gender but a Portuguese study[17] reported fewer differences between the genders. However, a recent in-vivo Cone beam computer tomography (CBCT) study on a Malaysian subpopulation[18] and a radiographic in-vivo study in a Ghanaian population[19] failed to observe any significant gender difference. Similar studies exploring gender differences in maxillary premolar teeth among Nigerians are lacking. Therefore, the present study aimed to evaluate the root morphology of maxillary first and second premolar teeth; and to identify any gender variation in a Nigerian population.

MATERIALS AND METHODS

The *in vivo* study was conducted at the Endodontic unit of the Department of Restorative Dentistry, University of Benin Teaching Hospital (UBTH), Benin City, Nigeria between November 2017 and July 2018; in compliance with the Helsinki declaration by the World Medical Association, after approval by the Local Ethics Research Committee in a protocol number

ADM/E22/A/VOL.VII/11205. Patients seeking root canal treatment of the maxillary first and/or second premolars who were 18 years and above and met the selection criteria were consecutively included. They received root canal treatment in single or multiple visits as indicated.

Two diagnostic digital radiographs (RVG 5100, Carestream Dental, Germany) were taken of each tooth using the paralleling technique and Walton's projection respectively. Before preparing the appropriate access cavity, local anaesthesia was achieved using 2% Lignocaine Hydrochloride (Alphacaine®, USA) with an adrenaline concentration of 1:80,000. Each tooth was then isolated using a rubber dam (Hygienic®, Whaledent Inc. USA). Canal(s) orifice(s) were located with the aid of a Dental Operating Microscope (Moller-Wedel, Germany) using sharp endodontic probes. Barbed broaches were used to extirpate vital pulp tissue while necrotic pulpal tissue was removed by chemico-mechanical means. Working length was determined using the Root ZX II Apex locator (J.Morita corp., Kyoto, Japan) and confirmed with digital radiographs. The radiographs were evaluated for the number of roots, the number of canals, and canal configuration with the aid of the Kodak dental smart software by ACN and SMA and stored in digital format. A Radiologist calibrated both authors before the commencement of the study using the previously-stored images of teeth not included in the study. The inter-examiner and intra-examiner reliability were 84% and 82%, respectively. Any disagreement during the evaluation of radiographs was resolved jointly with the radiologist.

Using a Rotary Endodontic Handpiece (Endo-Mate®, NSK, Japan) a thorough chemico-mechanical preparation of the canals was done by ACN employing the Crown Down technique under copious irrigation with 3% sodium hypochlorite solution (ProduitDentaires®, Switzerland) and 0.9% w/v normal saline (Juhel, Nigeria). The prepared canal(s) were dried using sterile paper points (Rite Dent®, USA) and then obturated with GuttaPercha (Gapadent®, Germany) and a Eugenol-based sealer (Fill Canal®) adopting the warm lateral compaction technique using a Machtou's Heat Carrier® (Hu-Friedy, USA). Teeth requiring multiple treatment visits received inter-appointment canal medication of non-setting calcium hydroxide (Henry Schein®, USA) mixed with normal saline and dispensed into the canal space with a spiral root filler. The calcium hydroxide medicament was removed at recall appointment using a reamer and normal saline as an irrigant; canals were dried and obturated in the absence of symptoms as indicated above. The coronal portion of each tooth was subsequently restored as appropriate after post-obturation radiographic assessment. The information garnered during the study included gender of study participants, age, tooth treated and reason for pulp disease, number of roots, working length, number of canals, and canal configuration according to Vertucci's classification (Figure 1).

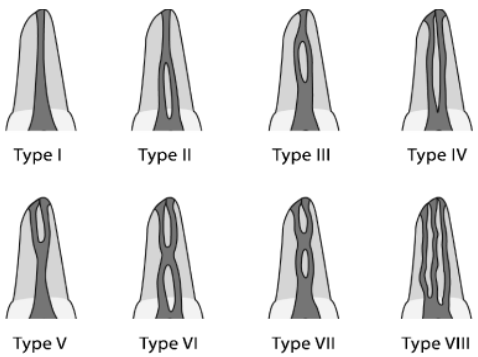

Figure 1: Diagrammatic representation of Vertucci's classification of root canal configuration[6]

Statistical analysis was done using the SPSS for Windows version 21.0 (Armonk, NY: IBM Corp. USA).Descriptive statistical analysis was carried out, and an Independent *t*-test was used to determine any significant difference in mean working length based on gender. **Chi-Square** test used to test any gender differences in root and canal morphology in the studied teeth. Statistically significant was set at $p<0.05$.

RESULTS

Root canal treatment was completed on 24 maxillary first and 29 second premolars teeth in 53 patients. The mean age of the study participants was 34.1±12.0 years, and ages ranged from 18 – 72 years. The participants had varying degrees of formal education(Table 1).

Table 1: Socio-demographic characteristics of the study participants

Variable	Frequency (N=53)	Percentage (%)
Age group (years)		
<20	3	5.7
21 – 30	16	30.2
31 – 40	21	39.6
41 – 50	5	9.4
51 – 60	6	11.3
>60	2	3.8
Mean age (Mean ± SD)	34.1 ± 12.0	
Tooth /Gender		
Maxillary first premolar		
Male	11	45.8
Female	13	54.2
Maxillary Second premolar		
Male	13	44.8
Female	16	55.2
Educational status		
Primary	1	1.9
Secondary	6	11.3
Tertiary	46	86.8

*SD=Standard deviation

Twenty-eight (52.8%) study participants were diagnosed with irreversible pulpitis sequel to dental caries, making it the most frequent indication for endodontic treatment in this study (Figure 2).

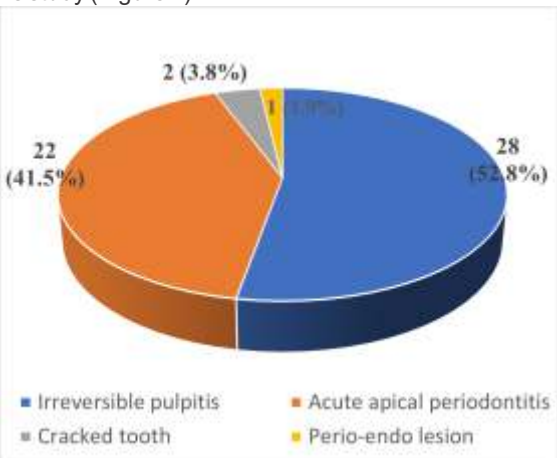

Figure 2: Indications for root canal treatment in the *in vivo* study participants

The majority of maxillary first premolars treated were two-rooted (66.7%), while most of the maxillary second premolars had single root (72.4%) (p=0.004) (Table 2). Two canals were predominantly observed in both maxillary first (87.5%) and second premolars (79.3%) teeth (Table 2).

The mean working length of the maxillary first premolars was 21.85 ±1.48 mm (range 18.00 - 25.00mm), while that of the maxillary second premolars was 21.75 ±1.66mm (range 18.50 - 24.80 mm) (Table 2).

Table 2: Morphologic characteristics of roots of maxillary premolar teeth in the study participants

Root and canal morphology	Tooth type: First premolar (n = 24) n (%)	Tooth type: Second premolar (n = 29) n (%)	*p*-value
Number of roots			
One root	8(33.3)	21 (72.4)	0.004‡
Two roots	16 (66.7)	8 (27.6)	
Number of canals			
One canal	3 (12.5)	6 (20.7)	0.429‡
Two canals	21 (87.5)	23 (79.3)	
Canal configuration			
Type I	3 (12.5)	4 (13.8)	0.816‡
Type II	5 (20.8)	5 (17.2)	
Type IV	16 (66.7)	19 (65.5)	
Type V	0 (0.0)	1 (7.7)	
Mean working length± SD (mm)	21.85 ± 1.48	21.75 ± 1.66	
(Range)	(18.00 - 25.00)	(18.50 - 24.80)	

‡c^2 test

*SD=Standard deviation

Four canal configurations (Figure 3) were observed in the studied maxillary premolars; three (3) in the first premolar and four (4) second premolars. The Vertucci type IV was the most prevalent canal configuration in maxillary first (66.7%) and second (65.5%) premolars.

Vertucci Type I canal configuration

(Maxillary 2nd Premolar)

Vertucci Type IV canal configuration

(Maxillary 1st Premolar)

Vertucci Type II canal configuration

(Maxillary 1st and 2nd Premolar)

Vertucci Type V canal configuration

(Maxillary 2nd Premolar

Figure 3: Canal configurations observed in the studied maxillary premolars

Most of the treated maxillary first premolars had two roots in both male (63.6%) and female (69.2%) study participants. Maxillary second premolars had a single root in a majority of treated teeth in both male (61.5%) and female (81.3%) participants (Table 3). There was more two-rooted second premolar among males in this study. The proportion of two canals in male participants was higher in the first than in the second premolars,but the difference was not significant (p≥ 0.05) (Table 3).

Table 3: Gender variation of morphologic characteristics in maxillary premolar teeth in the study participants

Root and canal morphology	First premolar Male (n = 11) n (%)	First premolar Female (n = 13) n (%)	*p-value*	Second premolar Male (n = 13) n (%)	Second premolar Female (n = 16) n (%)	*p-value*
Number of roots						
One root	4 (36.4)	4 (30.8)	0.772‡	8 (61.5)	13 (81.3)	0.237‡
Two roots	7 (63.6)	9 (69.2)		5 (38.5)	3 (18.7)	
Number of canals						
One canal	1 (9.1)	2 (15.4)	0.642‡	4 (30.8)	2 (12.5)	0.227‡
Two canals	10 (90.9)	11 (84.6)		9 (69.2)	14 (87.5)	
Canal configuration						
Type I	1 (9.1)	2 (15.4)	0.733‡	3 (23.1)	1 (6.3)	0.260‡
Type II	3 (27.3)	2 (15.4)		1 (7.7)	4 (25.0)	
Type IV	7 (63.6)	9 (69.2)		8 (61.5)	11 (68.7)	
Type V	0 (0.0)	0 (0.0)		1 (7.7)	0 (0.0)	

‡c^2 test

Overall, in both the first and second maxillary premolars the probability for the occurrence of two canals was higher in females than males.

The Vertucci type IV canal morphology accounted for 66.0% of all the canal configurations seen in both premolars among the male and female study participants. However, a more significant variation in root canal configuration was observed inthe maxillary second premolars of male participants compared to females (Table 3). In the second premolar, four canal configurations (Type I, II, IV and V) were observed in males as against three (Type I, II and IV) in the female participants. The difference in the type of canal configuration between the first and second maxillary premolars in males and females participants was not statistically significant (p≥ 0.05) (Table 3).

The mean working lengths of the palatal canals in maxillary first premolars were less than that for the buccal canals in both males and females (Table 4).

Table 4: Gender variation in working length of canals in maxillary premolar teeth in the study participants

Tooth type/Number of canals	Gender	Number of teeth	Minimum Length (mm)	Maximum Length (mm)	Mean±SD	t-value independent t-test	*p*-value
FIRST PREMOLAR							
One canal							
	Male	1	22.50	22.50	22.50±0.00	0.412	0.751
	Female	2	19.50	23.00	21.25±2.47		
Two canals							
Buccal							
	Male	10	20.50	25.00	22.50±1.49	0.696	0.495
	Female	11	18.50	24.10	22.01±1.72		
Palatal							
	Male	10	19.20	24.20	21.23±1.58	-0.535	0.599
	Female	11	18.00	23.00	21.60±1.61		
SECOND PREMOLAR							
One canal							
	Male	4	21.50	24.00	22.88±1.11	2.323	0.081
	Female	2	19.00	21.50	20.25±1.77		
Two canals							
Buccal							
	Male	9	19.00	24.50	21.54±2.08	0.002	0.998
	Female	14	18.50	24.10	21.54±1.31		
Palatal							
	Male	9	18.50	24.80	21.71±2.23	-0.014	0.989
	Female	14	19.50	24.50	21.72±1.43		

*SD=Standard deviation

The mean working length of maxillary first premolars with one canal was lower in females. However, in the first premolars with two canals, the mean working length of the palatal canals was higher in females. In the maxillary second premolars, the mean working length of teeth with a single canal was higher in males than females,although the difference was not statistically significant (p= 0.081). The difference between the mean working lengths in maxillary premolar teeth of male and female participants was not statistically significant (p≥0.05) (Table 4)

DISCUSSION

A crucial requirement for successful endodontic treatment is a thorough understanding of normal and unusual root canal anatomy.[7]Different methodologies [8, 10,12] have been employed to elucidate and create the desired understanding of root anatomy and canal morphology. In-vivo studies have been done using conventional intraoral radiographs[19], digital radiographs with or without loupes, and lately CBCT[16] or Micro CT which gives a 3D image of the root and canals. In the latter's absence, two radiographs in two planes are taken during routine endodontic treatment on teeth (parallel and cone shift technique) as done in this study.

In this in-vivo study, 24 maxillary first premolars and 29 maxillary second premolars were evaluated using endodontic files and digital radiographs with the aid of an operating dental microscope. The dental operating microscope allowed for improved lighting, magnification and ergonomics,thereby improving the ability to locate successfully, clean, shape, and obturate all canals. The majority of participants in this study were young adults within their 3rd and 4th decades of life. The dental care-seeking behavior in this age range of young adults has been previously linked to their higher incidence of dental caries; [20]perhaps the high level of education amongst this study participants is vital. The majority of the studied maxillary first premolars had two roots (66.7%), while maxillary second premolars were predominantly single-rooted (72.4%) (*p*=0.004). The high prevalence of two-rooted maxillary first premolars in this study agrees with the findings of a Jordanian study[21]. Still, it contrasts with the report of studies [7,22-24] among Caucasian and Asian populations. Studies in a Southern Chinese population [23] and other Asian populations [12,25] reported the prevalence of one root. This difference may be attributed to racial factors in the studied populations.The prevalence of 72.4% for single-rooted maxillary second premolars in this study is higher than the finding of two studies in Jordan[26] and Saudi Arabia[27] which reported 55.3% and 67% respectively, even though the present study evaluated fewer maxillary second premolars.

The majority (87.5%) of maxillary first premolars in this study had two canals, a finding that agrees with the report of other similar studies.[10,19,22,28,29] However, a lower prevalence (49.4%) of maxillary first premolars with two canals was reported in a Mexican population.[30] The prevalence of one root canal in the studied maxillary first premolar was 12.5%; a value that is higher than the results from Saudi Arabian,[11] Polish,[29] Turkish,[31] Spanish [32] and North American[33] populations where the incidence of a single canal was reported to range from 1.4% - 8.9%. The observed low prevalence of single canals in maxillary first premolars and the absence of teeth with three canals in this study is similar to previous Nigerian[10] and Ghana[19] reports. However, Agholor et al.,[34] in a 5-year retrospective study in our Teaching Hospital reported an incidence of 1.8% for maxillary first premolar with three canals; worldwide incidence of three canals in maxillary first premolar is in the range of 0 - 9.2%.[7,22,24,29,33]

The maxillary second premolar is generally thought to have a single root with one root canal.[2]However, studies[10, 11, 35,] have shown a wide variation amongst different populations. In this study, the overall prevalence of two canals in maxillary second premolars is higher than that of single canals in the studied teeth. This is similar to Ghanaian[19], Jordanian[26], Chinese[35], Saudi Arabian[27] and other Nigerian populations studied.[10,13] It is at variance with other studies[6,31]which reported the prevalence of maxillary second premolars with single canal in the range of 18.2% - 50.6% amongst Caucasians, Turks, and Turks Brazilians. This supports the possible influence of race on the number of root canals in maxillary second premolars. Unlike Al-Ghananeem et al.,[26] that reported a 0.46% incidence of three canals in second premolars; the three-canal variant was absent in the studied maxillary first and second premolars.This is in agreement with previous studies in other Nigerian populations.[10, 13] and a Ghanaian study.[19] The occurrence of a third root canal in second maxillary premolars has been reported as extremely rare in the literature, with percentages, ranging from 0 - 1%.[6,30] Thus the presence or absence of a third root canal in maxillary second premolars is influenced by racial factors since they are more frequently reported in Caucasian populations and rare in Asian and African populations.[13]

Gender has been postulated as a factor in the variation of canal anatomy.[9, 16] However, the documentary correlation of gender influence on the morphology of maxillary premolars in Nigerians is limited. This present study shows that the proportion of maxillary second premolars with two canals was higher in females than males; a finding that agrees with a previous Nigerian study[13] but in contrast with the report of a Saudi study[11] wherein males had a higher incidence of two canals than females.

Vertucci[6] described eight pulp space configurations referred to a Vertucci's root canal configurations(figure 2). In this present study, using the Vertucci's canal configuration, more variations in canal configuration were recorded in males(second maxillary premolar teeth)than female participants. There was a higher tendency among males to have a type I or IV canal configuration, while females were more likely to have type II or IV configuration. In a similar study by Vijayalakshmi and Pradeep,[36] reported an almost equally distributed canal configuration in both genders in a South Indian population.

This contrast may be due to differences in the racial background of the studied populations. Overall, the type IV root canal configuration was the most prevalent in both genders in this study. This is in agreement with the findings of Vertucci[6], Oginni[10], and Raj and Mylswamy.[37]

Contrary to the 7.7% prevalence of type V canal configuration in this study, Elnour et al.,[27] reported a 23% prevalence for the same canal configuration, which was the most common in a Saudi Arabian population. These variations may be attributed to racial differences in the studied populations. The mean working length of the maxillary first and second premolars in this study were 21.85mm and 21.75 mm respectively. Although, Africans were thought to have longer teeth than Caucasians based on racial factors;[38] the findings from this study are similar to those recorded in other populations.[7] They are also similar to the findings of Okpo and Akpata[38] who reported the mean length of maxillary first and second premolars in Nigerians as 21.9mm and 22.5mm respectively.

The mean buccal canal length (22.50mm) of the maxillary first premolar was observed in this study to be about 1mm longer than that of the palatal canal (21.40mm). This is in keeping with the finding from a previous study.[25] Generally, the mean working lengths of maxillary first premolars in thisstudy were shorter in females. However, the difference was not statistically significant.

CONCLUSION

The maxillary first premolars mainly were two rooted, while the second premolars predominantly had single root with a high prevalence of two canals in the studied population. Gender difference in the studied maxillary premolars was not statistically significant; however, the practitioner must anticipate some difference in root and canal morphology to avoid unnecessary treatment errors.

Recommendations Despite the limitation of sample size and the non-use of CBCT; the findings of this study will serve as a useful guide in the practice of endodontics in the West Africa subregion. Seeing how much a 2D based study has revealed, we recommend studies using 3-dimensional imaging.

REFERENCES

1. Carrotte P. Endodontics: Part 1. The modern concept of root canal treatment. Br Dent J 2004;197:181-3.
2. Vertucci FJ. Root canal morphology and its relationship to endodontic procedures. Endod Topics 2005;10:3-29.
3. Hull TE, Robertson PB, Steiner JC, delAgulia MA. Patterns of endodontic care for a Washington state population. J Endod 2003;29:553- 6.
4. Oderinu OH, Shaba OP, Adegbulugbe IC. Reason for endodontic treatment of permanent teeth seen in a Nigerian teaching hospital. Nig Q J Hosp Med 2006;16:37-40.
5. Khan M, Rehman K, Saleem M. Causes of endodontic treatment failure- a study. Pak Oral Dent J 2010;30:232- 6.
6. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol Oral RadiolEndod 1984;58:589-99.
7. PecoraJD , Sousa Neto MD, Saquy PC, Woelfel JB. Root form and canal anatomy of maxillary first premolars. Braz Dent J 1991;2:87-94.
8. Awawdeh LA, Abdullah H, Al-Qudah A. Root form and canal morphology of mandibular premolars in a Jordanian population. IntEndod J 2008;34:956-61.
9. Sert S, Bayirli GS. Evaluation of the root canal configurations of the mandibular and maxillary permanent teeth by gender in the Turkish population. J Endod 2004;30:391- 8.
10. Oginni A. Clinical radiographic estimation of the number of root canals in maxillary first and second premolars among Nigerians. Internet J Dent Sci 2004;2:65-83.
11. Al-Nazhan S, Al-Daafas A, Al-Maflehi N. Radiographic investigation of in vivo endodontically treated maxillary premolars in a Saudi Arabian sub-population. Saudi Endod J 2012;2:1-5.
12. Tian Y.-Y, Guo B, Zhang R, Yu X, Wang H, Hu T, et al. Root and canal morphology of maxillary first premolars in a Chinese subpopulation evaluated using cone beam computed tomography. IntEndod J 2012;45:996-1003.
13. Chima O. Number of root canals of the maxillary second premolar in Nigerians Odontostomatol Trop 1997;78:31- 2.
14. Rwenyonyi CM, Kutesa A, Muwazi L, Buwembo W. Root canal morphology of maxillary first premolar teeth in a Ugandan population. Open J Stomatol 2011;1:7-11.
15. Carrotte P. Endodontics: Part 4 Morphology of the root canal system. Br Dent J 2004;197:379 -83.
16. Mashyakhy M, Gambarini G. Root and root canal morphology differences between

genders: A comprehensive *in-vivo* CBCT study in a Saudi population.Actastomatol Croat 2019; 53:231-46.

17. Martins JNR, Marques D, Francisco H, Carames J. Gender influence on the number of roots

and root canal system configuration in human permanent teeth of a Portuguese subpopulation. Quintessence Int 2018;49:103-11.

18. Pan JYY, Parolia A, Chuah SR, Bhatia S, Mutalik S, Pau A. Root canal morphology of permanent teeth in a Malaysian subpopulation using cone-beam computed tomography. BMC Oral Health 2019;19:14. doi:10.1186/s12903-019-0710-z.

19. Ampofo P, Blankson PK, Nyako EA, Konadu A, Quartey-Papafio N. Radiographic in-vivo determination of the number of canals in maxillary premolars of Ghanaian population. Nig J Res Dent 2017;2:33-5.
20. Hopcraft MS, Patro BK, Kumar BR, Goswami A, Mathur VP, Nongkynrih B. Prevalence of dental caries among adults and elderly in an urban resettlement colony of New Delhi. Indian J Dent Res 2008;19:95-8.
21. Al-Ghananeem MMF, Al-Weshah M, ALSakarna BK, Alrawashdeh TN, Rumman KKA.

The number of roots and canals in the maxillary first premolars in a group of Jordanian population. J. Roy. Med Serv 2017;24:19-24.

22. Vertucci FJ, Gegauff A. Root canal morphology of the maxillary first premolar. J Am Dent Assoc 1979;99:194-8.
23. Walker RT. Root form and canal anatomy of maxillary first premolars in a southern Chinese population. Dent Traumatol 1987;3:130-4.
24. Loh HS. Root morphology of the maxillary first premolar in Singaporeans. Aust Dent J 1998; 43:339-402.
25. Dasrath K, Nisha A, Subodh S. Root morphology and tooth length of maxillary first premolar in Nepalese population. Dentistry 2015; 5:324. doi: 10.4172/2161-1122.1000324.
26. Al- Ghananeem MM, Haddadin K, Al-Khreisat AS, Al Weshah M, Al-Habahbeh N. The number of roots and canals in the maxillary second premolars in a group of Jordanian population. Int J Dent. 2014; 797692. doi: 10.1155/2014/797692.
27. Elnour M, Khabeer A, Al-Shwaimi E. Evaluation of root canal morphology of maxillary second premolars in a Saudi Arabian sub-population: An in vitro micro computed tomography study. Saudi Dent J 2016;28:162-8.
28. Atieh MA. Root and Canal Morphology of Maxillary First Premolars in a Saudi Population. J Contemp Dent Pract 2008;1:46-53.
29. Lipski M, Wozniak K, Lagocha R, Tomasik M. Root and canal morphology of the first human maxillary premolar. Durham Anthropol J 2005;12:2-3.
30. Pineda F, Kuttler Y. Mesiodistal and buccolingualroentgenographic investigation of 7275 root canals. Oral Surg Oral Med Oral Pathol 1972;33:101-10.
31. Kartal N, Ozcelik B, Cimilli H. Root canal morphology of maxillary premolars. J Endod 1998;24:417-19.
32. Chaparro AJ, Segura JJ, Guerrero E, Jimenez-Rubio A, Murillo C, Feito JJ. Number of roots and canals in maxillary first premolars: Study of an Andalusian population. Endod Dent Traumatol 1999;2:65-7.
33. Carns EJ, Skidmore AE. Configuration and deviations of root canal of maxillary first premolars. Oral Surg Oral Med Oral Pathol 1973;36:880-6.
34. Agholor CN, Ndeanaefo SU, Itimi E, Sede MA. Aberrant anatomy in endodontically treated teeth in a Nigerian Teaching Hospital. Nig J Dent Res 2020;5:99-107.
35. Weng XL, Yu SB, Zhao SL. Root canal morphology of permanent maxillary premolar teeth in the Han nationality in Chinese Guanzhong area: a new modified root canal staining technique. J Endod 2009;35:651-6.
36. Vijayalakshmi B, Pradeep S. Root canal morphology of maxillary first and second premolar using cone beam computed tomography in South Indian population. Int J Pharm Technol 2016;8:1387-91.
37. Raj UJ, Mylswamy S. Root canal morphology of maxillary second premolars in an Indian population. J Conserv Dent 2010;13:148-51.
38. Okpo HEA, Akpata ES. Tooth length in Nigerians. IntEndod J 1986;19:248-52.