RESEARCH ARTICLE

Root canal configuration of human permanent anterior teeth: A cross-sectional study using cone-beam computed tomography in the Pakistani population

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Abstract

Objective: To analyse and document internal root morphological variations in permanent anterior teeth using cone-beam computed tomography.

Methods: The cross-sectional, retrospective study was conducted from January 21 to June 19, 2021, at Jinnah Magnetic Resonance Imaging and Body Scan, and comprised data from July to December 2020 related to all the patients who had been referred to the centre for dental cone-beam computed tomography scan. The scans were evaluated at the Radiology Department of the School of Dentistry at Shaheed Zulfiqar Ali Bhutto Medical University, Islamabad, Pakistan. The morphology of the roots and root canals in all permanent anterior teeth was examined. Root canal configuration was categorised using Vertucci's classification. Data was analysed using SPSS 20.

Results: Of the 211 patients, 116(55%) were females and 95(45%) were males. The overall mean age was 39.9±1.02 years (range: 15-65 years). All the permanent anterior teeth exhibited a single root, with the exception 2(0.9%) mandibular right and 4(1.9%) left canines which had double roots. Type I root canals were observed in all 211 (100%) maxillary right central incisors, maxillary left central incisors and maxillary left canines. Among maxillary right canines, 208(98.6%) had type-I root canals, and the corresponding value for maxillary right lateral incisors was 209(99.1%), and for maxillary left lateral incisors, the value was 210(99.5%). Root canal polymorphism had no significant association with gender (p>0.05).

Conclusion: The presence of type-I root canal was common in permanent anterior teeth, and there was significant association of root canal polymorphism with gender.

Keywords: Cone-beam computed tomography, Dental pulp cavity, Anterior teeth, Vertucci's classification.

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Introduction

In treatment planning, the clinical importance of root canal variations in tooth morphology is crucial. Early identification of these morphological variations during preliminary diagnosis can prompt timely intervention, thereby minimising the necessity for later treatment. Dentists must possess an in-depth understanding of morphological variations in teeth to deliver high-quality treatment to patients.[1]

In human dentition, a wide array of morphological differences has been recorded in each type of tooth, encompassing the quantity and shape of crowns, roots and root canals.[2] These morphological variations have been linked to genetic diversity, environmental factors, and gender dimorphism.[3-6] The most common morphological variation in teeth, involving the number of roots and root canals, holds significant importance in endodontics.

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Vertucci's classification is employed to categorise teeth according to the morphology of their roots and root canals. The classification categorised human teeth into 8 types of root canals.[7] The quantification of roots, rather than solely canals, holds critical importance in the clinical management of teeth undergoing root canal therapy. It influences cavity preparation, instrumentation, the root canal filling process, and, ultimately, the outcome of the treatment.

Among various classes of teeth, premolars demonstrate significant variability in both root and root canal morphology.[8] Previous studies have indicated the presence of single, double and triple roots in first premolars, accompanied by two, three or even four root canals.[8,9] Similarly, research has revealed that second premolars may have a single or multiple root along with multiple root canals.[10,11]

Radiographic examination plays a crucial role in diagnosing and treating teeth, particularly in the field of endodontics.[12] Various radiological techniques have been employed to examine external and internal tooth morphology. However, in-office radiological techniques most commonly involve intraoral imaging with digital receptors. Extraoral

techniques have utilised both cone-beam computed tomography (CBCT) and panoramic radiography (PAN).[13]

The widely employed dental imaging method is PAN, offering a bird's-eye view of facial bones and teeth with reduced radiation exposure. PAN facilitates clear visualisation of external root morphology and the root canal system, although precise observation of root canals can be challenging. CBCT is increasingly used to explore dental root canal morphology.[14] CBCT provides more accurate imaging by generating a three-dimensional (3D) image of the cranio cervical region, offering enhanced visibility of deeper tooth structures, such as the root canal system. This method addresses limitations seen in traditional PAN.[15] CBCT finds applications in various dental areas, including endodontic surgery planning, diagnosis, treatment planning for dental trauma, alveolar bone topography, and more.[16] Additionally, CBCT proves valuable in evaluating both internal and external morphological variations in tooth roots.

In view of the scarcity of local data on the number of roots and root canal system morphology using CBCT, the current study was planned to fill the gap in literature by assessing internal root morphological variations in permanent anterior teeth of the Pakistani population using CBCT images.

Materials and Methods

The cross-sectional, retrospective study was conducted from January 21 to June 19, 2021, at Jinnah Magnetic Resonance Imaging and Body Scan, and comprised data from July to December 2020 related to all the patients who had been referred to the centre for dental CBCT scan, which were evaluated at the Radiology Department of the School of Dentistry at Shaheed Zulfiqar Ali Bhutto Medical University, Islamabad, Pakistan. After approval from the Centre of Study and institutional ethics review board, patient data was retrieved. Data related to all the intact anterior teeth from both the maxilla and mandible, totalling 12 teeth, was included. Unclear CBCT images, teeth that had undergone endodontic treatment, those with periapical pathologies, and teeth with posts and crowns were excluded. Evaluation of the anterior teeth focussed on determining the number of roots and the morphological configuration of the root canal system, as classified by Vertucci.[7]

The images had been obtained through a CBCT machine (Planmeca ProMax 3D, Planmeca, Roselle IL). Using the relevant software (Planmeca Romexis Viewer, Planmeca, Roselle IL), 2 researchers independently assessed the number of roots and root canal configurations.

The anterior teeth were divided into 4 groups; maxillary right anterior teeth group 1, maxillary left anterior teeth group 2, mandibular left anterior teeth group 3, and mandibular right anterior teeth group 4. The groups were further subdivided according to root numbers and root canal morphology on the basis of Vertucci's classification .[7] These groups were used to check the frequency of multiple roots and root canals in anterior teeth. Stratified analysis was done to check any gender predilection for multiple roots and canals in anterior teeth.

Data was analysed using SPSS 20. Data was expressed as frequencies and percentages, or as mean±standard deviation, as appropriate. Gender predilection of root and root canal variations was done using chi-square test. $P<0.05$was considered significant.

Results

Of the 211 patients, 116(55%) were females and 95(45%) were males. The overall mean age was 39.9±1.02 years (range: 15-65 years). There were a total of 844 central incisors (CIs), 844 lateral incisors (LIs) and 844 canines (Cs) from both the maxilla and mandible. All the permanent anterior teeth exhibited a single root, with the exception 2(0.9%) mandibular right and 4(1.9%) left canines which had double roots (Table 1, Figure 1).

Table-1: Root variations in anterior teeth evaluated by cone-beam computed tomography (CBCT).

Groups	Subgroups	n (%)
C^1	Single root	211 (100)
	Double root	-
LI^1	Single root	211 (100)
	Double root	-
CI^1	Single root	211 (100)
	Double root	-
CI^2	Single root	211 (100)
	Double root	-
LI^2	Single root	211 (100)
	Double root	-
C^2	Single root	211 (100)
	Double root	-
C^3	Single root	209 (99.1)
	Double root	2 (0.9)
LI^3	Single root	211 (100)
	Double root	-
CI^3	Single root	211 (100)
	Double root	-
CI^4	Single root	211 (100)
	Double root	-
LI^4	Single root	211 (100)
	Double root	-
C^4	Single root	207 (98.1)
	Double root	4 (1.9)

Type I root canals were observed in all 211(100%) maxillary right central incisors, maxillary left central incisors and maxillary left canines. Among maxillary right canines, 208(98.6%) had type-I root canals, and the corresponding value for maxillary right lateral incisors was 209(99.1%), and for maxillary left lateral incisors, the value was 210(99.5%) (Table 2, Figure 2).

Root canal polymorphism had no significant association with gender (p>0.05) (Table 3).

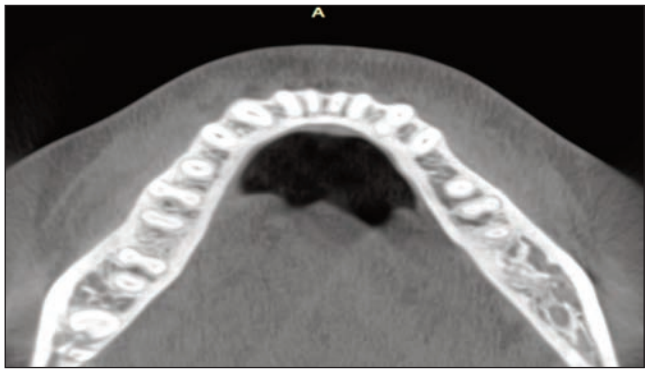

Figure-1: Permanent mandibular left canine showing two roots on a cone-beam computed tomography (CBCT) scan (axial view).

Table-2: Root canal morphology of anterior teeth based on Vertucci's classification.

Group	Types of root canal [n (%)]							
	I	II	III	IV	V	VI	VII	VIII
C^1	208 (98.6)	3(1.4)	-	-	-	-	-	-
LI^1	209 (99.1)	1(0.5)	-	-	0.5%	-	-	-
CI^1	211 (100)	-	-	-	-	-	-	-
CI^2	211 (100)	-	-	-	-	-	-	-
LI^2	210 (99.5)	1 (0.5)	-	-	-	-	-	-
C^2	211 (100)	-	-	-	-	-	-	-
C^3	198 (93.8)	3(1.4)	6(2.8)	3(1.4)	1(0.5)	-	-	-
LI^3	167(79.1)	16(7.6)	15(7.1)	4(1.9)	9(4.3)	-	-	-
CI^3	174(82.5)	19(9.0)	8(3.8)	2(0.9)	8(3.8)	-	-	-
CI^4	179(84.8)	17(8.1)	7(3.3)	2(0.9)	6(2.8)	-	-	-
LI^4	148(70.1)	28(13.3)	20(9.5)	4(1.9)	11(5.2)	-	-	-
C^4	192(91)	7(3.3)	5(2.4)	4(1.9)	3(1.4	-	-	-

Table-3: Gender-wise comparison of types of root canal morphology of anterior teeth.

Group	Gender	Types of root canal [n(%)]					*p*-value
		I	II	III	IV	V	
C^1	Male	94(98.9)	1(1.1)	-	-	-	0.575
	Female	114(98.3)	2(1.7)	-	-	-	
LI^1	Male	94(98.9)	-	1(1.1)	-	-	0.361
	Female	115(99.1)	1(0.9)	-	-.	-	
CI^1	Male	95(100)	-	-	-	-	N/A*
	Female	116(100)	-	-	-	-	
CI^2	Male	95(100)	-	-	-	-	N/A*
	Female	116(100)	-	-	-	-	
LI^2	Male	94(98.9)	1(1.1)	-	-	-	0.450
	Female	116(100)	-	-	-	-	
C^2	Male	95(100)	-	-	-	-	N/A*
	Female	116(100)	-	-	-	-	
C^3	Male	88(92.6)	2(2.1)	2(2.1)	3(3.2)	-	0.248
	Female	110(93.2)	1(0.8)	4(3.4)	-	1(0.8)	
LI^3	Male	76(80)	8(8.4)	6(6.3)	1(1.1)	4(4.2)	0.913
	Female	91(79.1)	8(7)	9(7.8)	3(2.60	5(4.3)	
CI^3	Male	81(68.1)	8(8.6)	2(2.2)	1(1.1)	3(3.2)	0.986
	Female	93(82.3)	11(9.7)	6(5.3)	1(0.9)	5(4.4)	
CI^4	Male	78(83.9)	9(9.7)	4(4.3)	1(1.1)	3(3.2)	0.898
	Female	101(87.8)	8(7)	3(2.6)	1(0.9)	3(2.6)	
LI^4	Male	67(73.6)	14(15.4)	8(8.8)	1(1.1)	5(5.5)	0.888
	Female	81(68.1)	14(11.8)	12(10.1)	3(2.5)	6(5)	
C^4	Male	89(94.7)	3(3.2)	1(1.1)	2(2.1)	-	0.418
	Female	103(88.8)	4(3.4)	4(0.4)	2(1.7)	3(2.6)	

Discussion

An understanding of the anatomical configuration, the number of roots, and the morphology of root canals in anterior teeth is crucial for the success of endodontic treatment. The current study provided a comprehensive insight into the root canal system of anterior permanent teeth in a Pakistani community setting, using CBCT analysis. CBCT eliminates the need for invasive procedures and provides detailed external and internal descriptions of the tooth and its supporting systems. Additionally, due to the isotropic nature of CBCT voxels, precise measurements can be anticipated.[17] Previous research has affirmed the authenticity of CBCT in displaying the morphology of the root canal system, making it suitable for cross-sectional surveys with large sample sizes.[6]

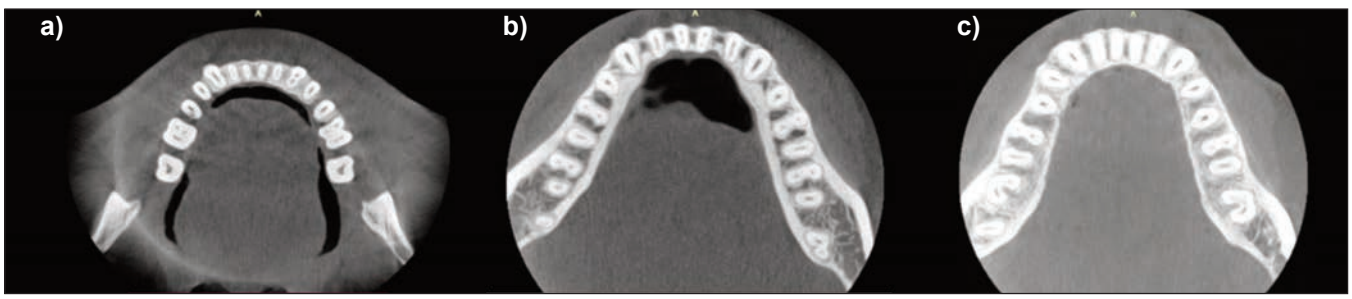

Figure-2 (a-c): Permanent anterior teeth showing multiple roots canals on a cone-beam computed tomography CBCT scan.

The present study noted that the majority of mandibular anterior teeth had a root canal of type-I variety, while type-II and type-III root canals were observed less frequently (Table 2). A study in Iran reported that almost all the permanent mandibular incisors had a type-I root canal. The majority 351(84.8%) of mandibular permanent central incisors showed type-I root canals, while 322(77.9%) of mandibular permanent lateral incisors showed type-I root canals.[18] A study in Chinese population using CBCT images of permanent mandibular anterior teeth reported that the majority of CIs 1084(84.2%), LIs 940(72.6%) and Cs 1210(93.7%) had a type-I root canal.[19] Another study on the Iranian population's mandibular anterior teeth reported that type-I root canal was found in higher prevalence, followed by type-III root canal.[20] A study in Pakistan reported that 80(29.9%) of CIs and 92(34.3%) of LIs showed type-III root canals, while the rest of the CIs and LIs showed type-I root canals.[21] A study in Karachi reported that 105(65.6%) of mandibular incisors show type-I root canals, followed by type-III 33(20.6%).[22] The current findings were in accordance with literature.

Furthermore, the current study indicated that the majority of permanent anterior maxillary teeth underwent type-I root canals, with type-II and type-V root canals following (Table 2). A study on Turkish population reported that the prevalence of root canals of type-I was higher in permanent anterior maxillary teeth 2948(96.8-99.7%), while type-II 38(1.3%), type-III 23(0.8%), and type-V 53(1.8%) root canals were less prevalent.[23] A study in Brazil reported that the majority of permanent anterior maxillary teeth 1176(98%) had a root canal of type-I variety.[24] A study in Saudi Arabia on permanent anterior teeth reported that the majority of both maxillary and mandibular teeth had root canals of type-I, followed by type-III and type-IV.[25] A study in Pakistan reported that 86(100%) of the maxillary canine had type-I root canal.[26] The current study agreed with literature on this count as well.

In the current study, there was no gender preference for root canal polymorphism among permanent anterior teeth. A study on Portuguese population reported that type-I root canals were more frequent in females compared to the males.[27] A study in Iran reported no significant difference between the root canal morphology of male and female groups[28] A study in Saudi Arabia reported no significant difference between root number and root canal structure of male and female groups.[299]

Limitations: The current study had limitations as it was based on data from a single center, and assessment was done within a restricted period a larger sample size could yield more definitive insights. Multi-centre studies with larger sample sizes are recommended to substantiate and validate the current findings.

Conclusion

Type-I root canals were frequently observed in permanent anterior teeth, with a notable prevalence in permanent mandibular anterior teeth. Root canal polymorphism in anterior teeth exhibited no discernible gender bias.

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Conflict of Interest: None.

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Author Contribution:
HN: Literature search, data analysis, interpretation and drafting.
SK: Data collection, study design and concept.