

Evaluation of Root Canal Morphology of Left Mandibular First Molar by using Cone Beam Computed Tomography

Vinay Mohan
Department of Oral Medicine and Radiology
K D Dental College
Mathura, U.P, India

Sonal Gupta
Dept of Pediatric Dentistry
K D Dental College
Mathura, U.P, India

Rohini Soni
Department of Oral Medicine and Radiology
BJS Dental College
Ludhiana, Punjab

Satendra Sharma
Dept of Periodontics
K D Dental College
Mathura, U.P, India

Abstract:-

Aim: Evaluation of the Root canal configuration of left mandibular first molars using Cone Beam Computed Tomography (CBCT).

Materials And Methods: 95 Patients attending the OPD of Oral Medicine and Radiology Department of K.D. Dental College and hospital, Mathura were recruited in the study. Study subjects comprised of patients having carious lesions in the left permanent mandibular first molar and requiring endodontic treatment. The written consent was obtained from all the subjects. Intraoral periapical X-rays of left mandibular first molars were taken.

Results: In the present study, 95 left mandibular first molars were evaluated by using CBCT and number of canals in the mesial and distal root were evaluated.

- Among 95 left mandibular first molars evaluated, mesial roots had 2 distinct canals in 91.57% cases; 3 canals in 7.36% cases and only 1.05% cases had 1 canal.
- In distal roots, 48.42% had 1 canal; 44.21% had 2 canals and only 7.36% had 3 canals.
- In mesial root, type-4 canal configuration was significantly higher as compared to various types of root canal configurations seen [p-value=0.000].
- In distal root, the most common canal configuration i.e. type-1 was compared with other types and p-value was calculated.

Conclusion: Cone Beam Computed Tomography scans provides an excellent practical tool for immediate, non-destructive, non-invasive imaging option with the potential to detect most anatomic variations, while creating an accurate representation of external and internal dental anatomy.

Keywords:- root canal configuration, molar teeth, CBCT.

I. INTRODUCTION

Variation in the root canal anatomy especially in the multirooted teeth, is the key factor for diagnosis and successful endodontic therapy. Root canal treatment can be done when all the canals are identified, thoroughly cleaned, shaped and obturated.¹ For this, clinician should be aware of proper root canal anatomy from coronal aspect to the apical foramina and the anatomic variations present.

It is generally accepted that mandibular first molars have two roots, mesial and distal; three or four canals; two in mesial and one or two in distal root.² Variation in the root and canal anatomy of mandibular first molar are common. Various techniques like tooth demineralization and canal staining; cavity preparation and IOPA's with files placed in the canals have been used in the past to determine the root canal morphology.⁵

Since the discovery of x-ray, dental radiology has played a vital role in diagnosis of diseases. With the emerging imaging modalities, dental radiology has played important role in determining diagnosis, treatment plan and prognostic value. Various three dimensional (3D) radiographic imaging, (E.g. stereoscopy, tuned aperture computed tomography) and computed tomography (CT) has been available, its application in dentistry has been limited because of cost, access, and dose considerations.⁶

However due to serious limitations of these methods and with the advancement in the field of Radiology, CBCT is a valuable tool and delivers immediate and accurate Three-Dimensional Radiographic images of the number and the location of the root canals, their curvature, size of pulp chamber and the degree of calcification.

The purpose of the study is to evaluate the root canal morphology of left mandibular first molar in Indian population with the help of cone beam computed tomography.

II. MATERIALS AND METHODS

A. Materials

- a) Diagnostic instruments for clinical examination
- Dental chair with good illumination.
 - Diagnostic instruments- Kidney tray, mouth mirror, twizzer, explorer, periodontal probe, sterilized cotton.
 - Mouth masks and sterilized gloves and patient drape.
 - Intra oral periapical X-RAY.
 - CBCT Machine.

B. Methodology

95 Patients attending the OPD of Oral Medicine and Radiology Department of K.D. Dental College and hospital, Mathura were recruited in the study. Study subjects comprised of patients having carious lesions in the left permanent mandibular first molar and requiring endodontic treatment. After the Ethical clearance taken from the Ethical Committee of K.D. Dental College, Mathura and the written consent was obtained from all the subjects. Intraoral periapical X-rays of carious left mandibular first molars were taken to examine the number and morphology of mesial and distal root canals.

- a) Inclusion criteria for selecting the teeth
- Patients who have signed the consent form.
 - Carious left mandibular first permanent molar requiring endodontic treatment.
 - No root canals with open apices, resorption, or calcification
 - Fully erupted teeth
 - No root fillings, posts and crown restorations
 - High quality CBCT images
 - Root canal fillings and posts.
- b) Exclusion criteria
- Patients who have not signed the consent form and are not willing to get CBCT scan.
 - Primary teeth
 - Pregnancy
 - Immature apex (in young permanent tooth)
 - Poor quality of CBCT images

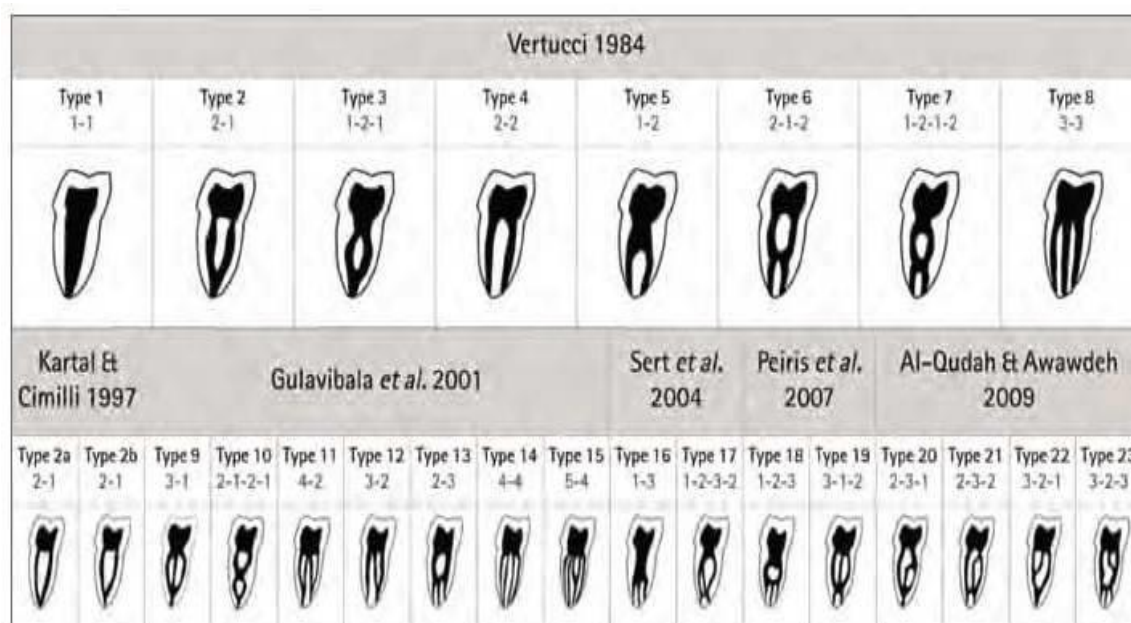
Patients included in the study were sent to 3-D Imaging centre in Agra and CBCT scan at exposure field (fov) 5X5 cm were taken with default exposure parameters 10.00 mA and 88 kVp and scan time of 6.15 seconds with CS 9300 Select CBCT machine with 90µm Voxel size.

Good quality images were viewed by using CS-3D imaging software.

The coronal cross-section of the mesial and the distal root were viewed for the root canal morphology and the canals were classified according to Vertucci's classification and its modifications as reported in the literature.¹

Vertucci classification (1984)¹: Vertucci classified the root canals into 8 types depending on-(A) one canal at apex, (B) two canals at apex, (C) three canals at apex

- Type 1- Single canal extends from the pulp chamber to the apex (1)
- Type 2- Two canals leave the pulp chamber and joins short of the apex to form one canal (2-1)
- Type 3- One canal leaves the pulp chamber and divides into two in the root; the two then merge to exit as one canal (1-2-1)
- Type 4- Two separate distinct canals extend from the pulp chamber to the apex (2)
- Type 5- One canal leaves the pulp chamber and divide short of apex into two separate distinct canals with separate apical foramina (2)
- Type 6- Two separate canals leave the pulp chamber, merge in the body of the root and redivide short of apex to exit as two distinct canals (2)
- Type 7- One canal leaves the pulp chamber, divides and then rejoins in the body of the root; and finally redivides into distinct canals short of the apex (1-2-1-2)
- Type 8- Three separate distinct canals extend from the pulp chamber to the apex (3)



III. RESULTS AND OBSERVATIONS

In the present study, 95 left mandibular first molars were evaluated by using CBCT and number of canals in the mesial and distal root were evaluated (Table 1)

Number of Canals	Mesial Root (%)	Distal Root (%)
1	1 (1.05)	46 (48.42)
2	87 (91.57)	42 (44.21)
3	7 (7.36)	7 (7.36)

Table 1: Number and percentage of Canals per examined root

A. Observations

- Among 95 left mandibular first molars evaluated, mesial roots had 2 distinct canals in 91.57% cases; 3 canals in 7.36% cases and only 1.05% cases had 1 canal.
- In distal roots, 48.42% had 1 canal; 44.21% had 2 canals and only 7.36% had 3 canals.

B. Inference-

- In mandibular first molars the mesial root has high frequency of two distinct canals.
- In mandibular first molar, the distal root has high frequency of a single canal.

The mesial and distal root canals were classified according to Vertucci classification (1984).

Type	Number	%age
1	2	2.11
2	17	17.89
3	0	0.00
4	63	66.32
5	2	2.11
6	1	1.05
Additional	10	10.53

Table 2: Incidence of different types in Mesial Root among subjects

A. Observations-

- The most common canal configuration in mesial root of left mandibular first molar was Vertucci type-4 which occurred in 66.32% cases.
- The second most common canal configuration in mesial root was Vertucci type-2 which occurred in 17.89% cases.
- 10.53% cases had additional canal configurations among which type-13 was found in 6.31% and it was observed that type-10, type-12 and type-21 were also less frequently found in 1.05%, 1.05% and 2.105 respectively.
- The other less common canal configurations present in mesial root were type-2, type-5 and type-6 in 2.11%, 2.11% and 1.05% cases respectively.

B. Inference-

The most common canal configuration in the mesial root of left mandibular first molar is Vertucci Type-4.

p-values were worked out by using Z-Test (i.e. tests of proportions). In mesial root, the most common canal configuration i.e. Type-4 was compared with other types and p-value was calculated (Table-3)

Type	Type	p-value
4 vs	1	0.000
	2	0.000
	3	0.000
	5	0.000
	6	0.000
	Additional	0.000

Table 3 :- Comparison of Type-4 with other types

A. Observations-

- In mesial root, type-4 canal configuration was significantly higher as compared to other types of root canal configurations seen [p-value=0.000].

B. Inference-

- This indicates that the p-value is not statistically significant.

In the mesial root, the second most common canal configuration i.e. type-2 was compared with other types seen and p-value was calculated (Table-4)

Type	Type	p-value
2 vs	1	0.007
	3	0.006
	5	0.007
	6	0.006

Table 4 :- Comparison of Type-2 with other types

A. Observations-

- In mesial root, type-2 was significantly higher than type-1[p-value=0.007], type-3[p-value=0.006], type-5[p-value=0.007] and type-6[p-value=0.006]

B. Inference-

- p-values are statistically significant.

The incidence of different types of canal configurations in distal root is shown in Table-5

Type	Number	%age
1	43	45.26
2	12	12.63
3	13	13.68
4	4	4.21
5	4	4.21
6	9	9.47
Additional	10	10.53

Table 5: Incidence of different types of canal configurations in Distal Root among subjects

A. Observations-

- The most common root canal configuration in distal root of the left mandibular first molar was type-1, which occurred in 45.26% cases.
- This was followed by type-3 and type-2 in 13.68% and 12.635 cases respectively.
- The third most common canal configuration found in distal root was type-6, found in 9.47% cases.
- Type-4 canal configuration was found in 4.2% cases and same incidence was found in type-5 also.
- Additional types of canal configurations were found in 10.53% cases which included type-23, type-9, type-7,

type-10 and type-22 in 3.15%, 2.10%, 1.05%, 1.05%, 1.05% cases respectively.

B. Inference-

- The most common root canal configuration in distal root of mandibular first molar is Type-1.

In distal root, the most common canal configuration i.e. type-1 was compared with other types and p-value was calculated (Table-6)

Type	Type	p-value
1 vs	2	0.005
	3	0.005
	4	0.004
	5	0.004
	6	0.005
	Additional	0.005

Table 6 :- Comparison of Type-1 with other types

A. Observations-

- In distal root, type-1 canal configuration was significantly higher than type-2[p-value=0.005], type-3[p-value=0.005], type-4[p-value=0.004], type-5[p-value=0.004], type-6[p-value=0.005] and the additional types[p-value=0.005]

B. Inference-

- p-values are statistically significant.

The second most common root canal configuration i.e. type-3 in distal root was compared with other types (Table-7)

Type	Type	p-value
3 vs	2	0.769
	4	0.043
	5	0.043
	6	0.182
	Additional	0.247

Table 7 :- Comparison of Type-3 with other types

Observations-

- Type-3 and type-2 were statistically at par[p-value=0.769].
- Type-3 was significantly higher as compared to type-4[p-value=0.043] and type-5[p-value=0.043].
- Type-3 and Type-6 were at par[p-value=0.182].



Fig. 1: Armamentarium for Clinical Examination



Fig. 2: CBCT Imaging of a patient

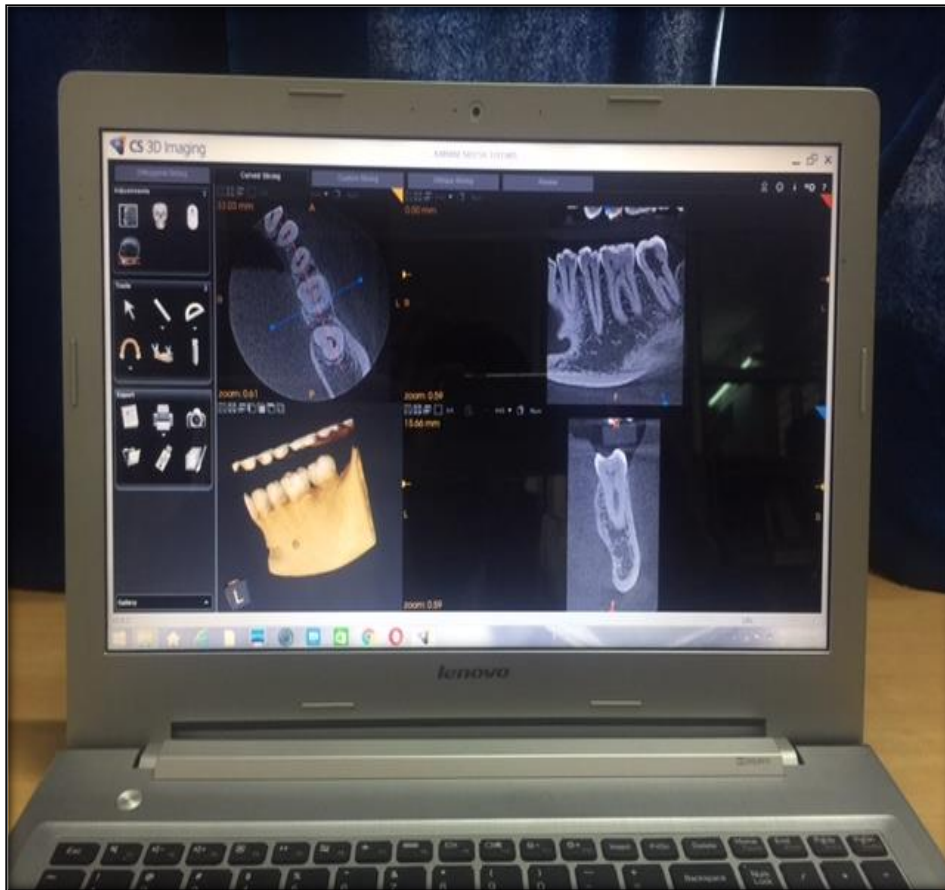


Fig. 3: CBCT images viewed by CS-3D Imaging Software Viewer

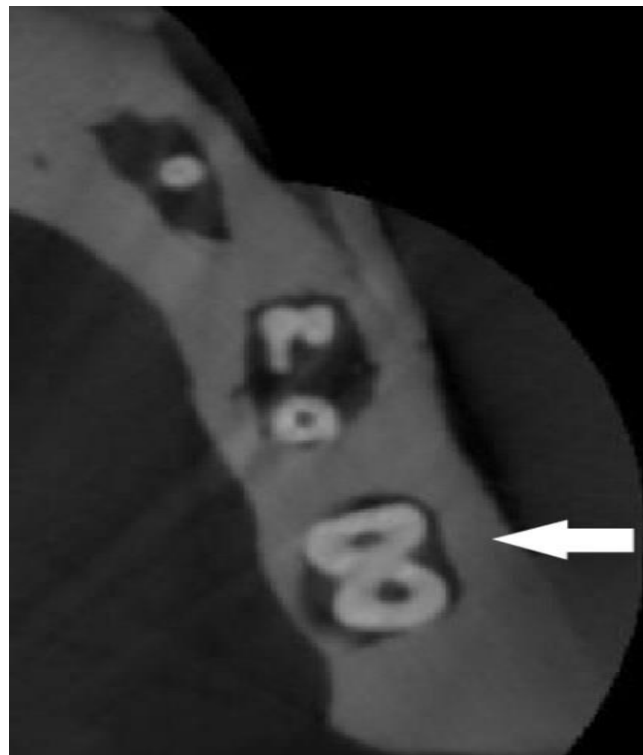


Fig. 4: Mandibular first molar showing 2 canals

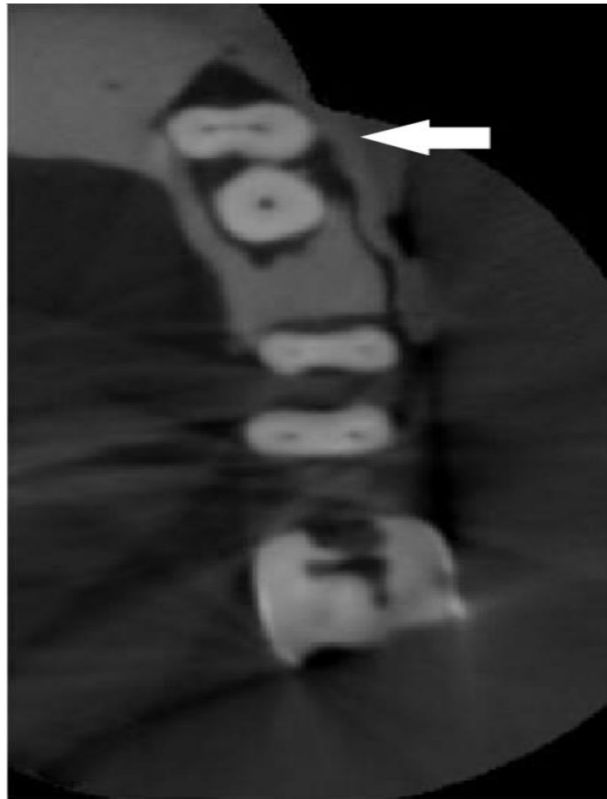


Fig. 5: Mandibular first molar showing 3 canals

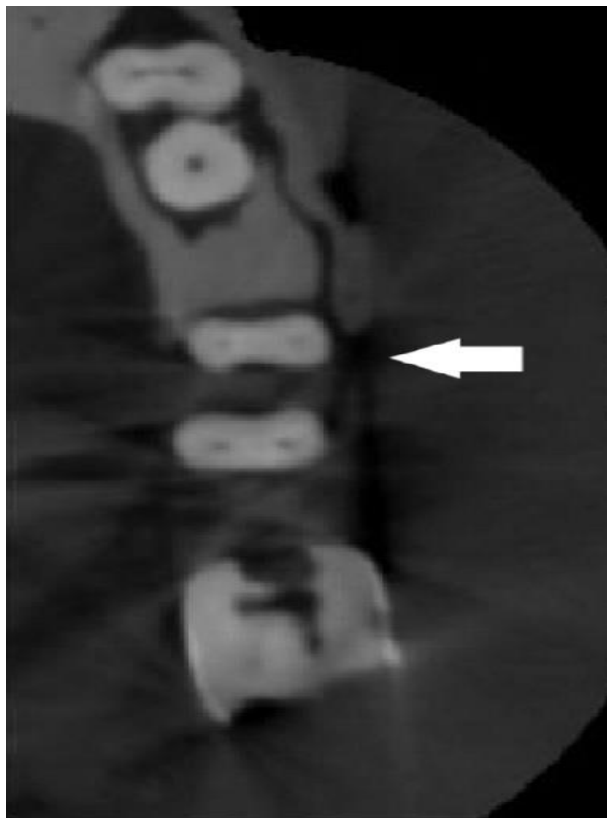


Fig. 6: Mandibular first molar showing 4 canals



Fig. 7: (A)

Fig. 7: (B)

Case 1:

- (A) Mesial canal showing Vertucci class-4 [2-2] canal configuration
- (B) Distal canal showing Vertucci class-10 [2-1-2-1] canal configuration



Fig. 8: (A)

Fig. 8: (B)

Case-2:

- (A) Mesial canal showing Type-2[2-2] canal configuration
- (B) Distal canal showing Type-1[1-1] canal configuration

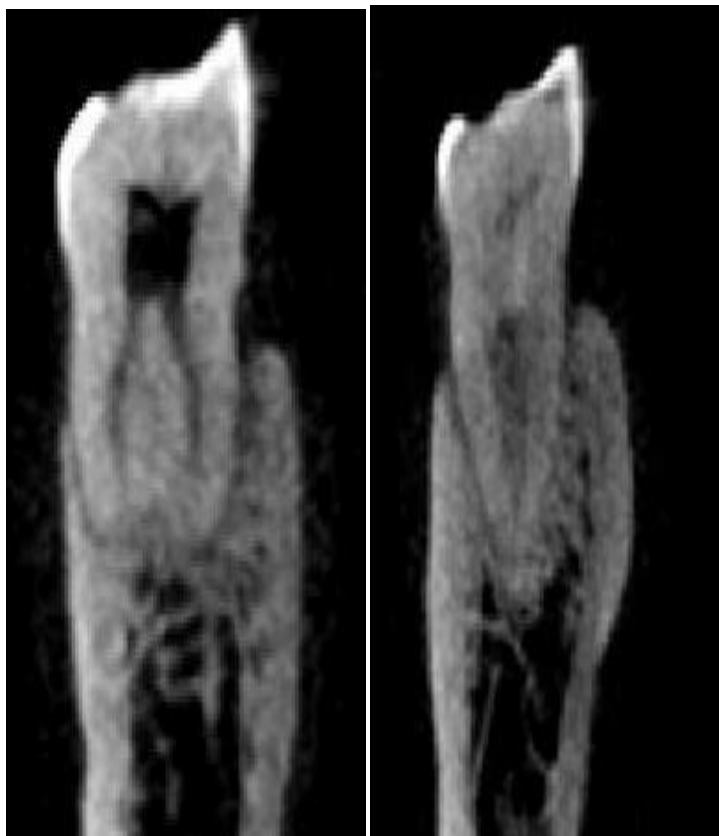


Fig. 9: (A)

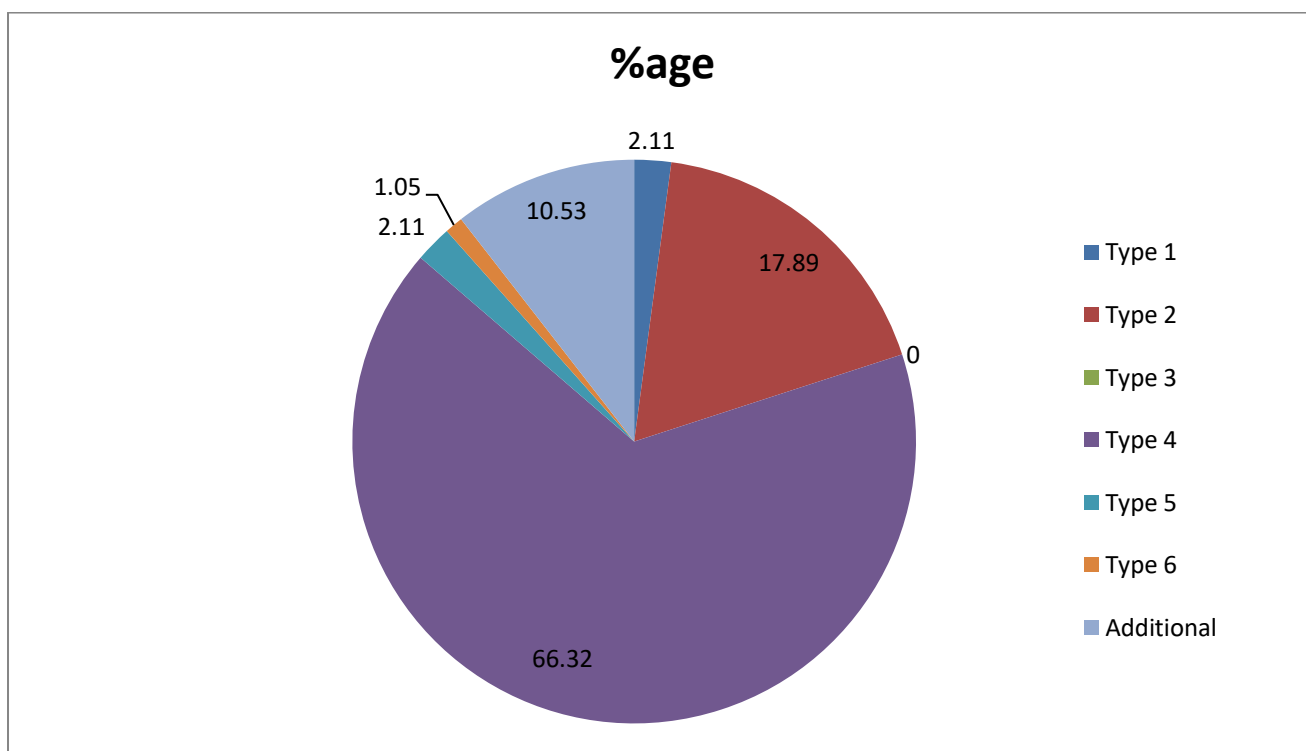
Fig. 9: (B)

Case-3

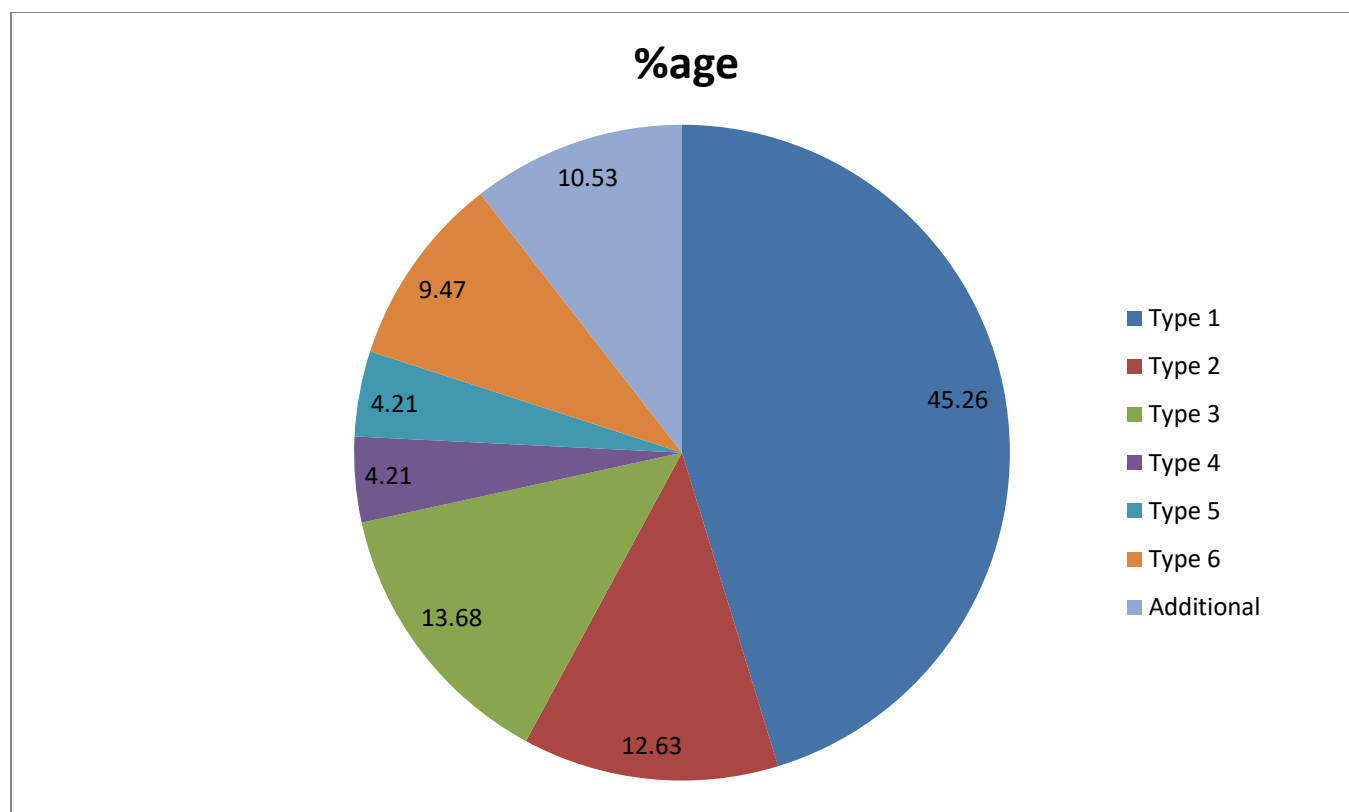
(A) Mesial root showing Type-13 [2-3] canal configuration

(B) Distal root showing Type-1 [1-1] canal configuration

IV. GRAPHS



Graph 1: Canal configuration of mesial root.



Graph 2: Canal configuration of distal root.

V. DISCUSSION

The study of root canal anatomy is important for clinical dental practice and has immense anthropological significance. Different *in vitro* techniques have been described to evaluate root canal morphology, the most popular of which are demineralization and staining of canals of extracted teeth. The root canal system anatomy is very complex and rather difficult to evaluate. The calcified pathways of the root canal should be paved so that the morphology of the root canals can be visualized.

Clinically, however, CBCT provides an excellent practical tool for immediate, non-destructive, non-invasive imaging option with the potential to detect most anatomic variations, while creating an accurate representation of external and internal dental anatomy. The quality of CBCT is significantly high to visualize root canal morphology for clinical endodontic treatment at low radiation and dosimetry.

It has been usually accepted that mandibular first molars have two roots located mesially and distally and three canals (one root canal in distal and two root canals in mesial root); but in populations with Mongoloid traits, the additional root in a mandibular first molar is considered to be a normal morphologic version and may be defined as a Mongolian trait or Asian trait.²⁸

In our study, among 95 left mandibular first molars evaluated with the help of CBCT; mesial root had 2 canals in 91.57% and 3 canals in 7.36%. Incidence of 1 canal in mesial root is very low i.e. only 1.05%. In distal root, 48.42% had 1 canal; 44.21% had 2 canals and incidence of 3 canals in distal

was less i.e. 7.36%. The high prevalence (29%) of the third roots was seen in Chinese subpopulation (Zhang et al).¹⁵ This is higher than 13% reported for Thai population (Gulabivala et al)³⁰. These differences reflect race-based variations.

In the present study, the most common canal configuration in mesial root is Vertucci type-4 in 66.32%, followed by Vertucci type-2 which occurred in 17.89% cases. 10.53% cases had additional canal configurations among which type-13 was found in 6.31% and it was observed that type-10, type-12 and type-21 were also less frequently found in 1.05%, 1.05% and 2.105 respectively. The other less common canal configurations present in mesial root were type-2, type-5 and type-6 in 2.11%, 2.11% and 1.05% cases respectively.

Raed Hakam Mukhaimer reported the 53.8% prevalence of type-4 canal configuration in mesial root followed by type-2 in 38.8%.² In Korean population, Kim et al reported a higher incidence (76.9%) of mesial root with type-4.² These higher incidences were also reported by Zhang et al in Chinese population: 81% of mesial roots with type-4.¹⁵ These slight variations in the canal morphology are due to difference in the ethnicity of the population.

In the present study, the most common root canal configuration in distal root of the left mandibular first molar was type-1, which occurred in 45.26% cases. This was followed by type-3 and type-2 in 13.68% and 12.63% cases respectively. The third most common canal configuration found in distal root was type-6, found in 9.47% cases. Type-4 canal configuration was found in 4.2% cases and same incidence was found in type-5 also. Additional types of canal

configurations were found in 10.53% cases which included type-23, type-9, type-7, type-10 and type-22 in 3.15%, 2.10%, 1.05%, 1.05%, 1.05% cases respectively. Raed Hakam Mukhaimer² reported the incidence of type-1(57.5%), followed by type-2(22.5%), type-3(10.6%) and type-4(8.1%). Higher incidence (66.6%) and 84% of type-1 canal configuration was also reported in Korean population² and Chinese populations¹⁵ respectively. These slight differences may be related to study design (*in vivo* versus *in vitro*), study techniques, sample size and sample population.

The present study indicates Cone Beam Computed Tomography is helpful for the investigation of root canal morphology. When root canal assessment is possible from traditional periapical images or clinical procedures, the use of CBCT may not be necessary. But since the variations in root canal morphology are very common and when there are abnormal findings on traditional periapical films or variations detected clinically, it may be impossible to evaluate the root canal system effectively. In such situations, it is necessary to adopt CBCT for further diagnosis, whilst at the same time ensuring that the patients' exposure to radiation is kept as low as reasonably.

VI. CONCLUSION

- Within the limitations of the study, it can be concluded that the most common canal configuration in mesial root of left mandibular first molars in Indian population was Vertucci type-4 which occurred in 66.32% cases.
- The second most common canal configuration in mesial root was Vertucci type-2 which occurred in 17.89% cases.
- 10.53% cases had additional canal configurations among which type-13 was found in 6.31% and it was observed that type-10, type-12 and type-21 were also less frequently found in 1.05%, 1.05% and 2.105 respectively.
- The other less common canal configurations present in mesial root were type-2, type-5 and type-6 in 2.11%, 2.11% and 1.05% cases respectively.
- The most common root canal configuration in distal root of the left mandibular first molar was type-1, which occurred in 45.26% cases.
- This was followed by type-3 and type-2 in 13.68% and 12.635 cases respectively.
- The third most common canal configuration found in distal root was type-6, found in 9.47% cases.
- Type-4 canal configuration was found in 4.2% cases and same incidence was found in type-5 also.
- Additional types of canal configurations were found in 10.53% cases which included type-23, type-9, type-7, type-10 and type-22 in 3.15%, 2.10%, 1.05%, 1.05%, 1.05% cases respectively.

Root canal information that is obtained with the help of CBCT is very useful and helps in satisfactory endodontic treatment outcomes.

A. Future Recommendation

- Large sample size.
- Different ethnicity and different population should be included.
- Different geographic areas should be included.

B. Clinical implications

Preoperative assessment of the root canal morphology of the left mandibular first molar with the help of CBCT will help in excellent root canal treatment outcomes as the clinicians will be able to diagnose the abnormal findings and variations in the canal morphology.

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