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Root dimensions and variations in maxillary canine in Pakistani population: A comparative and descriptive analysis using cone beam computed tomography technique

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Abstract

Introduction: Maxillary canine usually has a single root, but variations have been seen because of several events occurring during the tooth development. The variation in root morphology can be seen due to ethnicity and genetic differences. Few studies studies on morphology and root dimension of permanent maxillary canine using Cone Beam Computed Tomography (CBCT) Technique have been conducted in Pakistan. Hence the objective of the study was to assess the morphology and root dimension of permanent maxillary canine in Peshawar, Pakistan using CBCT Technique.

Material and Methods: A total of forty-three (43) radiographic (CBCT) archives of maxillary canine from November 2017 to February 2018 were studied and assessed. The CBCT along with history file was assessed to ensure that the CBCT of permanent maxillary canine included were of patients aged 15 and above. Each permanent canine was examined, and tooth length was measured. The mesio-distal width and bucco-palatal width at Cemento-Enamel Junction (CEJ) and deflection of tooth and root was observed using CBCT. The root canal pattern was assessed and classified according to Vertucci's classification. The data were analyzed in SPSS software (SPSS version 17) using the Chi-squared test and the t-test.

Results: All teeth examined under CBCT were having one root and Type I (100%) canal configuration. Maxillary canine revealed a predominantly straight root (65.1%). The anatomical length of maxillary canine and root was 22.7 mm and 15.49 mm while average mesio-distal and bucco-palatal width of the root at Cemento-Enamel Junction (CEJ) was 5.77mm and 6.70mm. 65.1% of the maxillary canines were having no deflection

Conclusions: The most frequent canal pattern reported in the maxillary canine was Type I (100%). The length of maxillary canine in Asian population ranges between 22.7mm – 26.4mm. The maxillary canines are bulkier on MD and BP aspect in Mardan then Peshawar.

Keywords: Displaced canine; computed tomography; root morphology

Introduction

The canines often referred to as cuspids are the third teeth from the midline. They are the longest and strongest of all permanent teeth and are designed to withstand high occlusal forces. The trapezoidal shaped maxillary canine is larger in both buccolingual and mesiodistal dimensions compared to mandibular counterpart which appears thinner in both dentitions.[1] The maxillary canine usually is the last tooth to erupt between 8 and 12 years

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of age after following more tortuous path of eruption than any other tooth.[2]

Maxillary canine usually has single root, but studies have found that root canal of maxillary permanent canines show variations.[3,4] These variations have been seen because of several events occurring during the tooth development.[5] Once crown formation has successfully completed, the apical mesenchyme proliferates into periodontium while the two layers of enamel epithelia cells fuse below the level of crown to form a sheath (Hertwig's Epithelial Root Sheath, HERS).[5] Though it has been accepted that Hertwig's Epithelial Root Sheath (HERS) plays a key role in root development but the mechanism is still not clear.

Studies however have found that the functions attributed to HERS ranged from inducers, root formation regulators, including the size number and shape of roots, inducers of differentiation of odontoblast cells to form root dentine or dental sac cells to differentiate into cementoblasts.[5-8] After completion of crown, the apical mesenchyme forms into the developing periodontium while enamel epithelia fuse forming a sheath known as Hertwig's Epithelial Root Sheath (HERS). Sometimes during root formation atypical morphology of root is seen as a result of discontinuity in Hertwig's Epithelial Root Sheath (HERS).[3] This leads to development of accessory root canal.[3] These accessory canals can occur anywhere and usually is the result of either splitting of Hertwig's Epithelial Root Sheath (HERS) or by folding of HERS to form two similar roots.[4,9] Though the etiology of HERS is controversial but studies show that several factors including ethnicity, certain diseases and developmental anomalies, genetic factors, external pressure and local traumatic injuries have been proposed to give rise to these canals.[9-14] For instance, the Caucasian population has only type I canal in maxillary canine, additional canal was found in Turkish population in maxillary canine and in Indians type I canal was found in maxillary canine (81.6%).[13-16]

Study conducted in Pakistan using manual x-ray parallax technique found that mean length of canine as 25.12 mm for males and 24.71 mm for females.[17] We did not find any study conducted in Pakistan to assess the root canal morphology of maxillary canine using CBCT. Therefore, this study was conducted on root canal anatomy of permanent maxillary canine in a private dental hospital in Peshawar, Pakistan. There are several procedures for studying the root morphology and variations but the radiographic study is one of the efficient and convenient ways.[18] Recently introduced cone beam computed tomography (CBCT) allows clinicians to study three orthogonal planes (sagittal, coronal and axial) and giving them an opportunity to visualize and understand the canal morphology in these three dimensions.[16,19,20] These variations in roots have been reported in many studies and hence it delineates a thorough understanding of the root canal morphology and variations for the success of root canal procedures. This study aims at to assess the morphology and dimension of permanent maxillary canine in Peshawar, Pakistan using CBCT.

Material and Methods

The cross-sectional study was conducted in a private dental hospital in Peshawar, where the CBCT images of maxillary permanent canine were reviewed from November 2017 to February 2018. Approval was obtained from the institutional ethical committee. All scans were obtained from hospital radiographic archives. All forty-three (43) radiographic (CBCT) archives of maxillary canine during the period were considered in the study. The CBCT along with history file was assessed to ensure that the CBCT of permanent maxillary canine included are of patients aged 15 and above. Teeth treated with root canal, carries, fractured, trauma, attrition, abrasion, eroded and having history of developmental disorders were excluded from the study. Similarly carries, eroded, abraded and teeth subjected to attrition were

not included in the sample. The aforementioned information was provided from the history file of each tooth and subsequent CBCT was obtained. The CBCT technique had been used using cross-sectional images in the axial, coronal, and sagittal planes. The voxel size of the images was 75 µm. The CBCT cross-sections were 1 mm thick taken from the apical to the coronal regions. The CBCT generated images were processed and examined for root and crown parameters. The root canal pattern was assessed and classified according to Vertucci's classification.[21] The canal was configured on the basis of Vertucci's classification.[21,22]

Canal classification	Canal configuration
Type I	A single canal extends from the pulp chamber to the apex
Type II	Two separate canals exit the pulp chamber and join short of the apex to form a single canal
Type III	One canal leaves the pulp chamber, divides into two within the root, and then merges to exit as a main canal
Type IV	Two separate and distinct canals are present throughout the extent from pulp chamber to the apex
Type V	Single canal exits the pulp chamber but divides into two distinct canals with two distinct apical foramina
Type VI	Two distinct canals leave the pulp chamber but join at the midpoint and divides again into two distinct canals with two separate apical foramina
Type VII	Single canal exits the pulp chamber, divides and rejoins within the canal, and finally redivides into two distinct canals short of the apex
Type VIII	Three distinct root canals exit the pulp chamber extending till the root apex

Each permanent canine was examined, and tooth length was measured. The mesio distal width and bucco-palatal width at Cemento Enamel Junction (CEJ) and deflection of tooth and root was observed using CBCT. Data was double coded, and cross checked for errors. SPSS software (SPSS version 17) was used using Chi-squared test and the t-test. The level of statistical significance was set at 0.05.

Results

A total of 43 maxillary canines were observed in this study. Out of 43 canines, 51.2% were right-sided while 48.8% were left-sided canines. According to this study, following findings were found;

a) All canines had one root and canal configuration in maxillary canines were Type I (100%, Table 1). Almost two third of maxillary canine (65.1%) had straight roots while about one third (34.9%) had distal angulation. These differences in the proportion of root direction between left and right canines were not statistically significant. P-value observed was 0.545.

Table I: Root canal pattern in maxillary canine in percentage using CBCT (n=43)

Authors	Population	Sample size (n)	Type I (%)	Type II (%)	Type III (%)	Type IV (%)	Type V (%)	Type VI (%)	Type VII (%)	Type VIII (%)
Nikhita et al.(15)	India	250	81.6	2.8	11.6	0.8	2	-	-	-
Preetham	India	100	96	3	1	-	-	-	-	-

Jain et al(22)										
Vertucci(21)	USA	100	100	-	-	-	-	-	-	-
F Pineda and Kuttler(23)	Mexico	260	100	-	-	-	-	-	-	-
Mehmet et al.(24)	Turkey	100	93.48	-	4.35	-	2.17	-	-	-
Present study	Pakistan	43	100	-	-	-	-	-	-	-

b) The average anatomical length of maxillary canine and root was 22.7 mm and 15.49 mm. No significant difference was found in the mean length of tooth and roots of right and left maxillary canines (p-value for length of maxillary canine and length of root is 0.265 and 0.127).

c) The average mesio-distal and bucco-palatal width of the root at Cemento Enamel Junction (CEJ) was 5.77mm and 6.70mm. No statistical difference was observed in the mesio-distal and bucco-palatal width of the root at CEJ (p-value 0.808 and 0.941 respectively).

d) Two thirds (65.1%) of maxillary canines had no deflection. The straight curvature of canine was seen mostly on left side. However, these differences between left and right maxillary canines were not statistically significant (Table II).

Table II: Tooth Deflection of right and left side of maxillary canine (n=43)

Side of tooth	Straight (n=28)	Mesial (n=6)	Distal (n=9)	p-value
Left	53.6%	33.3%	44.4%	0.638
Right	46.4%	66.7%	55.6%	
Total	*65.1%*	*14%*	*20.9%*	

Discussion

Several studies have been conducted on toot morphology around the globe and studies have proved that morphologic changes have been seen in roots attributing to ethnic and genetic differences.[10-14] Earlier studies conducted on Turkish, Indian, Caucasian, Chinese, Sri Lankan, Pakistani, Indian and Brazilian population show that pattern of root canal system follows a racial characteristic in terms of tooth length, canal number and pattern, curvature of root and width which makes it extremely challenging for the clinical practitioners.[10,12-17,20,25] A thorough knowledge and understanding of tooth, root morphology and variations is the pre-requisite for success of an endodontic treatment. This can further aid in understanding the etiology of canine impaction. Therefore, it is imperative to have sound knowledge and understanding of variations and dimensions of teeth. Different methods are being used to assess and study morphology of teeth and their roots which include but are not limited to histopathological studies, periapical radiographs, microscopy etc. Cone Beam Computed Tomography (CBCT) gives an opportunity to study three orthogonal planes (sagittal, coronal and axial), giving them an opportunity to visualize and understand the canal morphology in these three dimensions.[16,19,20]

It was found on the basis of this study that all maxillary canines had one root which is the most common pattern seen in maxillary canines.[3,4,20] The canal configuration was type I (100%) according to Vertucci's classification. Our findings were in line with earlier studies conducted on Turkish population (93.48%) by Mehmet et al.,[24] Mexican population by F Pineda and Kuttler,[23] American population by Vertucci [22] but were surprisingly different from Indian population by Nikhita et al and

Chinese population by Xi-Li et al.,[25] displaying type I canal configuration.

The average length of maxillary canine tooth and root was calculated as 22.7 mm and 15.49 mm with statistically insignificant difference in the mean length of the canines of both sides. Our findings were close to other studies in the region e.g. India 23.43 mm (Crown and Root length 9.61 mm and 16.82 mm),[15] Nepal having an average of 22.91 mm using periapical radiographs,[26] Pakistan evaluated through manual x-ray with an average of 25.12 mm for males and 24.71 mm for females.[17] The later studies were using conventional radiographic technique but the sensitivity and specificity of CBCT is significantly higher than those of periapical radiographs and is more reliable and accurate for measuring length of tooth and roots.[17,26] Another study conducted on Indian population found that maxillary canine has an average anatomical length of 26.43 mm[27] which was close to a study conducted on Georgian population, 27.5mm[28] but varied from our findings. Versiani reported that root canal anatomy and morphology varies in single rooted canines and the root length ranges from 12.53 – 18.08 mm which is similar to the findings of our study.[29] Though studies have reported that morphological and developmental deviations in the males and females dentition exist but the findings were statically insignificant in our studies.[30]

When using the periapical radiographs, the best reference point is Cemento Enamel Junction (CEJ) for measuring the length of root, however the film and angular variations between the root plays a statistically significant effect on the identification of some of these CEJ points.[31] Our study found that average mesio-distal and bucco-palatal width of the root at Cemento Enamel Junction (CEJ) was 5.77mm and 6.70mm. Previous conducted studies found that MD width in Indonesian population was 8.37mm (in males) while 7.87mm (in female)[(32)], and in Pakistani population with an average of 8.28mm.[33] The difference between our study and another study conducted in district Mardan, Pakistan could be attributed to the fact that the MD width was measured on dental cast in later study but the difference is usually less than one percent and is clinically acceptable.[33,34] Similarly, another study conducted by Javeria in Karachi shows that average (normal occlusion) mesio-distal and bucco-palatal width as measured on dental cast was 6.21 mm and 7.49 mm being very close to findings of our study[35] but average (malocclusion) was having mesio-distal and bucco-palatal width 8.3mm and 8 mm which was close to other studies. The study conducted by Javeria was a comparative study between normal and malocclusion group while in our study we were unaware if the subject were having normal or abnormal occlusion.

We found based on our study that 14% of maxillary canine had a mesial deflection and 20.9% had a distal deflection. Our study found that more than one third (34.9%) of maxillary canines had a distal root curvature. Hianne found that root curvature towards distal side was seen in the apical third in 46% of maxillary teeth[36] which is somewhere close to our study.

Conclusions

Our study concludes that most common canal pattern observed was Type I canal configuration in maxillary canine. The length of the canine varies within the race, but we conclude based on our study that in Asian

population it ranges between 22.7mm – 26.4mm. The maxillary canines are bulkier on MD and BP aspect in Mardan then Peshawar, the authors suggest further exploration of this aspect of the study using cone beam computed tomography technique.

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