Original Research Paper

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# Assessment of root morphology of human mature permanent mandibular canines using cone beam computed tomography: an institutional retrospective study

**Abstract:**

**Introduction:** Root morphology of mandibular canine vary widely in different population.

**Aim:-** The objective of present retrospective study is to observe the root morphology of permanent mature mandibular canine in Eastern Indian subpopulation.

**Materials and Methods:-** In this study 212 permanent mandibular canines of both male and female patients (14-50 years age group) collected from a tertiary health care centre were processed through iRYS NNT viewer software and evaluated for the variation in the root morphology.

**Results:-** Statistical analysis revealed that 85.4% of mandibular canines have single root with single canal. Among other canal configuration Type 3 was most commonly found while Type 2 was least common. significantly larger root dimensions observed in males than females. Labial surfaces showed highest dentin thickness while mesial and distal surfaces exhibited the least. The most common shape of canal cross section was reported oval at CEJ, flat shape at middle 3rd, oval at apical 3rd. Majority of root apex exhibited no curvature with laterally positioned apical foramen. Accessory canals were reported in 32.5% cases mostly at the apical third.

**Conclusion:-** Due to wide variation in root morphology of mandibular canines in different population, dentist should aware of it for successful endodontic management.

**Key-words:-** Permanent mandibular canine, root morphology, Cone beam computed tomography

## Introduction:

Permanent mandibular anterior teeth have variations in their root morphology. Like incisors mandibular canines exhibit high degree of variability among populations as reported in literature. As canines are considered as "**Cornerstone of dental arches"** for their significant esthetic and functional value,[1] preservation of any carious or traumatized permanent mandibular canine is essential to maintain our normal facial expression and proper intercuspal position of entire dentition.[2] The way of preservation is endodontic treatment and proper restoration. Long term prognosis rely on the perfection of the root canal treatment. Proper biomechanical preparation, irrigation & sealing of root canal system are the keys of successful root canal treatment for which dentist must have thorough knowledge of internal root anatomy.[3,4] Nowadays cone beam computed tomography is an effective tool for 3-D evaluation of root morphology.[5] To the best of our knowledge, literature reported very few studies on root morphology of mandibular permanent mature canines in Eastern Indian subpopulation. Present study is an institutional retrospective study aim of which to estimate the

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variation of the external and internal root anatomy of mandibular mature permanent caninesamong Eastern Indian subpopulation.

## Materials and methods:

For present study we collected CBCT scans of **212**permanent mandibular canines of male and female patients (age range 14-50 years) from our tertiary health care centreand processed through **iRYS NNT viewer** software.

The sample size for this study was determined by the=Z<2P(1-P)/d<2. (n=samplize, Z level of confidence, p=expected prevalence that can be obtained from a pilot study or same studies conducted by the researchersand d=desired level of precision).The average prevalence of Vertucci Type I configuration was found to be 79% from a previous study (Kurumboor et al.,2018) and was presumed for the calculation of sample size. Desired level of precision (d) is 10% of the assumed prevalence i.e, 7.9. Thus, substituting values in the equation, the generated output indicated that a minimum 212 sample size need to be screened at a 95% confidence level.

Only those CBCT scans presenting distinct visual representations of bilateral permanent mandibular mature canines were considered for this study while any distorted CBCT image or any previously treated or diseased canine (carious, presence of periapical lesion or apical resorption) was excluded. This study analysis was based on the data related to the following morphological features of mandibular canines which was tabulated in a spreadsheet using Microsoft Excel 2021.

1. configuration of root canal ( VERTUCCI classification)
2. Root length (in coronal section from CEJ to radiographic apex)
3. root diameter (Both labiolingual and mesio-distal diameters measured at the level of CEJ, middle 3$^{rd}$ (5 mm beyond CEJ) and apical 3$^{rd}$ (10mm apical to CEJ))
4. Dentinal thickness of all 4 surfaces (labial, lingual,mesial,distal) measured at CEJ level, middle 3$^{rd}$ (5 mm beyond CEJ) and apical 3$^{rd}$ (10mm apical to CEJ)
5. Shape of canal cross section at the level of CEJ, 5 mm beyond the CEJ and 10mm apical to CEJ
6. Number of accessory canal if any
7. Right vs left side comparison
8. Direction of root apex curvature
9. Apical foramina location classified as central (at the tip of root apex) or lateral (off centered)

Institutional Ethics committee clearance (**Reg.no.-EC/NEW/INST/2023/3191**) was obtained before conducting this study.

## Statistical analysis:

BM SPSS Statistics for Windows, Version 27.0 ((Armonk, NY: IBM Corp)) was used for this purpose. The categorical variables were analysed by chi-square test and intra-group analysis was carried out using Paired t-test Repeated measures analysis of variance (ANOVA) with post-hoc Bonferroni's test for pairwise comparisons—inter-group comparisons with the Unpaired t-test.

## Result:

### 1. Root Length, Root Diameter, and Dentin Thickness at various locations:

### I. Right vs left side

- the mean root length was slightly higher on left side (15.9 ± 1.69 mm) than the right (15.6 ± 1.72 mm), with a statistically significant difference (*P = 0.003*).
- Root Diameter at CEJ and Middle 3rd showed similar mean values between the sides (6.26 ± 0.522 mm vs. 6.24 ± 0.551 mm, *P = 0.62*; 5.43 ± 0.623 mm vs. 5.44 ± 0.644 mm, *P = 0.85*). Root Diameter at the Apical 3rd also showed no significant difference (*P = 0.59*).
- For Dentin Thickness, a significant difference was observed for CEJ Lingual Side (2.69 ± 0.391 mm vs. 2.54 ± 0.459 mm, *P = 0.0004*) and Middle 3rd Lingual Side (2.36 ± 0.558 mm vs. 2.25 ± 0.539 mm, *P = 0.01*). Other CEJ and Middle 3rd regions showed no statistically significant differences, with *P > 0.05*. At the Apical 3rd, all regions (Mesial, Distal, Labial, and Lingual) showed no statistically significant differences between the left and right sides (*P > 0.05*). These findings indicate regional differences in dentin thickness, with significant variations mainly observed at the CEJ Lingual and Middle 3rd Lingual sides.

### II. Comparisons between Gender:

- significantly larger root dimensions observed in males than females
- Root length was greater in males (16.1 ± 1.75 mm) than females (15.5 ± 1.63 mm, *P = 0.01*). Similarly,

root diameter at the CEJ (6.39 ± 0.51 mm vs. 6.14 ± 0.531 mm, *P = 0.0008*) and at the middle 3rd (5.58 ± 0.656 mm vs. 5.32 ± 0.592 mm, *P = 0.0035*) were significantly larger in males. However, no significant differences were observed for the root diameter at apical 3rd (3.9 ± 0.899 mm vs. 3.75 ± 0.74 mm, *P = 0.2*).

- For dentin thickness at the CEJ, middle 3rd, and apical 3rd across mesial, distal, labial, and lingual sides, the differences between genders were not statistically significant (*P > 0.05* for all) which indicates that while root dimensions are consistently larger in males,the dentin thickness remains similar between genders for mandibular canines.

## III. Dentin thickness between the sides:

- significant differences (*P*< 0.05) between sides at the CEJ, middle third, and apical third levels were observed across the left, right, and total datasets.
- At the CEJ, the lingual side was significantly (*P*< 0.05) thicker than the mesial and distal sides on the left, while the labial side was significantly thicker than mesial side (*P*< 0.05). On the right, the mesial side was significantly thinner than the labial, lingual, and distal sides (*P*< 0.05). In total dataset, the mesial side remained the thinnest, with the labial side significantly thicker than mesial and distal sides (*P*< 0.05).
- For the middle third, the labial side was consistently the thickest across all datasets. On the left, the labial side was significantly thicker than mesial and distal sides (*P*< 0.05). Similarly, on the right, the labial side was significantly thicker than the lingual, mesial, and distal sides (*P*< 0.05). In total dataset, the labial side was significantly thicker than the lingual side (*P*< 0.05), while the mesial and distal sides were the thinnest.
- At the apical third, the labial side on the left was significantly thicker than the lingual, mesial, and distal sides (*P*< 0.05). On the right, the labial side remained the thickest, followed by the lingual side, while the mesial and distal sides were the thinnest (*P*< 0.05). In total dataset, labial side was significantly thicker than lingual side (*P*< 0.05), with the mesial and distal sides consistently thinner.
- These findings highlight that the labial side exhibited greater dentin thickness compared to other sites, while the mesial and distal sides were generally thinner across all level.

## 1. Canal configuration according to Vertucci's type:

Table-1

| Vertucci's | Left (n=106) | Right (n=106) | Total (N=212) |
|---|---|---|---|
| I | 91 (85.8%) | 90 (84.9%) | 181 (85.4%) |
| II | 1 (0.9%) | 1 (0.9%) | 2 (0.9%) |
| III | 12 (11.3%) | 14 (13.2%) | 26 (12.3%) |
| V with 2 roots | 2 (1.9%) | 1 (0.9%) | 3 (1.4%) |

*n*:sample size per group,N:Total sample size

So, Vertucci Type 1 was found most commonly while Type II was least common according to the study findings. Bilateral symmetry found in 94.3% cases.

## 1. Cross-sectional shape of canals at various levels :

- At the CEJ, the majority of canals were oval in shape, observed in 55 (51.9%) left and 54 (50.9%) right canines, comprising 109 (51.4%) in total while flat shapes were less common.
- In the middle third, the flat shape was the most frequent, appearing in 50 (47.2%) left and 51 (48.1%) right canines, making up 101 (47.6%).
- At the apical third, the oval shape predominated, identified in 61 (57.5%) left and 62 (58.5%) right canines, totaling 123 (58.0%).

## 2. Distribution of subjects according to the presence of accessory canals (Table 2)

Table 2

| Accessory Canal | Left (n=106) | Right (n=106) | Total (N=212) |
|---|---|---|---|
| Absent | 70 (66%) | 73 (68.9%) | 143 (67.5%) |
| Present | 36 (34%) | 33 (31.1%) | 69 (32.5%) |

*n*:sample size per group,N:Total sample size

Accessory canals were identified exclusively in the apical region of permanent mature mandibular canines.

## 1. Apical curvature & position of apical foramen:

Mandibular canines exhibited no curvature noted in 60.4% of the left and 62.3% of the right sides, totaling 61.3%. Distal curvature was the most common and significantly higher

among the curvatures, found in 28.3% on the left and 25.5% on the right, contributing to 26.9% overall($P$<0.01). Other curvatures, including mesial (3.8%), labial (3.3%), mesio-labial (1.9%), lingual (0.9%), and disto-labial (1.9%), were much less frequent.

The apical foramen was most commonly laterally positioned (55.7%) while Central positioning was noted in 44.3% cases.

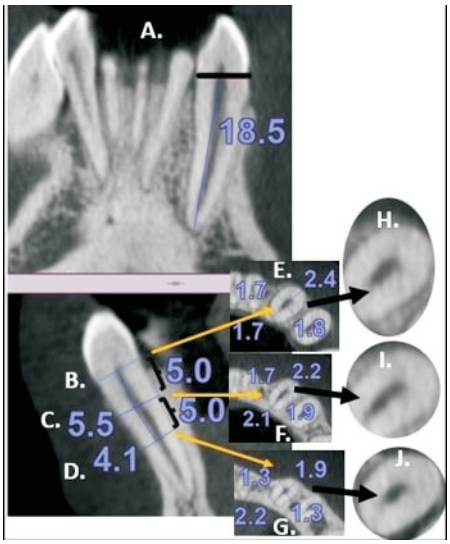
## Discussion:

There are various methods to identify root morphology like sectioning,[6] canal staining and tooth clearing technique,[7] radiography techniques[8,9]. 2-D images may be misleading which affects the success of endodontic treatment. Advanced technology like cone shaped beam of radiation,low radiation dose compared to conventional CT, less scan time with more accurate 3D-images makes CBCT more popular for this purpose.[5] All these advantages encouraged us to conduct this CBCT based study.

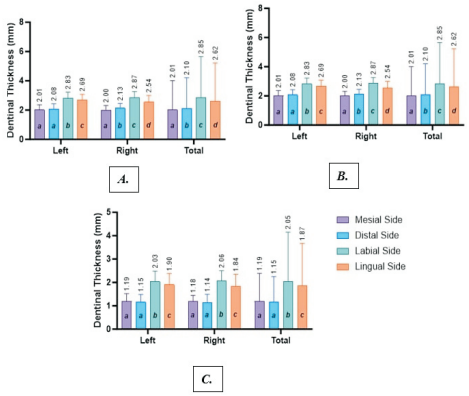
Our study found the prevalence of one root with single canal(Type 1) (85.4%)in case of mandibular canines as reported by literature also.[10,11,12,13,14]Among other canal configuration, Type III reported most commonly(12.3%) similar to Amardeep et al study (13.6),[10]another Indian subcontinent study,[11]Saudi populationstudy(4.7%),[12]Syrian population study(3.18%),[15] Turkish population study (6.8%)[15] but inconsistent with a north Indian population study[14] and Middle Eastern European region study[11] which found Type 2 as second most common after Type 1. Prevalence of 2 roots was observed in 1.4% cases which is consistent with previous subpopulation studies ((0.3% to 6.2%) ) and mostly unilateral with bifurcation at mid root region.[16,17] Maximum canines showed no root curvature in our study similar to an Iranian population study.[18]Rest of the canines exhibited mostly distal curvature in present study while buccal curvature was most common according to Iranian population study.[18] Iranian population study[18] also supported our finding for position of apical foramen which is mostly positioned laterally(55.7%).[19] But a Turkish subpopulation reported centrally positioned apical foramen in most of the mandibular canines(66.8%). According to our study, presence of accessory canals was higher (32%) compared to Amardeep et al and Green studies [10,20] but a Micro CT assessment showed 69% presence of accessory canals.[21]Considering all these variations thorough knowledge of root anatomy is very important because missed canal increase the risk of reinfection and failure of endodontic treatment.

Root diameter along with the dentin thickness are another important factors to determine the extent of biomechanical preparation and post space preparation because preservation of 1mm remaining dentin thickness is needed to reduce the risk of root fracture after endodontic management.[21] According to our study mesial and distal sides have least dentin thickness. Similar findings was reported by Amardeep et. al study.[10] So before planning the root canal treatment preoperative evaluation of dentin thickness specially at mesial and distal side should be considered as an important step.

## Legends for the figures:

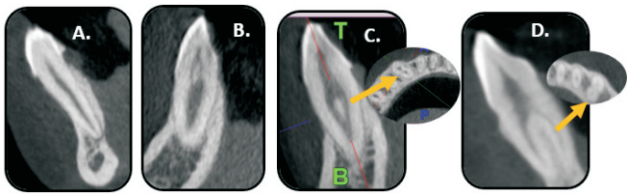



1.Assessment of root morphology of permanent mandibular canine in the scanned CBCT -A) Root length (B),(C),(D) Root diameter at CEJ, middle 3rd, apical 3rd(E),(F),(G)Dentine thickness of 4 surfaces at CEJ, middle 3rd , apical 3rd (H),(I),(J) Shape of root canal cross section-Long oval, Flattened respectively




2. Bar Graph showing difference between the dentin thickness between the sides A. CEJ level B. Middle 3rd C.

Apical 3rd [Note: Different subscript letter indicate statistically significant differences between the sides]




3. Variation in canal configuration of mandibular canine according to Vertucci classification-

a) Type I b) Type II c) Type III d) Type V with 2 roots

## Conclusion:

This retrospective study focused on the variation of external and internal root morphology of mandibular canines among Eastern Indian subpopulation. Variation of root anatomy reported in different studies is attributed to the difference in sample size, gender and ethnic background. So dentists should be careful about these variations of root morphology of mature permanent mandibular canines for successful endodontic management which increases the longevity of these teeth.

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