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Evaluation of Root Canal Morphology of Permanent Maxillary Canine Using CBCT – A Cross-sectional Study

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Abstract

Background : A clear understanding and thorough knowledge of anatomy of human teeth is the utmost of importance to all dental procedures especially in endodontic and orthodontics treatment. This includes the study of root canal anatomy and its variations according to the race and gender.

Aim : The scope of the research was to determine the root and canal morphology of the maxillary canine in Indian population by analyzing cone-beam computed tomography (CBCT) images.

Material and Method : Forty-six CBCT images consisting of 20 males and 26 females were examined in this study and a total of 88 maxillary canines were analyzed. The root anatomy of each tooth was evaluated for the following parameters: the root canal patterns, the shape of the access cavity, the mesiodistal width of the crown and the distance from occlusal pit to the pulp chamber. The data was analyzed and compared and p-value of the data was considered 0.05 statistically.

Result : It can be concluded that a higher prevalence of maxillary canines have Type I root canal pattern in both gender. The most common shape of access cavity in male subjects was oval. Round access cavity was the most frequently observed in female subjects. Maxillary canine in male population also had greater mesiodistal crown diameter than female population.

Conclusion : The present study reported the normal anatomy and variations of maxillary canines in Indian population. The incidence of root canal morphology differed with gender.

Keywords : *CBCT, maxillary canine, root canal morphology, Vertucci's classification.*

Introduction

Complete mechanical preparation of the root canal system plays an important role of a successful endodontic diagnosis and treatment. Nevertheless, many roots possess accessory canals and a wide variations of canal configurations which some are considered unusual[1].

Universally, canines are referred as the cornerstone of the human teeth with the canine eminence on their labial portion of the teeth. This is because canines help in normal facial appearance at the corners of the mouth and also functionally, they are important for determination of intercuspal position through the canine guidance in dental occlusion2. Maxillary canines typically present with a single root and a single canal. The root is oval in cross section containing an oval cross-section canal. However, root canal configurations in maxillary canines may vary according to the race, sex and population. There are many studies from past to the recent on root canal morphology and configurations have been reported which varies with the respect to the race, gender and ethnicity. All these demonstrated the complexities of the entire root canal space and frequently reported that a single root canal exists as a single foramen[3,4,5,6].

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As the root canal morphology varies from tooth to tooth and its classification is much needed for communication, diagnosis and treatment planning, numerous classification for root canal morphology and its modifications have been proposed over the years which figures the total number of root, the number of canal in every root and the course of canal which confines the root. The earliest classification of root canal morphology was given by Weine FS et al in 19697 and followed by Vertucci FJ in 1984. Vertucci FJ demonstrated configuration for three canals, after he studied the root canal morphology of maxillary first premolar using clearing technique. His classification contains eight types of root canal system and is the most commonly used in most of the studies8. Aminsobhani et al reported a significance number of mandibular canines had more than one root canal in Iranian population9. Caucasian population10 was identified with only Type l canal in maxillary canines and additional canal configuration (1-3-4-1) was found in Turkish population11.

It is well known that there are many methods can be done to study the root and canal morphology, which includes computed tomography (CT) scanning, cone beam computed tomography (CBCT) canal staining and tooth clearing techniques, conventional radiography techniques, contrast medium-enhanced radiography and sectioning. Cone beam computed tomography (CBCT) has become a successful tool to examine the root canal anatomy and has been widely used nowadays. It had been introduced in dentistry since the year of 1990 for endodontic purpose. CBCT works in the cone-shaped beam of radiation in a single 3600 rotation and it is more advantageous than CT scanning due to its improved accuracy, low radiation dosage and lesser scanning time12. Neelakantan et al. also supported that this technique is considered as the gold standard of identification root canal morphology13. This study aims to determine the root and canal morphology of the maxillary canine in Indian population by analyzing cone-beam computed tomography (CBCT) images.

Material and Method

Sample Collection

The sample size was determined based on the G Power analysis14. It was calculated by using prevalence of 0.05% and the precision (d) is 0.05. The power analysis indicated that 76 sample size were required. In order to increase power of this study, 86 maxillary permanent canines were examined.

$$\text{Sample size} = \frac{Z_{1-\alpha/2}^2\, p(1-p)}{d^2}$$

Here

$Z_{1-\alpha/2}^2$ is the standard normal variate. As in majority of studies p values are considered as 0.05 so, 1.99 is used in formula

p is the expected proportion in a population based on previous studies and the value is 0.05

d is the absolute error or precision and it is 0.05

$$\text{Sample size} = \frac{1.99^2 \times 0.05(1-0.05)}{0.05^2} = 76$$

A total sample of 46 CBCT images consisting of 20 males and 26 females were examined in this study and a total of 86 maxillary canines were analyzed. The root anatomy of each tooth was evaluated for the following parameters: the root canal patterns, the shape of the access cavity, the mesiodistal width of the crown and the distance from occlusal pit to the pulp chamber. The criteria selections are presence of erupted maxillary permanent canines, complete formed root apices and those with free of deep caries, fracture and root canal fillings.

Scanning Procedure

CBCT images were obtained in the Saveetha Dental College, Department of Oral and Maxillofacial Radiology and the software used was SICAT Galileo Viewer version 1.9. Tomography sections of 0.3 mm axial planes and magnification was 1 : 1 were created. Serial axial CBCT images were examined by carefully rolling the toolbar from the pulp chamber to the apex.

The shape of access cavity at cementoenamel junction (CEJ) was evaluated in cross sectional view and Jou et al.'s classification was used15. The root canal pattern of maxillary permanent canines was classified based on Vertucci's classification. Mesiodistal width of crown structure in mesiodistal planes was measured based on three levels; incisal third, middle third and apical third. The distance between occlusal pit and pulp chamber was also measured in this study.

Results

Root Canal Pattern

According to the present study, the most prevalent root canal configuration of maxillary canine in both gender were Type I (male 75% and female 79.2%). Maxillary canines in male patient had 15% of Type ll and equally 5% of Type lll and Type V. In female patients, their other root canal patterns were Type IV (8.3%), Type V (8.3%) and Type VI (4.2%). Both gender did not have root canal morphology Type VII and VIII. Present results are tabulated in Table 1 and Table 2 shows comparison with earlier studies on maxillary canines.

Shape of Access Cavity at CEJ

In male patients, a relatively highest percentage of the shape of the access cavity was oval (40%) and other shapes include; round (35%), long oval (20%) and flattened (5%). The most common shape of access cavity of maxillary canines in female patients was found to be a round shape (54.2) and the least was long oval (8.3%).

Mesiodistal Width of Crown

The average of mesiodistal width of crown structure in male patients was higher than female patients with the respect of incisal third, middle third and apical third.

Distance Between Occlusal Pit and Pulp Chamber

Present study showed maxillary canines in male patients (mean = 4.67) had longer distance between occlusal pit and pulp chamber than in female patients (mean = 4.17).

Table 1 : Root canal patterns in maxillary permanent canine of both gender in %

(n = 86)

Gender	Type l	Type ll	Type lll	Type IV	Type V	Type VI	Additional Type
Male	75	15	5	0	5	0	0
Female	79.2	0	0	8.3	8.3	4.2	0

Table 2 : Root canal patterns in maxillary permanent canine in %

Authors	Techniques	Number of teeth	Type l	Type ll	Type lll	Type IV	Additional Type
Vertucci [10]	Clearing and staining	100	100	0	0	0	0
Sert and Bayirli [11]	Clearing and staining	100	91	3	4	2	0
Pineda and Kuttler [18]	Radiographs	260	100	0	0	0	0

Table 3 : Shape of the access cavity at CEJ in %

Gender	Round	Oval	Long Oval	Flattened
Male	35	40	20	5
Female	54.2	16.7	8.3	20.8

Table 4 : Average value of mesiodistal width of crown structure

Gender	Parameter	Crown Diameter (Mesiodistal Width, mm)		
		Incisal Third	Middle Third	Apical Third
Male	Mean	6.73	6.79	5.70
	SD	0.77	0.82	0.69
Female	Mean	6.60	6.13	5.18
	SD	0.74	0.91	0.55

Table 5 : Average value of distance between occlusal pit and pulp chamber

Gender	Parameter	Distance Between Occlusal Pit and Pulp Chamber (mm)
Male	Mean	4.67
	SD	0.90
Female	Mean	4.17
	SD	0.61

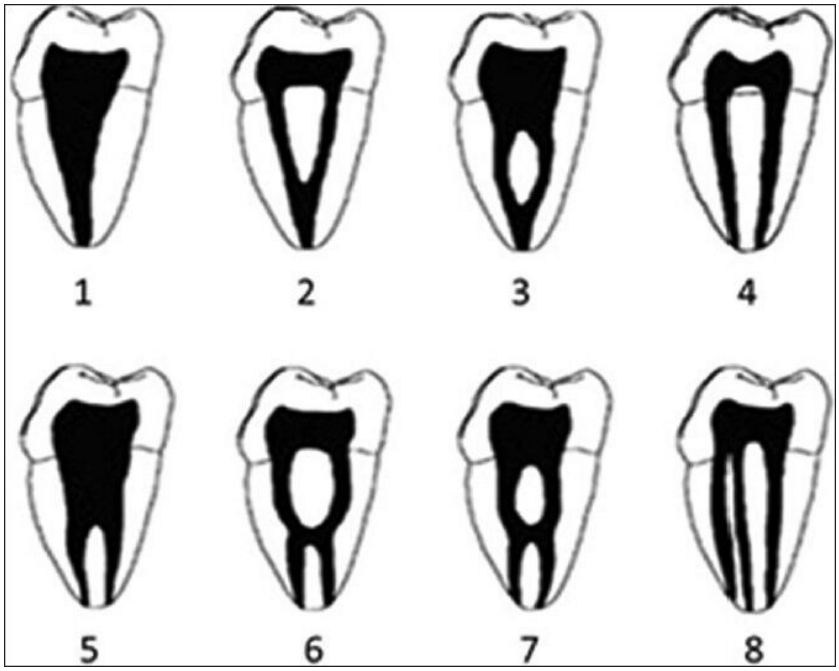

Figure 1 : Vertucci's classification of root canal system [16]

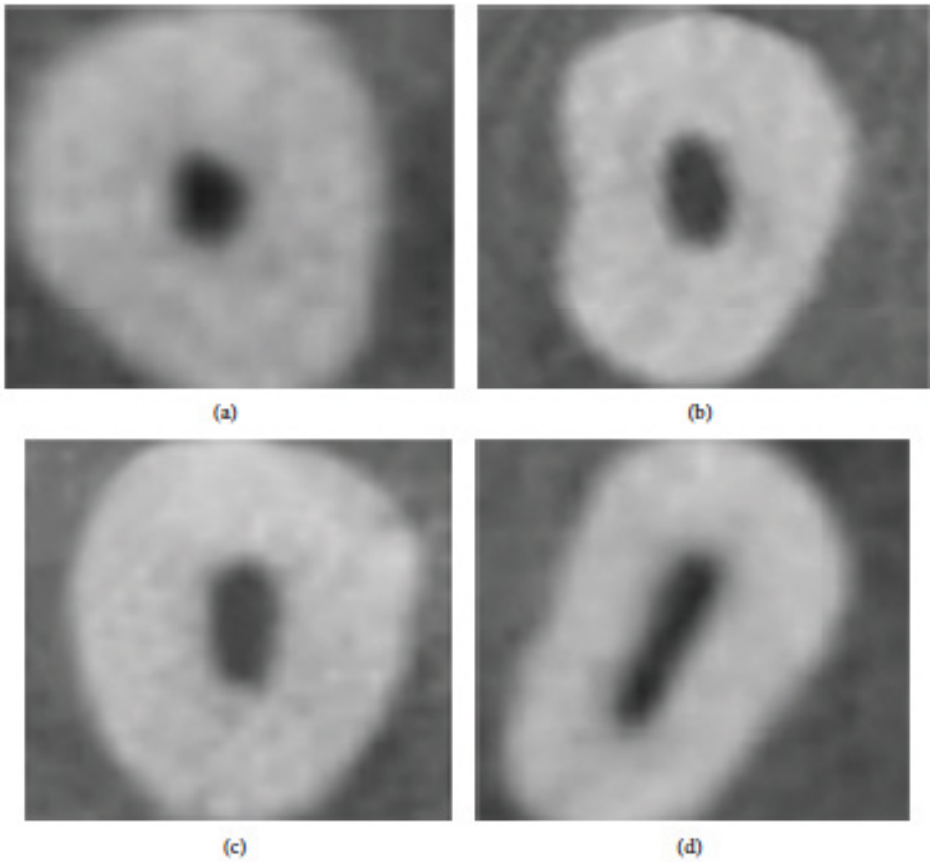

Figure 2 : Cross sections of cone beam computed tomography scans showing various shapes of the access cavity at cementoenamel junction [15]; (a) round, (b) oval, (c) long oval, and (d) flattened.

Discussion

Most of the methodologies to study root canal anatomy in the past such as periapical radiographs, clearing and demineralizing method and surgical operating endoscopy are invasive procedures as they are able to alter the actual canal morphology of the root. Based on a test done by Nguyen, it was proven that CBCT is an accurate measurement tool that can be used for measuring mesiodistal diameter of unerupted teeth16. Neelakantan et al. also said in his study that CBCT is the gold standard in the determination of root canal configuration since its technology overcomes some drawbacks of conventional radiography as relatively high-resolution, very thin and high contrast that is able to eliminate distortion, superimposition and artifacts of the imaging.

For centuries, a great number of researchers have been studying the morphology of root canal especially in human teeth and they occasionally concluded that the system of root canal morphology have always been varies in regards to the ethnicity, gender and also population. Most reported earlier studies include the population of America, Sudan, Chinese, Sri Lanka, Uganda and Turkey. The variation of root canal morphology extremely is challenging in endodontic and orthodontics management. Endodontists bear huge responsibilities to clean these canals from any microbial biofilms with a proper mechanical preparation and use of irrigants. All these can only be achieved with a thorough knowledge and comprehension of the root canal anatomy thereby reducing the number of post treatment failures17.

In the current study, the most common root canal pattern in both male and female Indian are Type I (75 % and 79.2 % respectively). Similar findings were found by Vertucci10 (100 %), Sert and Bayirli9 (91 %) and Pineda18 (100 %) in maxillary canines (Table 2). The second most common root canal in the maxillary canine of male was a Type Il (15 %), followed by Type lll and Type V, both in 5% of the samples. In the present study, the second most commonly occurring canal pattern in maxillary canines of female population was Type IV and Type V at 8.3% and followed by Type VI in 4.2% of the samples. Previous study10,11,19 did not report the presence of Type V and Type VI canal morphology in

the maxillary canine, but in the present study both types of canal pattern were seen in both gender.

The various shape of access cavity of maxillary canine is tabulated in Table 3. In maxillary canine of male population 14 teeth had round access cavity, which is at 35% of the samples. 16 teeth had oval access cavity, which makes up the most commonly (40%) occurring shape of access cavity in male population. Other shape include long oval access cavity at 20% and the least was flattened access cavity at 5%. In female population, the most commonly found was round access cavity at 54.2% (26 teeth), followed by 20.8% of flattened access cavity. Based on the report of Somalinga and Raghu20, the most common shape of the access cavity was oval, found in 94 teeth with the percentage of 37.6%. 66 teeth of maxillary canine had flattened access cavity, amongst which 59% of the teeth had more than one canal. Somalinga and Raghu also reported that a flattened shape of access cavity might have more than one canal pattern in both maxillary and mandibular canine.

Based on the result of present study, male population (mean value = 4.67mm) showed a greater distance between occlusal pit and pulp chamber than female population (mean value = 4.17mm). Precaution should be taken into notes during access opening preparation of canals in order to prevent perforation. The average measurements of crown diameter of male and female subjects at incisal third were 6.73mm and 6.6mm respectively. In male subjects, it was 6.79mm at middle third and 5.7mm at apical third. Meanwhile, the average crown diameter of female population was 6.13mm at middle third and 5.18mm at apical third. For this study, comparison was made and one can differ that male subjects highly has greater mesiodistal width than female subjects. This is very helpful in replacement of prosthetic teeth in the cross section of population.

Conclusion

The present study reported the normal anatomy and variations of maxillary canines in Indian population. The incidence of root canal morphology differed with gender. CBCT is truly a useful device for endodontic diagnosis and treatment. It can be concluded that a higher prevalence of maxillary canines have Type I root canal pattern in both gender. The most common shape of access cavity in male subjects was oval. Round access cavity was the most frequently observed in female subjects. Maxillary canine in male population also had greater mesiodistal crown diameter than female population.

Ethical Clearance – All datas were taken from examination of outpatients of Saveetha Dental College and Hospital

Source of Funding – Saveetha Dental College and Hospital

Conflict of Interest – Nil

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