DOI: 10.7860/JCDR/2021/48413.15106

Original Article

Dentistry Section

# A Retrospective Study of Roots and Root Canal Morphology in Mandibular Premolars using Cone Beam Computed Tomography in Delhi-NCR

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## ABSTRACT

**Introduction:** The anatomical heterogeneity of mandibular premolars has always been considered an enigma and it makes them potentially prone to high rates of endodontic failure. Only few studies have discussed the potential role of Cone Beam Computed Tomography (CBCT) in the assessment of root morphology, canal configuration and their complex variations.

**Aim:** To investigate the number of roots and root canals along with the canal configuration in mandibular premolars in the Delhi-National Capital Region (NCR) population using CBCT imaging.

**Materials and Methods:** The retrospective observational study was conducted where 432 CBCT images of 108 patients were acquired from different CBCT centres in Delhi-NCR region to determine the anatomy and morphology of mandibular premolars. The number of roots, root canals and their configuration and its association with symmetry and gender was evaluated. Pearson Chi-square test and Fisher's-exact test were used for statistical analysis.

**Results:** The mandibular first and second premolars reported with single root in 94.9% and 98.1% cases, respectively. Majority of 1st premolars displayed 2 canals (59.7%) whereas 2nd premolars exhibited single canal (58.3%) more frequently. Type I configuration was most prevalent in both 1st premolar (39.8%) and 2nd premolars (60.2%). Type V configuration was significantly reported on the left in both mandibular 1st and 2nd premolars (13.9% and 4.6%), respectively. There was no significant gender predilection observed for the morphology of roots, root canal and canal configuration.

**Conclusion:** In Delhi-NCR, there was a high prevalence of multiple canals and variable configurations in 1st premolars whereas single root canal and Type I canal configuration were more frequent in 2nd premolars with a significant bilateral distribution. However, in both mandibular premolars there was a slight inclination reported for multiple canals and variable configurations towards left with no gender predilection.


**Keywords:** Anatomic variations, Bilateral symmetry, National capital region, Number of canals, Number of roots, Root canal configuration, Vertucci's classification

## INTRODUCTION

Success of endodontic therapy depends on a thorough understanding of root canal morphology and internal canal complexities. Lack of knowledge on canal space anatomy is considered as the second most important reason that leads to failure of endodontic therapy [1]. The anatomical heterogeneity of mandibular premolars is one of the most enigmatic that also makes them potentially prone to high rates of endodontic failure [2,3]. Numerous factors like ethnicity, age, gender and position have contributed to the variation in morphology and configuration of mandibular premolars [4,5]. In endodontic literature, numerous studies have reported presence of multiple roots and variable canal morphology in mandibular premolars [6-8].

Various methods like canal staining, tooth clearing, root sectioning, microscopic examination, examination of conventional radiographs, etc. have been used in many studies to identify canal configuration [9-13]. There has been a recent shift towards the use of CBCT and micro-CT techniques for the purpose of identification of anatomical complexities over these methods which are more precise and relatively non invasive. Conventional radiographs provide 2-D information and are unable to tell the root canal complexities. The techniques to study 3-Dimensional (3D) morphology of the pulpal anatomy are in vitro methods like sectioning and clearing. However, the morphology of the exterior of tooth is destroyed in these methods. In contrast, CBCT provides non invasive 3D information of root canal morphology that helps in best management of such clinical challenge [14,15].

To the best of our knowledge, there was no previous study fron Delhi-NCR using CBCT to assess the root canal morphology and configuration of mandibular premolars and its association with symmetry and gender. Thus, this study aimed to retrospectively evaluate the root canal morphology and canal configuration of mandibular premolars using CBCT and determine its association with symmetry and gender in the Indian sub-population (Delhi-NCR region).

## MATERIALS AND METHODS

The retrospective observational study was conducted after obtaining clearance from ethical committee of the local Institutional Review Board under the protocol number ITSCDSR/IIEC/RP/2018/019. The CBCT data was collected from five CBCT centres selected across the region of Delhi-NCR where the study was conducted in the Department of Conservative Dentistry and Endodontics in conjunction with the Department of Oral Medicine and Radiology at ITS Centre for Dental Studies and Research, Muradnagar, Uttar Pradesh, India.

**Inclusion criteria:**

- Scan showing entire mandible including root apices of the premolars.
- Balanced distribution of right versus left premolars.
- Intact roots without fractures or cracks.
- Premolars without posts or previous root canal treatment.

**Exclusion criteria:**

- Apicoectomy or periapical surgery.
- Odontogenic or non odontogenic pathology.
- Developmental anomalies.
- External or internal root resorption.
- Calcifications.

- Previous endodontic treatment.
- Extensive coronal restorations or posts.
- Root caries reaching trifurcation.
- Poor quality images or artifacts.

Out of total 130 CBCT scans, 108 scans were selected and 22 scans were excluded as the images did not satisfy the inclusion criteria.

**Sample size calculation:** The sample size was estimated on the basis of a pilot study which was conducted in same department where 20 CBCT images (4 CBCT images were selected from each centre by simple random sampling) of the patients were evaluated which revealed that the prevalence for single root in majority of mandibular premolars was found to be 92.4% in this region. Thus, for expected prevalence of 92.4%, using the following formula for evaluation of sample size, authors found it to be 108 patients [16].

$$N=\frac{z^2\times p\ (1-p)}{d^2}$$

Where, N=Sample size

z=z statistic for level of confidence=1.96

p=Expected prevalence or proportion=92.4%=0.924 (From the pilot study)

d=Precision=5%=0.05

On the basis of availability, a total of 130 patients in the age group between 15-60 years, referred to CBCT imaging centres for complete mandibular CBCT scans between January 2016 to May 2019 (inclusive of the 20 CBCT scans taken for the pilot study) for their dental diagnosis and comprehensive treatment planning were taken up for the study and their records were evaluated in two weeks duration in June 2019. The patients were informed and consent was obtained. The CBCT machine used for data acquisition was NewTom Giano (NewTom, Verona, Italy). All the CBCT scans included were acquired at a resolution in the range of 150-200 microns, 8×5 cm FOV, 90 KVp, 10 mA and 3.6 seconds exposure time in reference to previous study [17].

Patients fulfilling the following eligibility criteria were selected for the study. The final sample was then analysed in the Multi-Planar (MPR) mode of the interactive CBCT software, NNT viewer (version 7.0) in axial, coronal and sagittal planes to assess the root canal morphology of mandibular first and second premolars. The tooth of interest and plane were triangulated in the axial, coronal and sagittal planes. The axial plane was evaluated from coronal aspect of the tooth to the root apex to evaluate the following parameters-

**a) The number of roots**

1. A single-rooted
2. A multiple-rooted

**b) The number of canals**

1. Single canal
2. Two/multiple canal

**c) Canal configuration**

The canal configuration was analysed according to criteria of Vertucci (1984) [18] into eight categories:

**Type I (1)** Single canal extending from pulp chamber to the apex.

**Type II (2-1)** Two separate canals extending from the pulp chamber to merge short of the apex to form one canal.

**Type III (1-2-1)** One canal extending from the pulp chamber, divides into two within the root, and then merge to exit as one canal.

**Type IV (2)** Two separate canals extending from the pulp chamber to the apex.

**Type V (1-2)** Single canal extending from the pulp chamber that divides short of the apex into two separate canals with separate apical foramina.

**Type VI (2-1-2)** Two separate canals extending from the pulp chamber that merge within the body of the root, and re-divide short of the apex to exit as two separate canals.

**Type VII (1-2-1-2)** Single canal extending from the pulp chamber that divides and then merge within the body of the root, and finally re- divides into two separate canals short of the apex.

**Type VIII (3)** Three separate canals extending from the pulp chamber to the apex.

Author analysed the predilection of above parameters with respect to gender and symmetry.

## STATISTICAL ANALYSIS

All the images were evaluated by an endodontist well versed in working with CBCT and confirmed by a certified maxillofacial radiologist experienced in CBCT imaging using manufacturer's software (NNT viewer, Newtom). Data was analysed with the Chi-square test and Fisher's-exact test using Statistical Package for the Social Sciences (SPSS) software version 16.0, and the significance was set at a 95% confidence level p-value.

## RESULTS

A total of 432 CBCT images (mandibular 1st and 2nd premolar; n=216 each) from final 108 patients (63 males and 45 females) with mean age group of 29.14±10.05 years were eligible for the study.

**1. Number of roots and its association with gender and symmetry**

Majority of the first premolars reported the presence of one root (205, 94.9%) followed by two roots (11, 5.1%) with no significant gender predilection (p-value=1) [Table/Fig-1]. In mandibular 2nd premolars, the prevalence was more for single root was (212, 98.1%) and rare (4, 1.9%) for 2-rooted cases with no significant gender preference ((p-value=0.113)) [Table/Fig-2]. High level of bilateral symmetry was observed in both the 1st and 2nd premolars in association with the number of roots [Table/Fig-3a,b] and no specific gender or side predilection was observed [Table/Fig-1,2]. Prevalence for 3 roots was not found in either of the premolars [Table/Fig-1,2].

**2. Number of canals and its association with gender and symmetry**

Majority of 1st premolars displayed two canals (129, 59.7%) [Table/Fig-1,3a,b] followed by single canal (86, 39.8%) with a propensity for left side with no significant gender predilection (p-value=0.171)) [Table/Fig-1]. There was a single case of 3 canals (1, 0.5%) reported in 1st premolar in males [Table/Fig-1]. Single canal was most frequent (126, 58.3%) in second premolars [Table/Fig-2]. followed by two canals (90, 41.7%) with no significant gender predilection (p-value=0.220) [Table/Fig-2,3a,b].

**3. Canal configuration and its association with gender and symmetry**

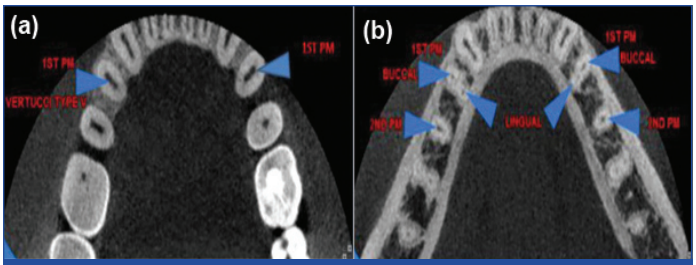
Majority of the first premolars reported with Type I configuration (86, 39.8%) followed by Type II (58, 26.9%) with a significant bilaterally symmetrical distribution but no significant gender preference (p-value=0.063) [Table/Fig-1]. In 1st premolars, Type III canal configuration was seen to be significantly more prevalent on right (12.1%) (p-value <0.005), with no significant gender predilection (p-value=0.063) [Table/Fig-1,4a-d]. In 1st premolars, type V canal configuration was seen to be more prevalent (13.9%) on left (p-value <0.005) with no significant gender predilection (p-value=0.063) [Table/Fig-1,5a-d]. Majority of the second premolars reported with higher percentage of Type I configuration (130, 60.2%) than that of 1st premolars, followed by Type II configuration (67, 31.0%) with a significant bilateral distribution but no significant gender predilection (p-value=0.330) [Table/Fig-2]. In 2nd premolars, Type V canal configuration was reported only on left side (4.6%) with no significant gender preference (p-value=0.330) [Table/Fig-2].

| Tooth Number/ Sex | Number of teeth | Number of roots (%) | | | | No. of canals% | | | | Canal configuration (Vertucci) (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | p-value | 1 | 2 | 3 | p-value | I | II | III | IV | V | VI | VII | VIII | Misc. | p-value |
| 34 Male | 63 | 93.6 | 6.3 | 0 | 0.692 | 38.1 | 61.9 | 0 | 0.547 | 38.0 | 31.7 | 4.7 | 7.9 | 9.5 | 6.3 | 0 | 0 | 0 | 0.614 |
| 34 Female | 45 | 95.5 | 4.4 | 0 | | 44.8 | 55.5 | 0 | | 28.8 | 17.7 | 15.5 | 4.4 | 13.3 | 4.4 | 0 | 2.2 | 0 | |
| 44 Male | 63 | 93.6 | 6.3 | 0 | 1 | 46.1 | 53.9 | 1.5 | 0.302 | 42.8 | 30.1 | 3.1 | 6.3 | 7.9 | 0 | 0 | 0.5 | 0 | 0.053 |
| 44 Female | 45 | 97.7 | 2.2 | 0 | | 42.3 | 57.7 | 0 | | 35.5 | 20 | 24.4 | 2.2 | 2.2 | 4.4 | 0 | 0 | 2.2 | |
| Total Male | 126 | 95.2 | 4.8 | 0 | 1 Fisher's exact test | 41.4 | 57.9 | 0.7 | 0.171 Pearson's Chi-square test | 40.4 | 30.9 | 3.9 | 7.1 | 8.7 | 3.1 | 0 | 0.7 | 0 | 0.063 Pearson's Chi-square test |
| Total Female | 90 | 95.6 | 4.4 | 0 | | 43.4 | 56.6 | 0 | | 32.2 | 18.8 | 21.1 | 3.3 | 7.7 | 2.2 | 0 | 0 | 0 | |
| 34 Total | 108 | 94.4 | 5.6 | 0 | <0.005 Fisher's exact test | 38.0 | 62.0 | 0 | <0.005 Pearson's Chi-square test | 38.0 | 26.9 | 9.3 | 6.5 | 13.9 | 4.6 | 0 | 0.9 | 0 | <0.005 Pearson's Chi-square test |
| 44 Total | 108 | 95.4 | 4.6 | 0 | | 41.7 | 57.4 | 0.5 | | 42.1 | 27.1 | 12.1 | 4.7 | 10.3 | 3.7 | 0 | 0.5 | 0.9 | |
| Total Mandibular 1st premolar n (%) | 216 (100) | 205 (94.9) | 11 (5.1) | 0 (0) | - | 86 (39.8) | 129 59.7) | 1 (0.5) | - | 86 (39.8) | 58 (26.9) | 23 (10.6) | 12 (5.6) | 26 (12.0) | 9 (4.2) | 0 (0.0) | 1 (0.5) | 1 (0.5) | - |

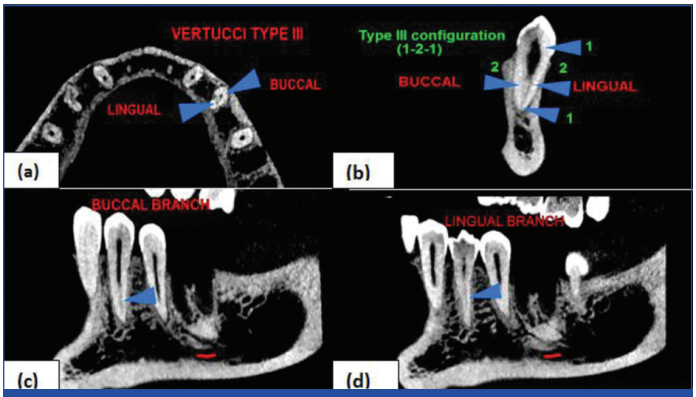
**[Table/Fig-1]:** Shows percentage of roots, number of canals and canal configuration in 1st premolar.
p-value <0.05 considered statistically significant

| Tooth Number/ Sex | Number | No. of roots (%) | | | | No. of canals (%) | | | | Canal configuration (Vertucci) (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | p-value | 1 | 2 | 3 | p-value | I | II | III | IV | V | VI | VII | VIII | Misc. | p-value |
| 35 Male | 63 | 96.8 | 3.2 | 0 | 0.509 | 55.6 | 44.4 | 0 | 0.696 | 65 | 26.9 | 1.5 | 0 | 4.7 | 1.5 | 0 | 0 | 0 | 0.650 |
| 35 Female | 45 | 100 | 0 | 0 | | 57.8 | 42.2 | 0 | | 66.6 | 24.4 | 4.4 | 2.2 | 4.4 | 0 | 0 | 0 | 0 | |
| 45 Male | 63 | 96.9 | 3.1 | 0 | 0.509 | 60.4 | 39.6 | 0 | 0.277 | 63 | 33.3 | 1.5 | 0 | 3.1 | 1.5 | 0 | 0 | 0 | 0.324 |
| 45 Female | 45 | 100 | 0 | 0 | | 66.7 | 33.3 | 0 | | 57.7 | 24.4 | 4.4 | 0 | 0 | 4.4 | 2.2 | 0 | 0 | |
| Total Male | 126 | 96.8 | 3.2 | 0 | 0.113 Fisher's exact test | 58 | 42 | 0 | 0.220 Pearson's Chi-square test | 64.2 | 30.1 | 1.5 | 0 | 3.9 | 1.5 | 0 | 0 | 0 | 0.330 Pearson's Chi-square test |
| Total Female | 90 | 100 | 0 | 0 | | 62.3 | 37.7 | 0 | | 62.2 | 24.4 | 4.4 | 1.1 | 2.2 | 2.2 | 1.1 | 0 | 0 | |
| 35 Total | 108 | 98.1 | 1.9 | 0 | <0.001 Fisher's exact test | 57 | 43 | 0 | <0.001 Pearson's Chi-square test | 60.2 | 30.6 | 2.8 | 0.5 | 4.6 | 0.5 | 0 | 0 | 0 | <0.001 Pearson's Chi-square test |
| 45 Total | 108 | 98.4 | 1.8 | 0 | | 58.3 | 41.2 | 0 | | 59.1 | 30.9 | 2.7 | 1.8 | 0 | 2.7 | 0.5 | 0 | 0 | |
| Mandibular 2nd premolar Total (%) | 216 (100) | 212 (98.1) | 4 (1.9) | 0 (0) | - | 126 (58.3) | 90 (41.7) | 0 (0) | - | 130 (60.2) | 67 (31.0) | 6 (2.8) | 1 (0.5) | 7 (3.2) | 4 (1.9) | 1 (0.5) | 0 (0) | 0 (0) | - |

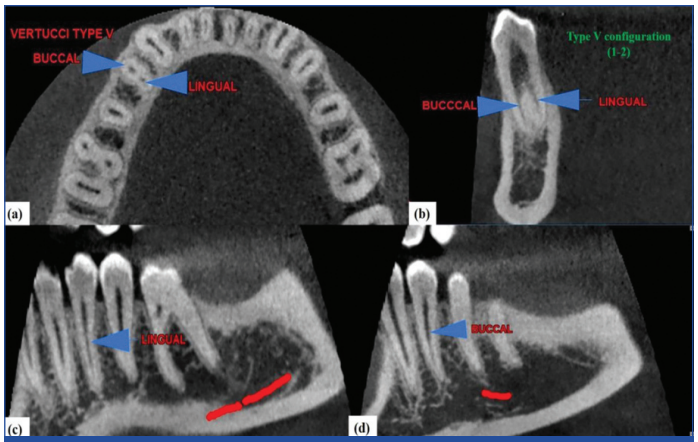
**[Table/Fig-2]:** Shows percentage of roots, number of canals and canal configuration in 2nd premolar.




**[Table/Fig-3a-b]:** Axial section of CBCT showing bilaterally symmetrical of root and canal morphology in mandibular premolars at (a) cervical and (b) apical third.




**[Table/Fig-4a-d]:** Mandibular First premolar with Type III configuration. (a) Axial section, (b) Coronal section, (c) and (d) Sagittal section.




**[Table/Fig-5a-d]:** Mandibular first premolar with Type V configuration. (a) Axial section, (b) Coronal section, (c) and (d) Sagittal section

## DISCUSSION

The propensity of mandibular premolars for anomalous variations in the radicular anatomy has been found to be implicated as a major reason for the failure [18-21]. Therefore, a thorough understanding of this complex system is necessary. The present study utilised the CBCT archives for evaluation of the canal morphology of mandibular premolars due to a high level of reproducibility of 3D information as shown in previous studies [22-24]. There was a high prevalence of single root with two canals in 1st premolars which was bilaterally symmetrical and in accordance with studies in German and Western Chinese population [25,26]. However, presence of multiple roots has been reported in Saudi, Iranian and Kuwaiti population [27-29]. The number of root canals in 1st premolars was found to be higher on the left. There was no significant gender predilection for both root and number of root canals. However, in different population, the association between morphology with gender and symmetry has been expressed variably which could be attributed to the sample size, ethnicity and methodology employed [29,30].

In the present study, a variety of canal geometries were observed in 1st premolars. Type I followed by Type II configuration was most prevalent which was consistently observed in previous studies [30-32].

Type III and Type V canal configuration were also reported, but with a lower percentage which was inconsistent with the results of Kottoor J et al., and Shetty A et al., [30,33,34]. A bilateral symmetrical distribution was observed in all the canal configurations but Type V configuration was expressed significantly higher on left and Type III configuration on the right. However, there was no gender predilection reported in association with variable configuration. In contrast, a review of literature by Kottoor J et al., concluded variability in configuration to be significantly present for the male population [30].

In case of 2nd premolar, most of the cases presented with single root and single canal which was similar with the results of Bulut DG et al., and Burklein S et al., [17,25]; but the prevalence rate of single canal was lower than that reported by Bulut DG et al., and Kottoor J et al., [17,30]. In contrast with present study, the Jordanian and Taiwanese-Chinese population reported with a higher predilection for multiple canals in 2nd premolars [35,36]. These contradictory findings could be the result of variations in methodology as well as the ethnic and geographic differences [27,30].

Type I and Type II canal configurations were reported to be most common in 2nd premolars, which was inconsistent with South Indian population that reported significantly higher percentage of Type IV [34]. Overall, mandibular second premolars had a lower rate of variations in the canal systems which were in accordance with Western Chinese population [26]. Bilaterally, a highly symmetrical distribution was reported for number of roots, root canals and canal configurations with no significant difference in gender predilection. This result was in accordance with Alfawaz H et al., and Corbella S et al., who also support its relevance in clinical cases [27,32]. However, Type V canal configuration was observed only on the left side in present study which could be because of the sample size distribution.

In context with the previous Indian studies, most of the population has reported the prevalence for single root in both 1st and 2nd premolars [9-11,13,34,37,38]. On the contrary, in terms of canal morphology, the present study showed a higher prevalence for 2 canals in 1st premolars [9-11,37-39]. In terms of canal configuration, higher propensity for Type IV configuration has been reported after Type I and Type II [10,37,38]. In contrast, present study reported with a higher prevalence for Type III and Type V configuration in Delhi-NCR population which corroborated with the finding of Shetty A et al., and Natanasabapathy V et al., [34,40]. In terms of gender preference, Iyer VH et al., reported that females presented with a higher variation in canal morphology and configuration than males in South Indian population [9], whereas Kamath A et al., reported a higher preference for males for the same [39]. This finding did not corroborate with the present study population where almost no significant gender preference was observed [Table/Fig-6] [7-13,17,25-27,31-40]. These variable findings in different subpopulation may again be a consequence of difference in the sample size distribution.

| S. No. | Name of the author | Population | Year of publication | Mode of investigation | Sample size | Conclusion/Clinical significance |
|---|---|---|---|---|---|---|
| **International Studies** | | | | | | |
| 1. | Awawdeh LA and Al-Qudah AA [7] | Jordanian | 2008 | Clearing Technique | 900 | 1st PM- 2 separate apical foramina and 2 canals (33%) and 2nd PM 72% single canal and foramina (significant). |
| 2. | Khedmat S et al., [8] | Iranian | 2010 | Cross-section And Radiography | 217 | 88.47% had single root canal with Type 1 canal configuration (significant). |
| 3. | Yu X et al., [26] | Western -Chinese | 2012 | CBCT | 149 | 98% single root and 87.1% single canal-1st PM (significant)<br>100% single root and 97.2% single canal-2nd premolars (significant)<br>More canal variation-1st PM and Type V (significant)<br>0.5%- C shaped canal (significant) |
| 4. | Llena C et al., [31] | Spanish | 2014 | CBCT | 126 | 100% single root and 83.3% single canal with no gender and tooth type differences. Type 1 and type V most prevalent (significant) |
| 5. | Bulut DG et al., [17] | Turkish | 2015 | CBCT | 1147 | Single root and 2 canals (69.9%) and Type 1 configuration (62.6%) (significant) |
| 6. | Burklein S et al., [25] | German | 2017 | CBCT | 700 | Single root and single canal with Type 1 configuration; Men>women predominance for variable configuration (significant) |
| 7. | Corbella S et al., [32] | Caucasians | 2019 | CBCT | 100 | Single root and foramen and type 1 canal configuration (significant) |
| 8. | Chen YC et al., [36] | Taiwanese-Chinese | 2018 | CBCT | 580 | 2nd PM; prevalence of C-shaped root (3.45%) and buccal and lingual radicular grooves found. Bilateral symmetry (significant) |
| 9. | Alfawaz H et al., [27] | Saudi | 2019 | CBCT | 707 | 1 root and Type 1 root canal configuration, bilateral symmetry and gender association (significant) |
| 10. | Arayasantiparb R and Banomyong D [33] | Thai | 2021 | CBCT | 349 416 | 1st PM-Multiple roots (19.48%) and 2nd PM-Multiple roots (3.85%) (significant)<br>C shaped canal present.<br>Variable configuration as Type V (significant) |
| **Indian Studies** | | | | | | |
| 1. | Iyer VH et al., [9] | Chennai | 2006 | Radiography (in vivo) | 500 | Type I configuration (75.4%); Anatomical variations (overall (24.6%)).<br>Prevalence=Vertucci Type IV>Type V>Type II>Type VIII.(sig.)<br>Anatomic variation(gender) F (31.76%)>M (16.9%) and 1st PM>2nd PM<br>3.2% Bilateral symmetry |
| 2. | Velmurugan N and Sandhya R [10] | Indian | 2009 | Decalcification and clearing | 100 | 1st PM- 44% oval orifice and Type 1 configuration (72%); Type IV variation most prevalent (10%) |
| 3. | Sandhya R et al., [11] | Indian | 2010 | Spiral computed tomography | 100 | 1st PM- Pattern of root canal (ii) Tooth length (iii) Position of the bifurcation of the canal (iv) Invagination of the root (v) Root thickness. An 80% single canal, 2% C-shaped canal, canal configuration-Type I (80%)>Type II (9%)>Type V (4%) |
| 4 | Parekh V and Shah N [12] | Gujarat | 2011 | Clearing | 80 | Canal variation 1st PM>2nd PM<br>Type IV most common in 1st PM (25%) whereas Type I most common in 2nd (80%). |
| 5. | Jain A and Bahuguna R [13] | Gujarat | 2011 | Decalcifying And Clearing | 138 | 97.1% single root and 88.4% single orifice and 67.3% type 1 configuration(1st PM) (significant) |
| 6. | Shetty A et al., [34] | South Indian | 2014 | CBCT | 1086 | Single rooted teeth and canals.1st and 2nd PM-Vertucci Type 1 (83.81% and 93.48%) followed by Type V (11.97% and 3.5%), respectively. (significant) |
| 7. | Singh S and Pawar M [37] | South-Asian Indian | 2014 | Clearing | 200 | 1st PM-94% single root, 76% single canal and orifice, Type I configuration (80%) and Type IV (10%);sig.<br>2nd PM-92% single root, single canal 58%; 88% Type I and Type II(30%) sig. |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8. | Felsypremilla G et al., [38] | Indian sub population | 2015 | CBCT | 447<br>398 | 1st PM-98% one root and 94.6% single canal(significant)<br>2nd PM-95.7% single root with single canal(significant)<br>Prevalence of C-shaped canal |
| 9. | Kamath A et al., [39] | South Indian | 2020 | Radiography (in vivo) | 550 | Mandibular 2nd PM-Single canal M(9%) <F(11%) and on right side(44%) than left (40%)(sig.).Complex anatomy M>F. |
| 10. | Natanasabhapathy V et al., [40] | Chennai | 2020 | CBCT | 406<br>396 | 1ST PM and 2nd PM, respectively. Prevalence of Root Canal Isthmus (RCI) premolars and Inter-Orifice Distance (IOD) and their correlation.<br>Presence of RCI-11.5% 1st PM(single root 94%,48% Type III configuration(most common)>Type I.)(sig.)<br>Presence of RCI -3% in 2nd PM (Type II=Type III configuration(46%))(sig.)<br>No strong correlation found between RCI and IOD. |
| 21. | Present Study | Indian Sub-population (Delhi-NCR) | 2021 | CBCT | 108<br>(216)<br>(216) | 1st PM and 2nd PM (216 each, bilaterally).<br>Variation in canal anatomy and canal configuration - 1st PM >2nd PM.<br>1st PM-single root (94.9%), 2 canals (59.7%), Type I (39.8%)>Type II (26.9%) >Type V (12.0%)>Type III (10.6%))canal configuration most prevalent.<br>2nd PM-single root (98.1%), 1 canal (58.3%), Type I (60.2%)>Type II (31.0%)Type V(3.2%)-most prevalent canal configurations.(sig.)<br>Side prevalence-1st PM:2 canals L>R. Type V config L>R and Type III config R>L.(sig.)and 2nd PM: Type V config L(4.6%)>R(0%) and Type III config R(1.8%)>L(0.5%).(sig.)<br>High level of bilateral symmetry but no significant gender predilection. |

**[Table/Fig-6]:** Shows previous national and international studies to determine root canal morphology and configuration in various populations by different investigation techniques [7-13,17,25-27,31-40].
siig.: Statistically significant result; config.: Configuration; R: Right side; L: Left-side; PM: Premolars

The present study not only reported with a high prevalence for multiple canals and variable configuration, but a tendency for splitting/bifurcation of the canals at the level of the middle and apical half of the root was observed. A single case of Vertucci Class VIII and an atypical canal configuration (that could not be classified according to the Vertucci's classification and was kept in miscellaneous group) were reported in 1st premolars. The propensity and prevalence for such complex anatomy necessitates caution for better clinical management [41,42]. Such cases may be easily disguised in routine radiographs in clinical situations and hence should be overall highly suspected [43,44].

Root canal system presents with a variable course from orifice till the apex and may include single and multiple bifurcations as well as union [45]. Thus, it is paramount to be thorough with the variations in canal configurations that have been commonly reported in mandibular premolars for predictable success in endodontic management of such cases.

It is imperative to note that this study revealed some highly interesting findings in terms of morphology of mandibular premolars. This study also emphasised on diagnostic value of CBCT in complex cases which may be of crucial importance for dental personnel, who treat large numbers of Delhi-NCR group of population, both in decision making and during treatment. Considering the variations reported in previous studies, more retrospective studies with a larger sample size may help understand and add to the knowledge of mandibular premolars. The data of present study can be compared to those of other populations and will facilitate diagnosis and treatment planning in this region of Indian population.

### Limitation(s)

The present study showed few limitations. The parameters like root and canal curvature, foramen location/shape, tooth length, position of the bifurcation of the canal, invagination of the root, root thickness, lateral canals as well as presence of C-shaped canals were not evaluated. A recent CBCT study in the population of Chennai demonstrated parameters like Root Canal Isthmus (RCI) and Inter-Orifice Distance (IOD) in mandibular premolars and their correlation which was not taken up in the present study [40]. Also, other than Vertucci's classification, no other classification system was considered which would have enabled a more comprehensive understanding. Use of CBCT was preferred over radiographs which require more exposure to radiation. Also, scattering and beam hardening artefacts due to presence of high density structures like enamel, restorations, metal post, implant, etc., in vicinity to the area of interest may have affected the image quality. Also, the sample selected may not have been a precise representation of the Delhi-NCR population which has the highest share of inter-state migrant urban agglomeration in the total population [46].

## CONCLUSION(S)

To the best of our knowledge, the present study was the first CBCT based investigation in the region of Delhi-NCR that served as a guide to the root canals of the premolar teeth for this ethnic group. A high prevalence was reported for single root with two canals and Vertucci Type I configuration in 1st premolars and single root with single canal and Type I configuration in 2nd premolars. A higher variability in canal configuration was reported in mandibular 1st premolars with no significant gender predilection. Most cases presented with middle and apical splitting of canal that accounts for percentage of failures and require a detailed preoperative radiographic examination along with adjuncts like CBCT, whenever necessary.

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**PLAGIARISM CHECKING METHODS:** [Jain H et al.]
- Plagiarism X-checker: Jan 08, 2021
- Manual Googling: May 14, 2021
- iThenticate Software: Jun 01, 2021 (18%)

**ETYMOLOGY:** Author Origin

**AUTHOR DECLARATION:**
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Jan 07, 2021**
Date of Peer Review: **Mar 16, 2021**
Date of Acceptance: **May 15, 2021**
Date of Publishing: **Jul 01, 2021**