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Canal Configuration in Lower Second Premolar Tooth: A Study of 200 Cases

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Abstract
Background: *Knowledge of root canal anatomy of the lower second premolar (mandibular second premolar) is critical for successful endodontic treatment. Anatomical variations may lead to missed canals and treatment failure.*
Objective: *To evaluate the canal configuration of 200 lower second premolars and report the prevalence of Vertucci canal types and relevant demographic correlations.*
Methods: *This retrospective cross-sectional study analyzed 200 lower second premolars treated or extracted between January 2021 to December 2023 at a Department of Conservative Dentistry and Endodontics, Bangladesh Dental College, Dhaka, Bangladesh. All samples were assessed using periapical radiographs taken at multiple angulations; a subset of 50 teeth underwent cone-beam computed tomography (CBCT) for validation. Canal configurations were classified according to Vertucci's classification. Demographic data (age, sex) and tooth-related data (side, clinical status) were recorded. Statistical analysis included descriptive statistics and chi-square tests to assess associations between canal configuration and sex/side. Significance was set at $p< 0.05$.*
Results: *Among 200 lower second premolars, the most common canal configuration was Vertucci Type I (single canal from orifice to apex) in 122 teeth (61.0%). Other distributions were Type II in 22 teeth (11.0%), Type III in 16 (8.0%), Type IV in 24 (12.0%), Type V in 10 (5.0%), Type VI in 4 (2.0%), Type VII in 1 (0.5%), and Type VIII in 1 (0.5%). The mean patient age was 35.6 ± 10.2 years (range 15–68). Females represented 54% (108/200) of cases and males 46% (92/200). No statistically significant association was found between canal type and sex ($p = 0.27$) or side (right vs left, $p = 0.41$). CBCT validation in the subset of 50 teeth confirmed radiographic classifications in 47 cases (94%).*
Conclusions: *In this series of 200 lower second premolars, a single canal (Vertucci Type I) predominated, but a clinically relevant proportion (39%) exhibited multi-canal or complex configurations. Clinicians should maintain a high index of suspicion and consider advanced imaging when conventional radiographs are inconclusive.*
Keywords: *Lower Second Premolar, Root Canal Configuration, Vertucci Classification, Endodontics, CBCT.*

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I. Introduction

The mandibular second premolar is widely regarded as one of the most anatomically variable teeth in the human dentition, and understanding its root canal configuration is essential for achieving predictable endodontic outcomes. Although traditional descriptions characterize this tooth as having a single root with a single canal, numerous studies have demonstrated that considerable morphological variations exist across different populations, age groups, and imaging modalities used for assessment. These variations include bifurcation, trifurcation, canal merging, and C-shaped canal patterns that may complicate clinical procedures such as negotiation, cleaning, shaping, and obturation. Failure to detect and manage these anatomical complexities is a major cause of persistent periapical disease and endodontic failure [1–3]. Endodontic success largely depends on the clinician's ability to understand the internal anatomy and apply diagnostic strategies that reveal potential variations. Conventional periapical radiography remains the most commonly used imaging tool in daily practice; however, its two-

dimensional nature may limit the detection of additional canals, accessory pathways, or apical morphology variations. Cone-beam computed tomography (CBCT), introduced over the past two decades, has significantly enhanced the accuracy of anatomical assessment by providing three-dimensional visualization. Several studies have shown that CBCT can reveal canal configurations that are not evident on standard radiographs, particularly in premolars with complex anatomy [4,5]. Despite these advantages, routine CBCT use is restricted due to radiation considerations, cost, and limited availability in many clinical settings. Globally, the reported prevalence of single-canal systems in mandibular second premolars range widely—from 50% to more than 80%—reflecting ethnic, genetic, and methodological differences among studies. For instance, Vertucci reported a predominance of Type I configurations, whereas later studies in Asian and Middle Eastern populations documented significantly higher rates of multi-canal systems, including Vertucci Types II, IV, V, and even Type VIII variations [1,6,7]. These discrepancies underscore the need for region-specific data to guide clinical expectations for local populations. However, in many regions, including South Asia, large-sample studies evaluating canal morphology in mandibular second premolars remain limited. Given the clinical importance of detecting canal variations and the lack of comprehensive data from this geographic context, this study aimed to investigate the canal configuration of 200 mandibular second premolars using periapical radiographs supplemented by CBCT validation. By applying Vertucci's widely accepted classification system, the study sought to determine the prevalence of various canal types and assess potential correlations with demographic and tooth-related variables. The findings from this investigation are expected to enhance clinical awareness, contribute to the growing body of anatomical literature, and support improved endodontic decision-making in routine practice.

II. Materials and Methods

Study design and ethical approval

This retrospective cross-sectional study was conducted at Department of Conservative Dentistry and Endodontics, Bangladesh Dental College, Dhaka, Bangladesh. The institutional review board approved the study protocol. Patient consent was waived for retrospective anonymized data; where stored radiographs belonged to living patients, records were anonymized according to institutional policy.

Sample selection

Inclusion criteria:

- Lower second premolars (mandibular second premolars) treated endodontically or extracted between January 2021 to December 2023.
- High-quality preoperative periapical radiographs with at least two angulations (straight and mesial or distal angulated) available in the radiographic archive.

Exclusion criteria:

- Teeth with prior root canal treatment where canal morphology could not be reliably determined.
- Grossly resorbed roots or fractured specimens preventing anatomical assessment.
- Incomplete radiographic records.

A total of 200 teeth meeting the criteria were consecutively included. For a subset validation, 50 teeth (randomly selected using a random number generator from the 200-sample pool) had preoperative CBCT scans available and were used to validate periapical radiograph-based classifications.

Radiographic evaluation

Periapical radiographs were reviewed on a calibrated monitor. For each tooth, two radiographs (straight and a mesial/distal angulation) were examined. Canal configuration was classified according to Vertucci's classification (Types I–VIII). When two radiographs were inconclusive or suggested complex anatomy, the CBCT (if available) was used as the reference standard. Two endodontists (Reviewer A and Reviewer B) independently assessed all images; disagreements were resolved by consensus or by consulting a third senior reviewer.

Data collection

For each case, the following data were recorded:

- Patient demographics: age and sex.
- Tooth side: right/left.
- Clinical status: vital, necrotic, or previously symptomatic.
- Canal configuration (Vertucci Type I–VIII).

Statistical analysis

Data were entered into a spreadsheet and analyzed using standard statistical software. Continuous data are reported as mean ± standard deviation (SD). Categorical variables are presented as counts and percentages. Associations between categorical variables (e.g., canal type vs sex) were tested using the chi-square test or Fisher's exact test where appropriate. A p-value < 0.05 was considered statistically significant.

III. Results

Sample Characteristics

A total of 200 mandibular second premolars were included in this study. The mean patient age was 35.6 ± 10.2 years (range 15–68). Females accounted for 108 cases (54%), whereas males represented 92 cases (46%). Regarding tooth laterality, 98 teeth (49%) were located on the right side and 102 (51%) on the left. All included radiographs met the required diagnostic quality, and CBCT scans were available for 50 randomly selected cases.

Table 1. Sample Characteristics (N = 200)

Variable	Category	n	%
Sex	Female	108	54
	Male	92	46
Age (years)	Mean ± SD	35.6 ± 10.2	—
	Range	15–68	—
Tooth Side	Right	98	49
	Left	102	51

Canal Configuration (Vertucci Classification)

Analysis of the 200 mandibular second premolars revealed a predominance of Vertucci Type I configuration, which was identified in 122 teeth (61%). Type IV configuration was the second most common (12%), followed by Type II (11%), Type III (8%), Type V (5%), Type VI (2%), Type VII (0.5%), and Type VIII (0.5%). Thus, 78 teeth (39%) demonstrated multi-canal or complex patterns.

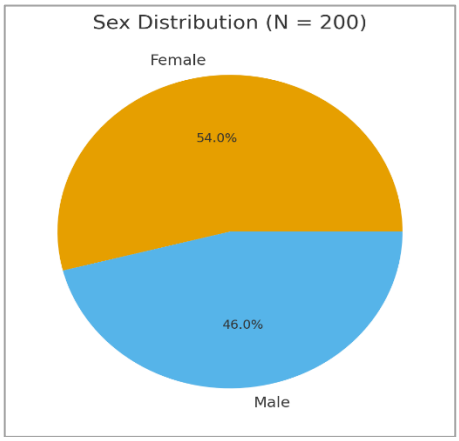

Figure 1. Sex Distribution of the Sample (N = 200)

Table 2. Distribution of Canal Configurations According to Vertucci Classification

Vertucci Type	Description	n	%
Type I	Single canal (1-1)	122	61.0
Type II	2 canals joining to 1 (2-1)	22	11.0
Type III	1-2-1	16	8.0
Type IV	2 separate canals (2-2)	24	12.0
Type V	1 canal dividing into 2 (1-2)	10	5.0
Type VI	2-1-2	4	2.0
Type VII	1-2-1-2	1	0.5
Type VIII	3 separate canals (3-3)	1	0.5
Total	—	**200**	**100.0**

Association Between Demographics and Canal Configuration

Statistical analysis showed no significant association between canal configuration and patient sex ($p = 0.27$). Similarly, no significant difference was observed between right- and left-sided teeth regarding canal type distribution ($p = 0.41$). These findings indicate that neither sex nor laterality influenced the presence of anatomical variations in the root canal system.

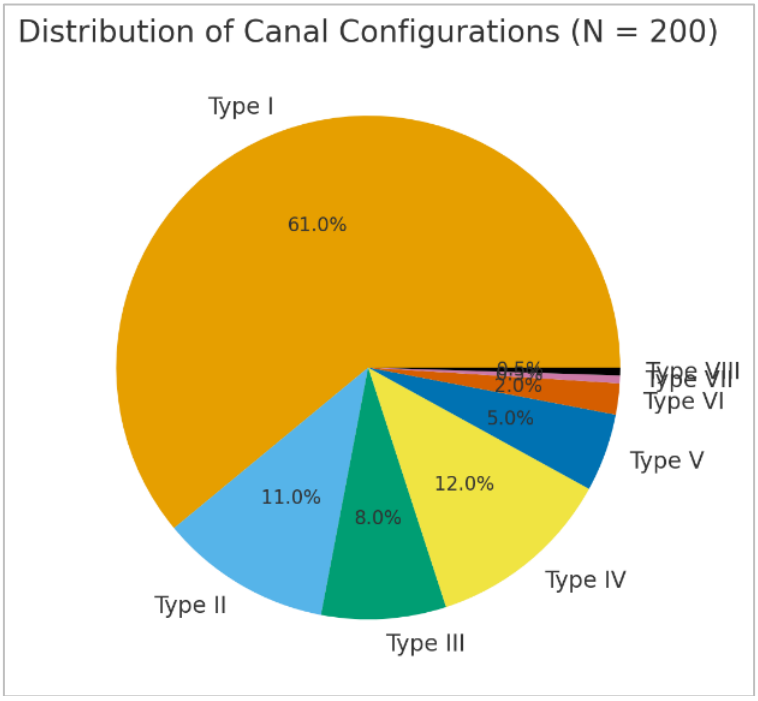

Figure 2. Distribution of Root Canal Configurations in Mandibular Second Premolars (N = 200)

Table 3. Association of Canal Configuration with Sex and Tooth Side

Variable	Category	Most Common Types	p-value
Sex	Male vs Female	Similar distribution of Types I–V	0.27
Tooth Side	Right vs Left	No significant variation	0.41

CBCT Validation Findings

Among the 50 CBCT-evaluated cases, 47 (94%) showed complete agreement with configurations identified on periapical radiographs. In 3 cases (6%), CBCT revealed additional complexity that was not visible radiographically. Two teeth initially classified as Type II on radiographs were reclassified as Type IV on CBCT, and one tooth considered Type I on radiographs demonstrated a Type III configuration. These findings highlight the high reliability of multi-angulated radiographs while also emphasizing the role of CBCT in identifying subtle anatomical variations that may affect clinical decision-making.

IV. Discussion

The present study evaluated the root canal configuration of 200 mandibular second premolars using periapical radiographs supplemented by CBCT validation. The findings reaffirm that although Vertucci Type I anatomy predominates in this tooth, a considerable proportion of cases demonstrate more complex canal systems. This highlights the ongoing clinical challenge of identifying anatomical variations in a tooth often assumed to have a straightforward morphology.

In this study, 61% of the teeth exhibited a Type I configuration, consistent with classical anatomical descriptions and earlier studies by Vertucci, who reported that the majority of mandibular premolars have a single canal [1]. However, 39% of teeth displayed variations ranging from Type II to Type VIII. This percentage aligns with more recent studies employing advanced imaging techniques, which have shown higher detection rates of multiple canals and intricate patterns [2,3]. Such findings emphasize that clinicians should avoid assuming a single-canal system in all mandibular second premolars, particularly in populations where anatomical diversity has been reported. The significant presence of variants such as Type IV (12%) and Type II (11%) in the current study suggests a notable degree of internal complexity. Previous research has indicated that the prevalence of multi-canal systems in mandibular second premolars varies across populations. Studies in Asian and Middle Eastern cohorts have reported higher rates of two-canal systems compared with Western populations [4,5]. These

discrepancies may be attributable to ethnic, genetic, or developmental factors. As the present sample likely reflects a South Asian demographic, the distribution observed here adds valuable region-specific data to the global literature. The role of imaging methods in identifying root canal configurations cannot be overstated. In the CBCT-validated subset of 50 cases, the agreement between radiographs and CBCT was 94%, demonstrating the reliability of multi-angulated periapical radiography when properly performed. Nonetheless, in 6% of cases, CBCT identified additional anatomical details that were missed on radiographs. This is consistent with prior studies showing that CBCT enhances detection of bifurcations, apical canal multiplicity, and merging patterns that are often obscured in two-dimensional imaging [6]. Although CBCT is not routinely recommended for all endodontic cases due to radiation considerations, its selective use in anatomically ambiguous or clinically challenging premolars is justified. The absence of significant associations between canal configuration and sex or tooth laterality in this study is consistent with findings from several previous investigations [7-10]. While some reports have proposed minor differences related to sex or arch side, such variations have not been consistently reproducible across studies or populations. The similarity in distribution observed here supports the notion that anatomical variation is more strongly influenced by population-specific or developmental factors rather than sex or laterality. From a clinical standpoint, the identification of multi-canal systems is crucial for avoiding missed anatomy, a well-recognized cause of endodontic failure. Missed canals may harbor persistent microbial biofilms and prevent complete cleaning and obturation. The present findings underscore the importance of careful radiographic assessment, the use of angled projections, and the consideration of CBCT when conventional views suggest complexity. Additionally, clinicians should evaluate access cavity design carefully, as a more conservative or overly narrow access may impede the detection of additional canals. One of the strengths of the current study is its relatively large sample size, which enhances the reliability of the prevalence data. The inclusion of CBCT for validation in a randomly selected subset adds further credibility to the radiographic assessments. Nevertheless, the study has limitations. Its retrospective design may introduce selection bias, as only teeth with adequate radiographs or available CBCT scans were included. Furthermore, CBCT was not used for all cases, and micro-CT—considered the gold standard for anatomical evaluation—was not available. Overall, the results align with the growing body of literature demonstrating that mandibular second premolars exhibit a greater degree of anatomical variation than traditionally assumed. These findings reinforce the need for heightened clinical awareness and meticulous diagnostic protocols to ensure comprehensive canal management and improved endodontic outcomes.

V. Conclusion

While the mandibular second premolar most commonly contains a single root canal, clinicians should be aware that a notable proportion possess multi-canal or complex configurations. Careful radiographic assessment using multiple angulations and selective use of CBCT can help detect additional anatomy and reduce the risk of missed canals.

Clinical implications

- Anticipate a single canal in most lower second premolars, but check carefully for additional canals in nearly 4 out of 10 cases.
- Use multiple angulated radiographs routinely; consider CBCT when radiographs and clinical signs are discordant.

Conflicts of interest

The authors declare no conflicts of interest.

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