"A RETROSPECTIVE CROSS-SECTIONAL STUDY OF ROOT AND CANAL MORPHOLOGY OF MANDIBULAR ANTERIOR TEETH USING CBCT"

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ABSTRACT

Aim: The aim of this study is to observe and evaluate the root and the root canal configuration of mandibular anterior permanent teeth using Cone Bean Computed Tomography (CBCT).

Methodology: The present study was a retrospective conducted on CBCT image of anterior mandibular permanent teeth in Dr. Aditya Mahajan, Mahajan Imaging, Radio Diagnostic Centre, Hauz Khas, New Delhi, India. The sample size calculated for the study was 200. The data analysis was completed using SPSS package for relevant statistical comparisons.

Result: The central incisor one canal shows the frequency of more than one canal in 34.58% of the teeth. Lateral incisor shows 37.44% of the teeth. The frequency of more than one canal in mandibular Canine was 18.05%.There was non-significant difference between right and left side of the tooth. In Central Incisor, the prevalence of type I canal was 65.41% fallowed by type III canal with 17.54%. In Lateral Incisor, the prevalence of type I canal was 62.56% fallowed by type III canal with 22.86%. In Canine, the prevalence of type I canal was 81.95%, type II canal was 3.51%, and type III canal was 11.03%. The type I canal is the most common fallowed by type III canal in among mandibular anterior teeth.

Conclusion: The second canal frequency was considerably higher in mandibular incisors than in mandibular canals. The most prevalent type of canal type was type I followed by type III in Vertucci's classification. There was no difference in the frequency of second canal shows among right and left side of mouth.

Keywords: Root canal configuration, Cone Bean Computed Tomography, Vertucci's classification

INTRODUCTION

The effective root canal therapy calls for the knowledge of anatomy and the physiology of root canal, which within the normal range can differ considerably.[1] The morphology of the root canal differs between ethnic groups, since racial and genital conditions are considered.[2]

Unfilled canals are supposed to remain a possible source of infection and may cause periapical diseases following treatment, the precise recognition of second canal is a requisite.[3] Unidentified second canals are one of the most significant causes of root canal therapy failure in mandibular incisors. This problem is most commonly identified in mandibular incisors as second canal is not identified by many dentists.[4]

The single canal in a root of permanent anterior mandibular teeth is the most common form of anatomy. However, it is not easy to understand the permanent anterior root canal morphology of the mandible teeth, as the presence of the second, lateral and apical deltas will complicate it.[2] Typically the lingual canal is missed in the presence of a second canal. It is mentioned that two canals in the apical third of the root are interconnected in most cases; thus one of the canals filling is expected to be sufficient to seal the apical foramen. The completion of only one canal cannot, however, guarantee the effectiveness of the treatment.[4–6]

In the past few years, various methods have been used to determine the internal root morphology. These techniques are divided into two classes: laboratory and clinical method. Laboratory approaches involve decalcification[6], dye injection[7], periapical radio-graphs, Micro-CT techniques[8] and scanning electron microscopy for assessing the pulpal floor.[9] Clinical procedures include endodontic care observation (with or without magnification tools[10], radiography[11] and investigation of previous records of patients.[12]

Due to the inherent limitations of the different techniques described above, the root system anomalies are not exposed in detail. The periapical x-ray offers a certain amount of knowledge but its interpretation can be inconclusive since it is a 2D technique. Moreover, because of restrictions like the distortion and overlay of the ion and dental structures which may occur in the images taken, these radiographs are not accurate. In order to address these limitations, cone beam computed tomography has recently been implemented.

CBCT benefits include low-dose radiation, short duration of exposure and cost-effectiveness. The implication of CBCT in dentistry root canal therapy consists, however, of defining the root morphology, number of the root canals, and their convergence or discrepancy between them can be visualized on three levels. CBCT is not a replacement of panorama and traditional x-ray, and is best used as a supplementary tool.[13] These benefits allow the clinician to gain a more comprehensive understanding of root canal system factual morphology.

The present study was under taken to observe and evaluate the morphology of root and root canal in permanent mandibular anterior teeth and report any variations and aberrant morphology in root canal of mandibular permanent anterior as detected among North Indian population.

AIMS

The present study aimed to detect and assess the root and the configuration of root canal in anterior permanent teeth of mandible with the help of Cone Bean Computed Tomography (CBCT) technique.

OBJECTIVES

To observe 200 CBCT scans those have imaged the permanent anterior teeth of mandible in Indian males and females of different age groups to:

1. Evaluate root canal internal configuration in permanent front teeth of mandible according to classification given by Vertucci.
2. Comparison of frequency of more than one canal between the right and the left side of lower anterior teeth.
3. Observe and report any aberrant root canal configurations in North Indian population.

Materials and method

The current study is a Retrospective cross-sectional study and comprised of adult patients who had undergone CBCT imaging of mandibular anterior permanent teeth of desired area. The study tried to evaluate the configuration of root canals among mandibular anterior permanent teeth. The present study was done in Department of Conservative Dentistry and Endodontics, Teerthanker Mahaveer Dental College & Research Centre, Moradabad. Then research got approval from Institutional Ethical Committee. Written permission was obtained from the director of Dr. Aditya Mahajan, Mahajan Imaging, Radio Diagnostic Centre, Hauz Khas, New Delhi, India.

Inclusive Criteria

- Good quality CBCT images of mandibular anterior permanent teeth of desired area
- Both male and female adult patients
- Fully developed root canal apices

Exclusive Criteria

- Calcification of root canal
- Cervical restoration
- Root caries
- Internal or external root resorption
- Deciduous teeth
- Previously root canal treated anterior teeth

The 200 selected CBCT images including central Incisor, Lateral Incisor and Canine were evaluated for root canal on the basis of Vertucci's Classification.

The sampled size has been computed with the programmenMaster 2.0. The power of the analysis was estimated at 80% and confidence (C.I.) was presumed by 95%.The sample size calculation was done as per the article by Zhengyan et al.[14] The sample size was estimated to be a minimum of 200.

Input: Tail(s) = One

P1 = 0.0000000 (proportion on one side)

P2 = 0.05(proportion on other side)

***α* error =** 95% = 1.96

Power (1-β) = 0.85783

Sample size = 200

The CBCT images were further divided into Central incisor, Lateral Incisor, Canines tooth. The samples were further divided into right and left side in order to find the difference in prevalence of root canal configuration between both sides of jaw.

A team of one postgraduate students and principal investigator examined the CBCT images of the study subjects and completed the assessment form – primary investigator to examine the CBCT image and the other to record the observations. The social science – background worker, help the dentist to coordinate with the management of the Mahajan Imaging, Radio Diagnostic Centre. 3-4 scans were studied every day on average.

Axial, coronal and sagittal images were used to assess root canal anatomy and the following were evaluated:

(i) Roots and canals count.

(ii) The classification of canal according to Vertucci's classifications

(iii) Additional roots prevalence.

(iv) Any others special observation.

All the images and features were independently assessed by two independent observers.

Any difference of opinion was re-evaluated and a consensus was achieved.

VERTUCCI'S CLASSIFICATIONS [6]

Type I: A Single canal arises from the pulp chamber and continues till the apical canal

Type II: A Single canal starting from the base, then division of canal in two parts around the middle third of the root and finally terminates as one canal at apical foramen.

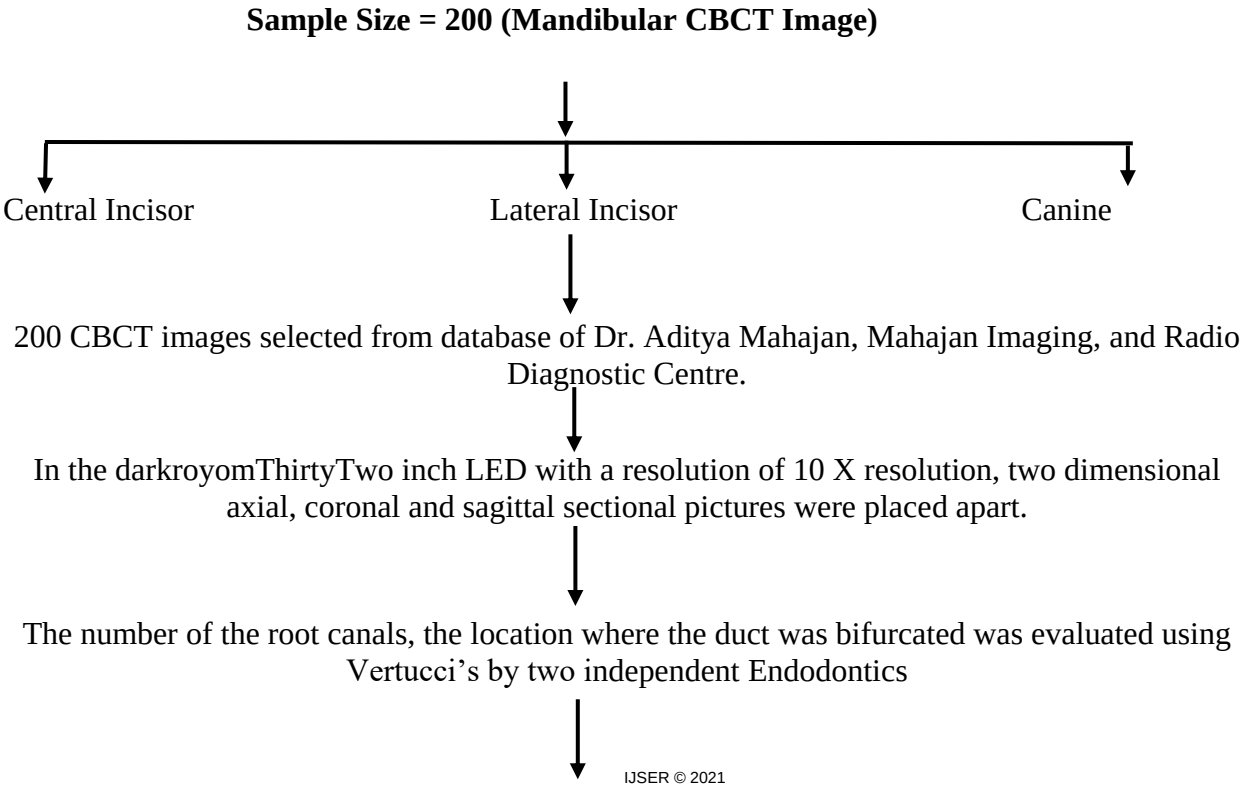
Type III: A Single canal starting from the base, then separate into 2 canals and concluding as one canal by integration.

Type IV: Two canals starting from pulp chamber and concludes as two separate canals.

Type V: A Single canal starting from the base and then separates into two discrete canals and ends with two different apical foramens.

Type VI: 2 discrete canals starting from the base integrate in the middle of the root and then splitting into two and end with two different apical foramens.

The data was entered into Microsoft Excel and analyzed using SPSS (Statistical Package for Social Sciences) package for relevant statistical comparisons. Results were presented in the form of tables and graphs. Descriptive statistics had been performed by calculating mean, standard deviation, frequencies and percentages for the Continuous variables. Categorical variables were summarized as frequencies and percentages.



In the case of questions, a third oral radiologist was asked to make a definitive decision

↓

The number of canal were compared with chi square test between right and left side

Results

The current Research was conducted to observe and assess the root & different configuration of root canal among anterior permanent teeth in mandible. The Cone Bean Computed Tomography (CBCT) method was used to visualize the root canal of the tooth.

Table 1: Percentage of tooth present in the study population

Teeth	Present	Absent
Right Central Incisor	199(99.5%)	1(0.5%)
Right Lateral Incisor	198 (99.0%)	2(1.0%)
Right Canine	199(99.5%)	1(0.5%)
Left Central Incisor	200(100%)	0(0%)
Left Lateral Incisor	200(100%)	0(0.0%)
Left Canine	200(100%)	0(0%)

The table shows the comparison of percentage of one canal in different teeth. In the central incisor one canal was found in 261(65.41%) teeth while more than one canal was present in 138 (34.58%) of the teeth. In the lateral incisor one canal was present in 249 (62.56%) while more than one canal was found in 149 (37.44%) teeth and in Canine one canal was present in 327 (81.95%) teeth while more than one canal was found in 72 (18.05%) teeth. The chi-square

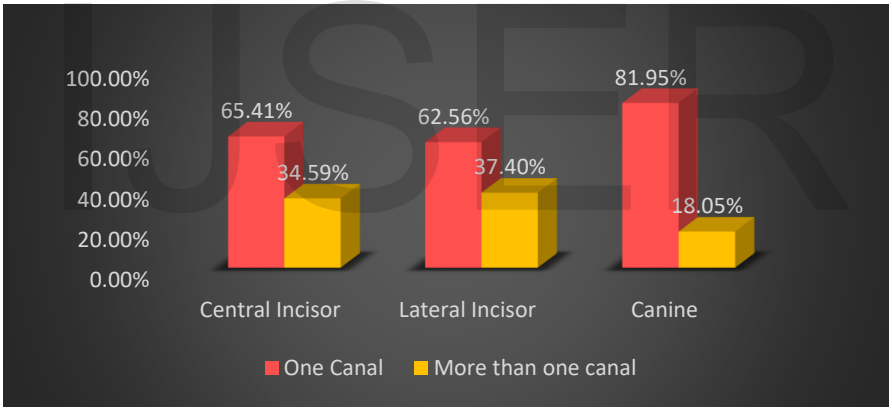
test shows the presence of significantly high percentage of more than one canal in the incisor in comparison to the canine teeth (Table 2).

The prevalence of more than one canal was Central Incisor ≈ Lateral Incisor > Canine

Table 2: Comparison of Frequency of more than one canal in different teeth

Teeth	One Canal	More than one canal	Chi square value	P Value
Central Incisor	261(65.41%)	138(34.58%)	69.95	0.001*
Lateral Incisor	249 (62.56%)	149(37.44%)		
Canine	327(81.95%)	72(18.05%)		

Graph 1: Comparison of Frequency of more than one canal in different teeth



The Presence of more than one canal was compared between right and left side. The right central incisor shows the prevalence of more than one canal in 35.7% while 33.5% left central incisors showed two canals. The χ^2 test doesn't shows significant variation among right & left side in central incisor with χ^2 value 0.94 and p value 0.89.

The prevalence in Right Central Incisor is equivalent to Left Central Incisor

The right Lateral incisor shows the prevalence of more than one canal in 37.4% in right side while 37.5% was seen in left side of the teeth. The χ^2 test doesn't shows significant variation

among right & left side in Lateral incisor with χ^2 value 0.33 and p value 0.95.

The prevalence in Right Lateral Incisor is equivalent to Left Lateral Incisor

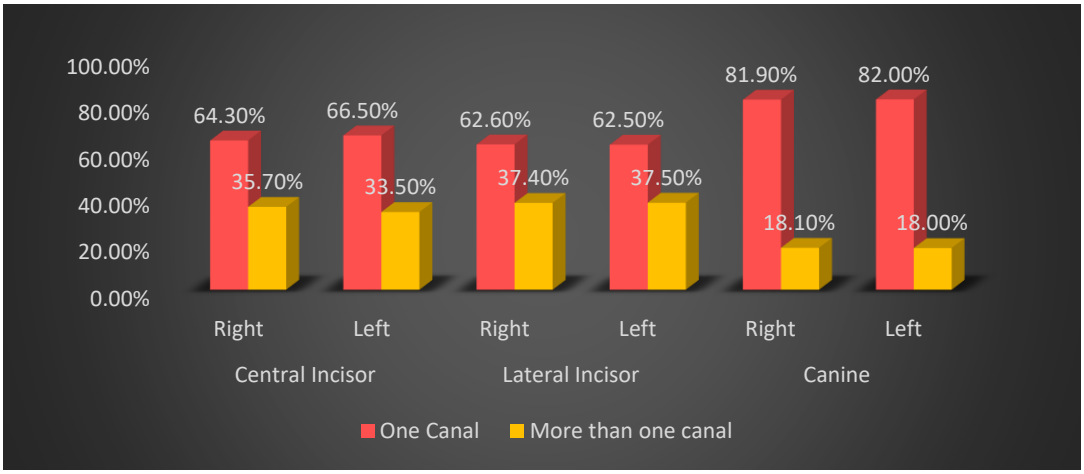
The right Canine shows the prevalence of more than one canal in 18.1% in right side while 18.0% was seen in left side of the teeth. The χ^2 test doesn't shows significant variation among right & left side in Canine with χ^2 value 0.24 and p value 0.98 **(Table 3)**.

Prevalence of More than One Canal Right Canine ≈ Left Canine

Table 3: Comparison of frequency of more than one canal between right and left side

Teeth		One Canal	More than one canal	Chi square value	P Value
Central Incisor	Right	128(64.3%)	71 (35.7%)	0.94	0.89
	Left	133 (66.5%)	67 (33.5%)		
Lateral Incisor	Right	124 (62.6%)	74(37.4%)	0.33	0.95
	Left	125 (62.5%)	75 (37.5%)		
Canine	Right	163(81.90%)	36(18.1%)	0.24	0.98
	Left	164(82.0%)	36(18.0%)		

Graph 2: Comparison of frequency of more than one canal between right and left side



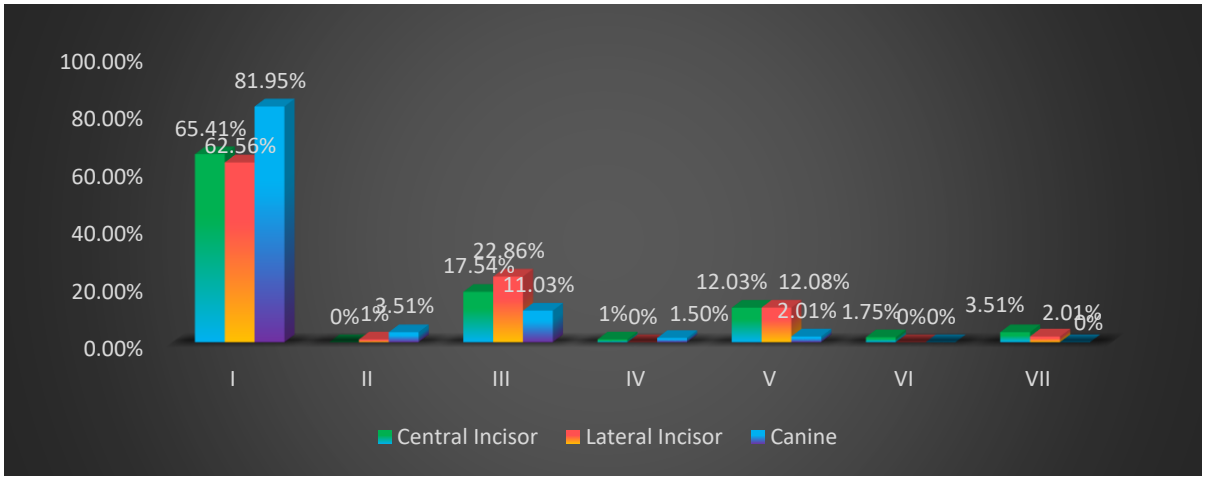
The occurrence of different type of canal on the basis of Vertucci's classification was

compared among different tooth. In Central Incisor, the prevalence of type I canal was 65.41%, type III canal was 17.54%, type IV was 1.00%, type V was 12.03%, type VI was 1.75% and type VII was 3.51%. In Lateral Incisor, the prevalence of type I canal was 62.56%, type II canal was 1.00%, type III canal was 22.86%, type V was 12.08%, and type VII was 2.01%. In Canine, the prevalence of type I canal was 81.95%, type II canal was 3.51%, type III canal was 11.03%, type IV was 1.50% and type V was 2.01%. The chi square test shows significant difference in the prevalence of type of canals in different tooth with χ^2 value 39.96 and p value 0.001 **(Table 4)**.

Table 4: Frequency and percentage of the canals among different tooth

Teeth	Central Incisor	Lateral Incisor	Canine	Chi square value	P Value
Type I	261 (65.41%)	249 (62.56%)	327(81.95%)	39.96	**0.001***
Type II	0 (0.00%)	4(1.00%)	14(3.51%)		
Type III	70 (17.54%)	91(22.86%)	44(11.03%)		
Type IV	4 (1.00%)	0(0.00%)	6(1.50%)		
Type V	48 (12.03%)	46(12.08%)	8(2.01%)		
Type VI	7 (1.75%)	0(0.00%)	0(0.00%)		
Type VII	14 (3.51%)	8 (2.01%)	0(0.00%)		
Type VIII	0 (0.00%)	0(0.00%)	0(0.00%)		

Graph 3: Frequency and percentage of the canals among different tooth



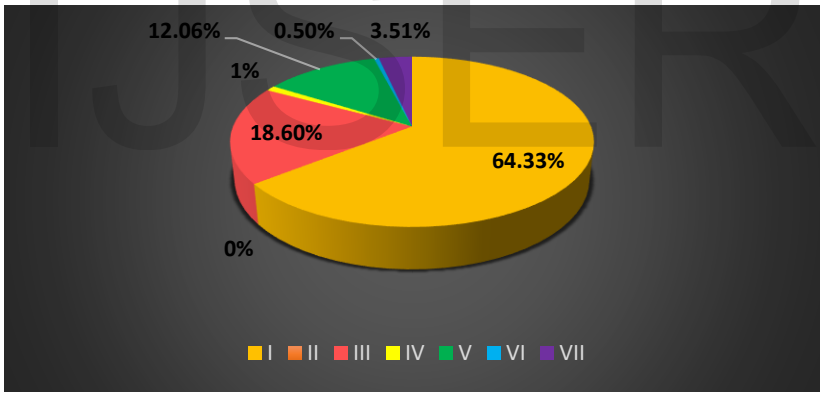
The occurrence of various type of canal on basis of Vertucci's classification as seen in

right Central Incisor. The prevalence of type I canal was 64.33%, type III canal was 18.60%, type IV was 1.00%, type V was 12.06%, type VI was 0.50% and type VII was 3.51% **(Table 5)**.

Table 5: Frequency and percentage of canals of right central incisor

Type of canals	Frequency	Percent
I	128	64.33
II	0	0.00
III	37	18.60
IV	2	1.00
V	24	12.06
VI	1	.50
VII	7	3.51
Total	199	100.0

Graph 4: Percentage of canals in right central incisor



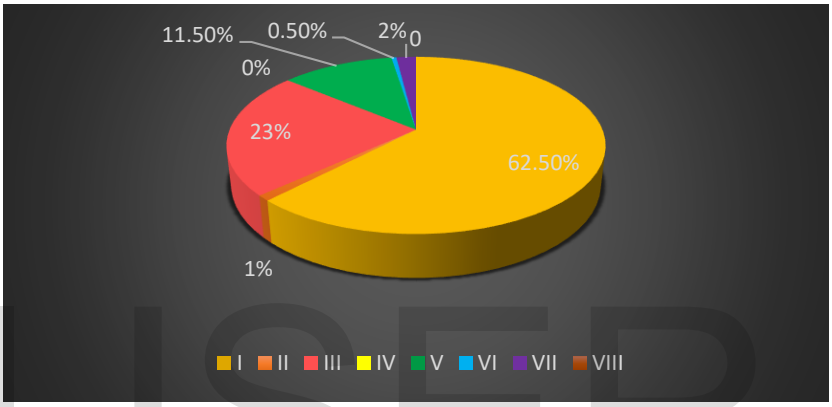
The occurrence of various type of canal on the basis of Vertucci's classification was seen in left Central Incisor. The prevalence of type I canal was 66.50%, type III canal was 16.50%, type IV was 1.00%, type V was 12.00%, type VI was 0.50% and type VII was 3.50% **(Table 6)**.

Table 6: Frequency and percentage of canals of left central incisor

Type of canals	Frequency	Percent
I	133	66.5

II	0	0.00
III	33	16.5
IV	2	1.0
V	24	12.0
VI	1	.5
VII	7	3.5
VIII	0	0.00
Total	200	100.0

Graph 5: Percentage of canals in left central incisor

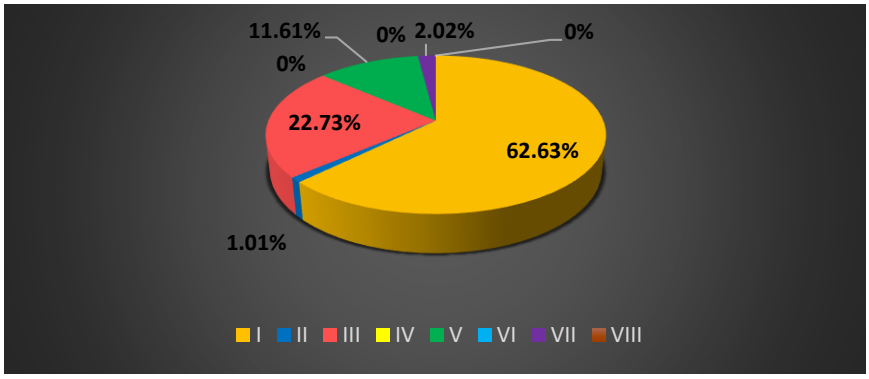


The occurrence of various type of canal on basis of Vertucci's classification was seen in right Lateral Incisor. The prevalence of type I canal was 62.63%, type II 1.01%, type III canal was 22.73%, type V was 11.61% and type VII was 2.02% **(Table 7)**.

Table 7: Frequency and percentage of canals of right lateral incisor

Type of canals	Frequency	Percent
I	124	62.63%
II	2	1.01%
III	45	22.73%
IV	0	0%
V	23	11.61%
VI	0	0%
VII	4	2.02
VIII	0	0%
Total	198	100.0

Graph 6: Percentage of canals of right lateral incisor

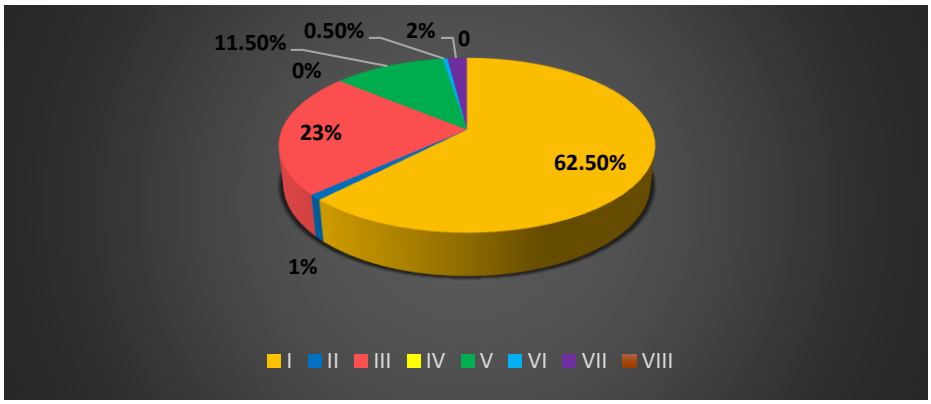


The occurrence of various type of canal on the basis of Vertucci's classification was seen in left Lateral Incisor. The prevalence of type I canal was 62.50%, type II 1.00%, type III canal was 23.00%, type V was 11.50%, type VI was 0.5% and type VII was 2.00% **(Table 8)**.

Table 8: Frequency and percentage of canals of left lateral incisor

Type of canals	Frequency	Percent
I	125	62.5
II	2	1.0
III	46	23.0
IV	0	0.00
V	23	11.5
VI	1	0.00
VII	4	100.0
VIII	0	
Total	200	

Graph 7: Frequency and percentage of canals of left lateral incisor

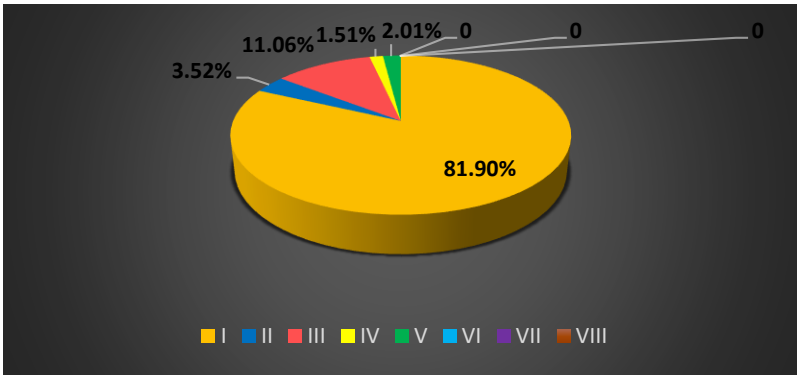


The occurrence of various type of canal on the basis of Vertucci's classification was seen in right Canine. The prevalence of type I canal was 81.90%, type II was 3.52%, type III canal was 11.06%, type IV was 1.51% and type V was 2.01% **(Table 9)**.

Table 9: Frequency and percentage of canals of right canine

Type of canals	Frequency	Percent
I	163	81.90
II	7	3.52
III	22	11.06
IV	3	1.51
V	4	2.01
VI	0	0.00
VII	0	0.00
VIII	0	0.00
Total	199	100.0

Graph 8: Frequency and percentage of canals of right canine

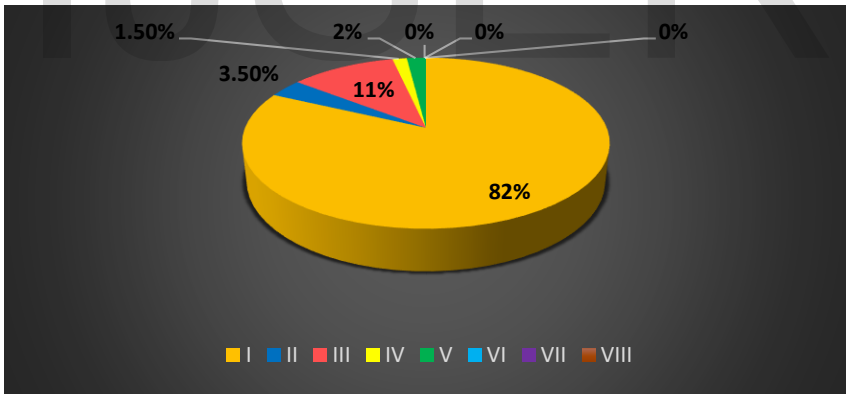


The occurrence of various type of canal on the basis of Vertucci's classification was seen in left Canine. The occurrence of type I canal was 82.0%, type II was 3.5%, type III canal was 11.00%, type IV was 1.50% and type V was 2.00% **(Table 10)**.

Table 10: Frequency and percentage of canals of left canine

Type of canals	Frequency	Percent
I	164	82%
II	7	3.5%
III	22	11.0%
IV	3	1.5%
V	4	2%
VI	0	0%
VII	0	0%
VIII	0	0%
Total	200	100.0%

Graph 9: Frequency and percentage of canals of left canine



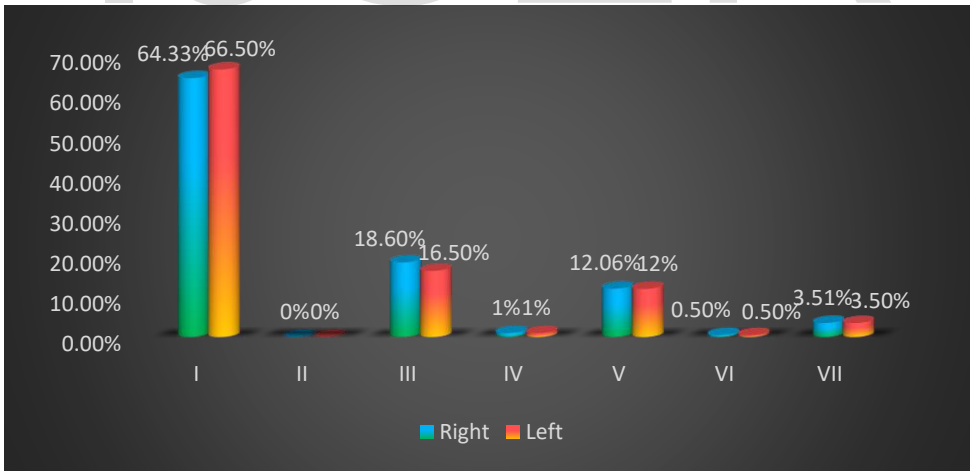
The occurrence of various type of canal on the basis of Vertucci's classification was compared between right and left Central Incisor. In Right Central Incisor, the prevalence of type I canal was 64.33%, type III canal was 18.60%, type IV was 1.00%, type V was 12.06%, type VI was 0.50% and type VII was 3.51%. In Left Central Incisor, The prevalence of type I canal was 66.50%, type III canal was 16.50%, type IV was 1.00%, type V was 12.00%, type VI was 0.50%

and type VII was 3.50%. The chi square test shows non-significant difference between the two sides with χ^2 value 1.23 and p value 0.83 **(Table 11)**.

Table 11: Comparison between right and left side of central incisor

Type of canals	Right		Left	
	Frequency	Percent	Frequency	Percent
I	128	64.33	133	66.5
II	0	0.00	0	0.00
III	37	18.60	33	16.5
IV	2	1.00	2	1.0
V	24	12.06	24	12.0
VI	1	.50	1	.5
VII	7	3.51	7	3.5
Total	199	100.0	200	100.0
Chi square value	1.23			
P value	0.83			

Graph 10: Comparison between right and left side of central incisor



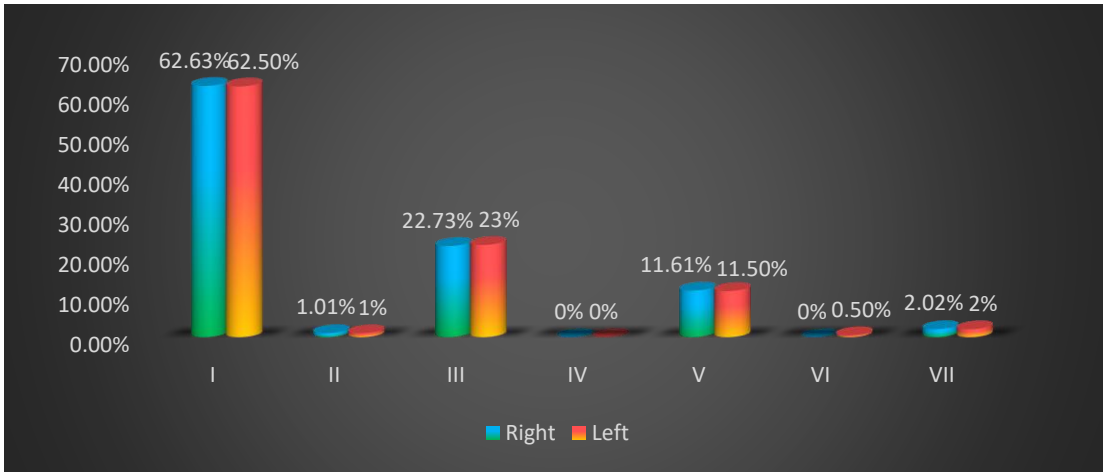
The occurrence of various type of canal on the basis of Vertucci's classification was compared between left and right Canine. In Right Lateral Incisor, the prevalence of type I canal was 62.50%, type II 1.00%, type III canal was 23.00%, type V was 11.50%, type VI was 0.5% and type VII was 2.00%. In Left Lateral Incisor, the prevalence of type I canal was 62.50%, type

II 1.00%, type III canal was 23.00%, type V was 11.50%, type VI was 0.5% and type VII was 2.00%. The chi square test shows non-significant difference between the two sides with χ^2 value 0.37 and p value 0.92 **(Table 12)**.

Table 12: Comparison between right and left side of lateral incisor

Type of canals	Right		Left	
	Frequency	Percent	Frequency	Percent
I	124	62.63	125	62.5
II	2	1.01	2	1.0
III	45	22.73	46	23.0
IV	0	0.00	0	0.00
V	23	11.61	23	11.5
VI	0	0.00	1	.5
VII	4	2.02	4	2.0
VIII	0	0.00	0	0.00
Total	198	100.0	200	100.0
Chi square value		0.37		
P value		0.92		

Graph 11: Comparison between right and left side of lateral incisor



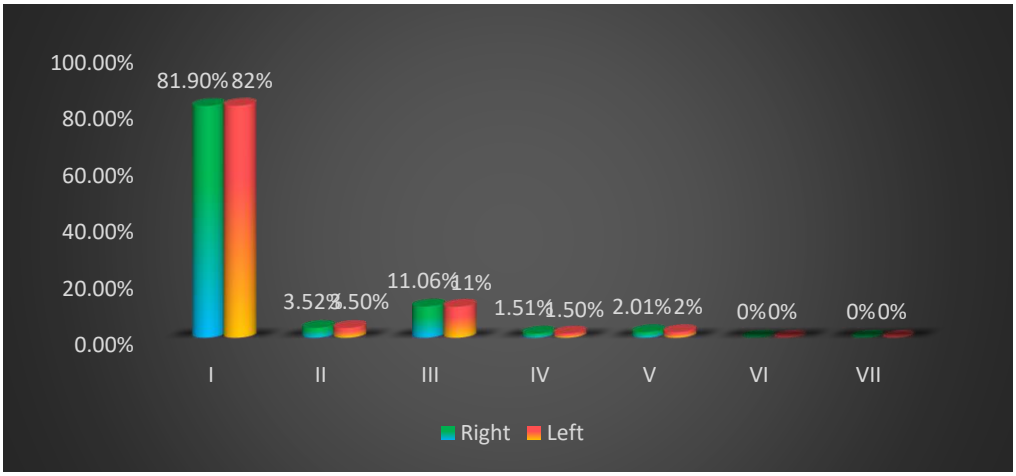
The occurrence of various type of canal on the basis of Vertucci's classification was compared between left and right Canine. In Right Canine, The prevalence of type I canal was 81.90%, type II was 3.52%, type III canal was 11.06%, type IV was 1.51% and type V was

2.01%. In left canine, the prevalence of type I canal was 82.0%, type II was 3.5%, type III canal was 11.00%, type IV was 1.50% and type V was 2.00%. The chi square test shows non-significant difference between the two sides with χ^2 value 0.37 and p value 0.92 **(Table 13)**.

Table 13: Comparison between right and left side of Canine

Type of canals	Right		Left	
	Frequency	Percent	Frequency	Percent
I	163	81.90	164	82.0
II	7	3.52	7	3.5
III	22	11.06	22	11.0
IV	3	1.51	3	1.5
V	4	2.01	4	2.0
VI	0	0.00	0	0.00
VII	0	0.00	0	0.00
VIII	0	0.00	0	0.00
Total	199	100.0	200	100.0
Chi square value		0.24		
P value		0.96		

Graph 12: Comparison between right and left side of Canine



DISCUSSION

Extensive information about tooth morphology, appropriate access & tooth exploration is required for effective treatment of teeth. The latest in vitro research focuses on the anatomy of the roots of human maxillary and jaw canines to solve cleaning and forming problems.

Variations in the root canal must be detected and handled. In the past, approaches for anatomical exploration, such as histopathological studies,[15] periapical intra-oral x-rays, clearing and demineralizing,[16] and surgical operating microscopy, have been applied differently.[16] Invasive methods alter actual morphology of the canal. Intraoral X-rays captured images are only two dimensions. Recently experiments have been carried out using a noninvasive spiral-based tomography that offers 3D imaging and is non-invasive technology. Although scan time and effective dosages were significantly reduced, they were not as reliable and the dose was not so low as realistically possible.[9] To address this downside, the study of root canal anatomy was proposed for CBCT- a relatively new diagnostic imaging.[14]

Mandibular incisors have been quiet notorious so far as endodontic treatment is concerned mainly because of the second canal, if not diagnosed and treated would lead to root canal therapy failure.[4] In previous researches, the occurrence of the additional canal in incisors of mandible was 11.5% to 45%.[16–18]

Patel et al.,[19] have informed CBCT precision was comparable to updated staining of canal methods and tooth clearing methods for the assessment of the canal. This approach can be more appropriate and efficient for patients, provided that CBCT is valid for in vivo research, and in comparison to the studies that have been carried out in vitro design.[20–22]

In the present study Axial, coronal and sagittal images were used to assess root canal anatomy and the following were evaluated:

(i) Roots and canals count.

(ii) The classification of canal according to Vertucci's classifications

(iii) Additional roots prevalence.

(iv) Any others special observation.

In our research, one canal were found in 261 (65.41%) of central Incisor teeth while more than one canal were seen in 138 (34.58%) of the teeth in Central Incisors while one canal were observed in 249(62.56%) of lateral incisors teeth while more than one canal were seen in 149 (37.44%) of the teethy

In 26.2 percent of mandibular incisors, Al-Qudah et al.,[4] recorded 2 canals that is like the results of our research. The study examined 450 extracted teeth in Jordanian population by using the staining of canals fallowed by clearing methods.

In Iranian population, Ezoddini et al.,[23] had done examination of 68 extracted mandibular incisors and recorded a 55% incidence for the second canal that are not matching with our study findings. The disparity in sample sizes and techniques used in two studies can be due to this reason.

In the study conducted by Amin Sobhani et al[24] CBCT imaging was performed on six hundred thirty two central and six hundred fourteen mandibular lateral incisors, The study was done among Iranian population, each samples was having single root. The second canal prevalence was 27.3% in central Incisor and 29.4% in lateral incisor.

Thirty six percent of lower incisors had the presence of a second canal in study by Geduk et al.,[25] in a population of Turkey. In the present sample, the additional canal frequency in the lateral mandibular incisors was higher (37%) compared to the central mandibular incisors in the

Zitong Lin et al[5] study (34.5%). In the lateral and central mandibular incisors, they indicated that their double canal frequency was 25.5% and 10.9%, respectively. The variations in the races and the sample sizes can be cause to these differences in the results.

Sert et al[27] conducted a study on extracted permanent mandibular incisors using clearing and staining methods. The result showed sixty eight percent of the second canal in central mandibular incisors and 63% in lateral incisors. Differences in sample size, methodology and ethnicity can be related to the findings of the present analysis.

If only single canal is treated only then due to necrosis and destructive compounds in other canals may result in failure of treatment. Therefore, adequate understanding of root canal anatomy in such dentition would be useful for treating their root canals (number and type of canal).[28]

While most anterior mandible teeth had one root foramen, it could not always be exact. In this analysis, the mandibular incisors detected all canal styles. Type 1 (65.41%), followed by type 3 (17.54%) and type 5 are the most common canal type recorded on Vertucci's classification (12.03%) in Central Incisor while in lateral incisors type 1 was (62.56%) fallowed by type 3 (22.86%) and type 5 (12.08%) in the present study.

The present study was in agreement with the study by Mirhosseini F et al[3] on Iranian population with type I (53.45%) and Type III (40.2%). Geduk et al[25] analyzed mandibular incisor morphology using CBCT radiography and founded that all incisors of mandible had single root & the majority of incisors had type 1 canal (64.4%) second most common was type 3 (19.4%). The most common canal type after type 3 canals was type 2 with fifteen percent, type V around

one percent and type IV with 0.2% The Type V was 13%, Type IV was 0.7% and Type 2 was 0.3% of our sample were respectively commonest following canal type 3.

Zitong Lin et al.,[5] have carried out a research using CBCT for the mandibular incisors and stated that the canal forms are the most common in type 1 (81.8%) and type 3 (12.7%), in keeping with our studies. Type II Vertucci's class was the 3rd most prevalent canal form in their investigation while type V was in our study (12.9%).

It is worth noting that CBCT imaging is not routinely prescribed for any root canal therapy because of the higher cost of taking CBCT image and the higher radiation dose which must be given to patients. The clinician shall put all efforts in identifying the anatomy while performing endodontic therapy on mandibular anterior teeth. Our findings also confirm that the use of CBCT for potential secondary canal determination has its own benefits in the case of failed mandibular incisors treated after procedure complications and reprocessing. The incidence of secondary mandibular incisors for the middle and lateral teeth was comparatively similar in most of these current studies. Their incidence was not significantly different.

No substantial difference between the central and side incisors is presented in our study (p-value >0.05), whereas this incidence was utterly different in Han et al,[29] result which had shown the prevalence of second canal in mandibular lateral incisors then the (27.36%) central incisors (15.71%) (p-value < .05). Regarding the gender, in the present study there was non-significant difference in the canal configuration between genders (p-value > 0.05).

Maximum percentage of canine teeth in our research had type I (81.95%), next in the list was type III (11.03%) and type II configuration (3.51%). The configuration of the Type IV canal has been observed at 1.5% and Type V at 2.01%.

Similar to our research, these results of different researches conducted in different part of world shown to indicate a prevalence of type I was (81.5% of the Mexican population),[30] 80.39% of the Turkish population,[21] 95.4 percent of the Iranians,[31] and 92% among South Asian people.[32]

The single root in mandibular canine was 88.46%-100% and more than one root was 0%-11.54%, while one root canals had shown prevalence of 84.9%-100% and more than one canals was 0%-15.1%.(4)

Between the different researches published on mandibular canines, in 92.2% of the teeth of various studies in mandibular canines, maximum type I incidence the second most frequent channel design was type III in this study and found in 13.6% of the samples. In the Vertucci's report, instead,[6] type II (14%), followed only by type III in 2% of the teeth, was the second most frequently present canal pattern. Aminsobhani et al[24] described one canal percentage was 71.8% while more than one canal was found in 28.2% in mandibular canines in Iranian population.

CONCLUSION

A single diagnostic method might not be sufficient when dealing with anatomic variation of the root canals. Thus, numerous diagnostic aids, such as multiple pre-operative and intra operative radiographs with different horizontal angulations, proper clinical inspection of pulp chamber floor using DG 16 probe, toughing of anatomic grooves by using tips of ultrasonic instrument, exploring the floor with the help of dye staining, carrying out champagne bubble test with sodium hypochlorite, visualizing the pulp chamber anatomy by red and white line test etc should be utilized to locate extra canals. Besides, proper illumination, magnification is also one of the important supplementary aids for location of extra canal orifices.

Recently, Cone Beam Computed Tomography (CBCT) has revolutionized dentistry and it has become one of the most valuable tools for extra canal location in endodontics. Clinically, all these measures are important to look for additional canal in anterior teeth of mandible. The second canal frequency in the lateral mandibular incisors (37.44%) is higher than the central mandibular incisors (34.05%). In most situations, mandibular canines are considered to have 1 root and 1 root canal but this study showed 18.05% of the mandibular canines have two canals with one or two foramina.

The most common type of canal in the central and lateral incisor is Type 1 followed by Type III and Type V in the Vertucci's. In mandibular lateral incisors, the second canal frequency is greater in comparison to central incisors of mandible. The second canal occurrence is smaller than the mandibular incisors in the mandibular canines. The typical form of canal is Type 1. Vertucci's classification in mandibular canines follows Type III and Type II. In Mandibular Central Incisors, Lateral Incisor, and Canines, the frequency of second canals reveals only minor variations between right and left hand sides.

Understanding of anatomy and physiology of the root canal is important for effective and predictable endodontic care. It also needs adequate resources and experience for efficient use of these tools.

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