**Original Research Article**

# Assessment of Root and Canal Morphology of Mandibular Second Molar Teeth in a Group of Kashmiri Patients: A Cone Beam Computed Tomography Study

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## Abstract

Mandibular second molars exhibit considerable anatomical variability, posing challenges during endodontic procedures. This study aimed to analyze the root and canal morphology of 100 mandibular second molars from 62 Kashmiri patients using cone beam computed tomography (CBCT). The study emphasized Vertucci's and Fan's classifications for canal configurations and C-shaped canals. Two-rooted molars predominated (86%), with Type IV (48%) and Type I (84%) configurations being most common in mesial and distal roots, respectively. C-shaped canals were present in 12% of cases, emphasizing the need for advanced diagnostic tools like CBCT to enhance clinical outcomes. These findings contribute to understanding the anatomical diversity in the Indo-Aryan Kashmiri population.

## Key words

Root, Canal, Morphology, Mandibular, Second molar, Computed tomography, CT.

## Introduction

The mandibular second molar is among the most anatomically complex teeth, with wide variability in root number, canal configuration, and accessory features [1, 2]. These variations complicate endodontic treatment, often leading to failure when anatomy is inadequately addressed [3].

Root canal morphology is influenced by ethnicity, with South Asian populations exhibiting unique patterns distinct from East Asian or European groups [4]. Kashmiri individuals, primarily of Indo-Aryan origin, represent a genetically distinct population [5], necessitating region-specific anatomical studies.

Vertucci's classification provides a systematic method to describe root canal configurations, categorizing them into eight types [1]. Fan, et al.'s classification focuses on C-shaped canals, a frequent anatomical variation in mandibular second molars, particularly in single-rooted teeth [6]. CBCT has emerged as the gold standard for accurately assessing such complex anatomy, offering detailed three-dimensional visualization of root canals and accessory features [7, 8].

This study aimed to evaluate the root and canal morphology of mandibular second molars in Kashmiri patients, focusing on Vertucci's and Fan's classifications to understand region-specific anatomical variations better.

## Materials and methods

### Study Design

A retrospective analysis of CBCT scans of 62 patients was conducted. A total of 100 mandibular second molars were included. CBCT were obtained from CBCT centre located in Srinagar city and were done for some other diagnostic purpose. Ethical approval was obtained from institutional ethical committee (IEC-GDC & H, Srinagar) Approval No: 1825 and informed consent was secured for the use of patient data with annonymization of data.

### Inclusion criteria

- Age group: 18–60 years.
- Intact mandibular second molars.
- High-quality CBCT scans.
- Kashmiri ethnicity.
- Fully developed roots.
- Informed consent.

### Exclusion criteria

- History of endodontic treatment.
- Pathological conditions (e.g., lesions, cysts).
- Congenital anomalies or supernumerary roots.
- Poor-quality CBCT scans.
- Severe caries or fractures.
- Systemic or skeletal disorders.
- Repeat scans or duplicate data.

### CBCT Imaging Protocol

CBCT scans were acquired using a Carestream 9300 scanner with the following parameters: Voxel size: 0.125 mm, Field of view: $10 \times 10$ cm, Exposure settings: 90 kVp, 6.5 mA, 14 seconds. Scans were analyzed using multiplanar reconstructions to evaluate:

- Number of roots.
- Canal configurations (Vertucci's classification).
- C-shaped canals (Fan's classification).
- Accessory canals and root fusions.

### Statistical Analysis

Chi-square tests were conducted to evaluate the significance of differences in canal morphology based on vertucci ($p < 0.05$) and Fan's classification.

## Results

### Root Morphology

- Single-rooted: **12%**
- Two-rooted: **86%**
- Three-rooted: **2%**

**Table - 1:** shows the distribution of canal configurations (Vertucci's type) across the two roots (mesial & Distal)

Canal Configurations (Vertucci's Classification)

| Root | Type I | Type II | Type IV | Others |
|------|--------|---------|---------|--------|
| **Mesial root** | 15 (17.4%) | 26 (30.2%) | 41 (47.7%) | 4 (4.7%) |
| **Distal Root** | 72 (83.7%) | 10 (11.6%) | 4 (4.7%) | 0 (0.0%) |

**Table - 2:** shows the observed variations in C-shaped canal configurations based on Fan's classification.

C-Shaped Canals (Fan's Classification, n=12)

| Fan Classification Type | Description | n (Number of Teeth) | Percentage (%) |
|------|--------|---------|---------|
| Type C1 (Continuous C) | Continuous C-shaped canal | 5 | 41.7% |
| Type C2 (Semicolon shape) | Semicolon-shaped canal | 3 | 25.0% |
| Type C3c (Discontinuous - coronal) | Discontinuous C-shaped canal, coronal segment | 2 | 16.7% |
| Type C3d (Discontinuous - distal) | Discontinuous C-shaped canal, distal segment | 1 | 8.3% |
| Type C4 (Separation with isthmus) | Separated canals with an isthmus | 1 | 8.3% |
| Type C5 (No canal communication) | Completely separate canals, no communication | 0 | 0.0% |
| Total | | 12 | 100% |

Accessory canals were observed in 22% of cases, predominantly in the mesial root.

The analysis of canal morphology based on Vertucci's classification revealed significant variability between the mesial and distal roots of mandibular second molars in the studied Kashmiri population. The Chi-Square test for independence yielded a highly significant result ($p < 0.05$), confirming that the distribution of canal configurations is not uniform across the two roots. Specifically, Type IV configurations were predominantly observed in the mesial roots, whereas Type I configurations were more frequent in the distal roots (**Table – 1**).

The observed variations in C-shaped canal configurations based on Fan's classification do not show significant differences ($p > 0.05$) within the Kashmiri population studied. However, the predominance of Type C1 canals (41.7%) emphasizes the clinical importance of understanding these configurations when managing C-shaped canals (**Table – 2**).

## Discussion

The high prevalence of two-rooted mandibular second molars (86%) aligns with findings in other South Asian populations, indicating consistent patterns across the region [9, 10, 11]. The relatively low prevalence of single-rooted molars and C-shaped canals (12%) suggests that Kashmiri populations exhibit less root fusion compared to East Asian populations, where rates exceed 20% [12, 13].

In the Kashmiri population, we observed a 12% prevalence of C-shaped canals in mandibular second molars, which is notably higher than the reported prevalence of 6% in the broader Indo-Aryan population [11, 14]. This discrepancy could be attributed to various genetic, environmental, and developmental factors unique to the Kashmiri ethnic group.

Kashmiri individuals, despite being predominantly of Indo-Aryan origin, represent a genetically distinct subgroup due to prolonged geographical and cultural isolation. Studies have shown that such isolated populations often exhibit unique anatomical traits, possibly due to genetic drift or adaptation to specific environmental conditions [5, 14]. The increased prevalence of C-shaped canals in this population may reflect such genetic variability.

Vertucci's classification remains integral to understanding canal configurations [15, 16]. The dominance of Type IV and Type I in mesial and distal roots, respectively, necessitates a focused approach to canal exploration and preparation (**Figure - 1**). Meanwhile, Fan's classification of C-shaped canals provides a framework for managing these rare but challenging cases, emphasizing tailored cleaning and obturation techniques [17, 18]. Distinct morphological changes in C – shaped canals along the root length (from coronal to apical 3$^{rd}$) were identified in this study. The most frequent pattern included transition such as Fans type C1-C2-C4 (**Figure - 2**). This unique morphological transition in C shaped canals were documented first time in kashmiri population.

CBCT significantly enhances diagnostic accuracy, particularly for detecting complex morphologies like C-shaped canals and accessory anatomy. In this study, CBCT identified accessory canals in 22% of cases and higher detection rate of C shaped canals (12%) compared to studies relying on traditional techniques, highlighting its superiority over conventional radiography [19].

**Figure - 1:** a) mandibular 2$^{nd}$ molar with two roots (b) canal configuration in axial view (c) vertuccis type IV in mesial root d)vertuccis type I in distal root
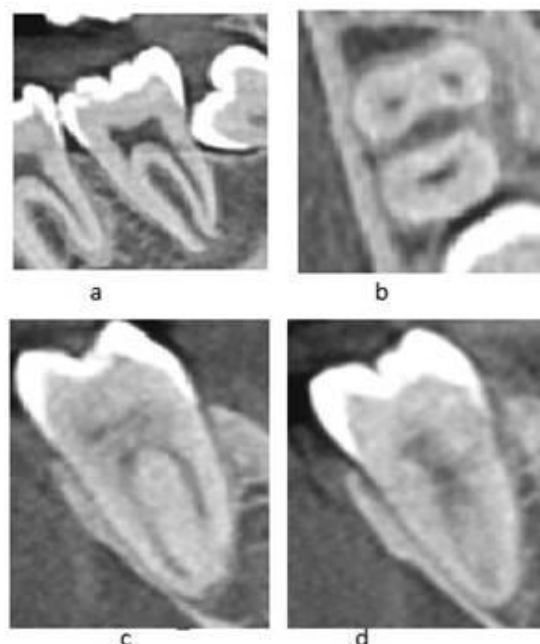


**Figure - 2:** a) single (fused) root morphology (c shaped canal) b) type c1 Fans classification in coronal 3$^{rd}$ c) fans C2 in middle 3$^{rd}$ d) C4 in apical 3$^{rd}$.
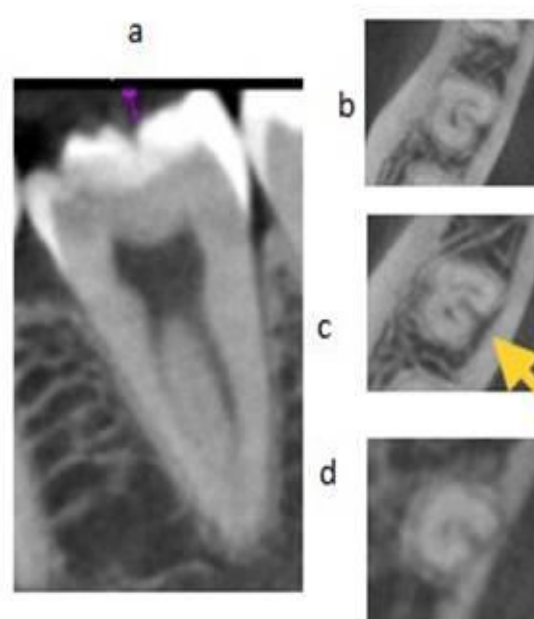


The study's retrospective design and limited sample size are limitations. Future studies should involve larger samples, possibly incorporating

automated CBCT analysis through artificial intelligence [20]. Exploring the influence of age, systemic conditions, and environmental factors on mandibular second molar anatomy could provide further insights.

## Conclusion

Mandibular second molars in Kashmiri patients demonstrate significant anatomical diversity, with a predominance of two-rooted morphology and Type IV canal configurations in mesial roots. The use of CBCT is indispensable for accurately diagnosing complex configurations like C-shaped canals. These findings contribute to understanding population-specific anatomical variations, enhancing the success of endodontic treatments.

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