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Diversity in maxillary premolars: From historical records to contemporary case finding

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Abstract
Maxillary first premolars typically present with one or two roots and canals. However, anatomical variations such as the presence of three roots and three canals can occur, complicating endodontic therapy. This case report describes the diagnosis and successful nonsurgical root canal treatment of a maxillary first premolar with three separate roots and canals. The use of magnification and advanced imaging played a pivotal role in the diagnosis and management of this unusual anatomy.

Keywords: Maxillary first premolar, root canal anatomy, three roots, CBCT, endodontic treatment, anatomical variation

1. Introduction
A comprehensive grasp of root canal anatomy has a significant impact on the effectiveness of root canal therapy. The likelihood of treatment failure is increased by even minor anatomical differences in the root canal system, which pose difficulties for endodontists and dentists. Research has indicated that the success rate of root canal therapy varies. Treatment difficulties is significantly influenced by the root morphology and canal configuration system, which takes into account elements such as the number, curvature level, and orientation of the root canal. As a result, both nonsurgical and surgical endodontic therapies require a deep comprehension of the morphology [1].

Endodontic success relies heavily on thorough debridement and obturation of all canals. Maxillary first premolars generally have one or two canals, but three-rooted maxillary premolars are rare, occurring in 0.5- 6% of cases, depending on the population studied [1]. Failure to detect and treat additional canals can result in persistent periapical pathology [2]. Cone-beam computed tomography (CBCT) has become a valuable diagnostic adjunct in such cases [3].

Reports have indicated wide variations in the root and canal anatomy of maxillary premolars. A comprehensive under- standing of these variations is crucial for increasing the success rate of such treatment [2].

According to research, root canal shape differs greatly between ethnic and geographic groups, most likely as a result of environmental and genetic factors influencing dental development. There are still few comparison research involving diverse populations, even though the majority of the available knowledge comes from studies that concentrate on Asian and European subpopulations. Despite the fact that studies on Central American populations have the potential to uncover anatomical characteristics unique to the region, there is a notable research void in this area. Closing this gap could improve endodontic treatment options particular to a given location by improving physicians' understanding of population-based anatomical variances [3].

Variations in root and root canal morphology may be attributed to a number of factors including ethnic background, gender and age of the study population, and the evaluation technique.

Martins *et al.* noted alterations in root canal morphologies over an individual's lifespan, with distinct canal types being impacted by the gradual accumulation of secondary dentin. Torres *et al.* documented discrepancies in the root morphology and canal configuration of mandibular molars between Belgium and Chile, with variations also noted between Asians and Caucasians. Additionally, root canal characteristics vary based on tooth position, as evidenced by a relatively higher occurrence of C-shaped canals in mandibular second molars compared to mandibular first molars [4].

Maxillary premolars are well-known for their anatomical complexity, which poses challenges during endodontic treatment. Proper knowledge of their root and canal morphology is essential to avoid missed canals, which are a major cause of endodontic

failure. This case report along with literature review helps clinician to understand the significance of missed canals, post endodontic failure if correct clinical diagnosis and treatment is not executed.

This article's goals were to accomplish the internal and exterior anatomy of maxillary first premolars has been the subject of anatomic investigations and clinical instances. Also to identify the variables that could influence these teeth's morphology. This article discusses about the clinical implications of these morphological variations and endodontic treatment for same [4].

Typical Anatomy

Maxillary First Premolars

a) Most commonly have two roots (buccal and palatal).
b) Usually exhibit two canals (87- 98%).
c) Less commonly, they may present three canals or a single canal.

Maxillary Second Premolars

a) Typically have a single root.
b) **Canal configuration is variable:** One canal (single and straight), two canals (buccal and palatal), or bifurcating canals.

Root Canal Configuration (According to Vertucci's Classification)

Common configurations in maxillary first premolars

a) Type IV (2 separate canals from orifice to apex)
b) Type II (2 canals join into one)

Maxillary second premolars

a. Most frequent: Type I (single canal).
b. Others: Types II, III, and IV.

Anatomical Variations

Number of Canals

a) First premolars: up to three canals (rare).
b) Second premolars: 1- 3 canals; most commonly one.

Canal Shape

a) Oval, ribbon-shaped, or bifurcating.

Unusual Morphologies

a) C-shaped canals (rare but reported).
b) Fused roots.
c) Accessory canals.

Factors Influencing Variability

- **Ethnic variations:** Higher prevalence of multiple canals in some populations (e.g., Middle Eastern and Indian).
- **Age and gender:** Not strongly correlated but may influence calcification and canal size.
- **Imaging:** CBCT studies reveal a significantly higher rate of complex configurations than traditional radiography.

Clinical Implications

- Missed canals due to anatomical variations are a common reason for treatment failure.
- Pre-operative CBCT imaging is highly recommended for complex or retreatment cases.
- Proper access cavity design and magnification help identify additional canals.

Case Report

Patient History: A 26 year young female patient reported to our specialised department of conservative dentistry and endodontics in college with the chief complaint of spontaneous pain in the upper right posterior region for the past three days. The pain was continuous, moderate in intensity, and exacerbated on biting. No history of any pus discharge or any trauma in the past.

Clinical_Examination: Intraoral examination revealed a deep carious lesion on tooth #14 along with loss of loss of distal cusp and marginal ridge. The tooth was tender to vertical percussion. No swelling or sinus tract was observed. The tooth did not respond to thermal or electric pulp testing, indicating pulp necrosis.

Radiographic Findings: Initial periapical radiograph revealed an unusual divergence in the root outline of tooth #14, suggestive of more than two roots (Fig. 1A). 3 roots distinctly visible in the radiograph with no periapical radiolucency observed.

Treatment Procedure

Access Opening & Canal Identification

Under rubber dam isolation, an endodontic access cavity was prepared. Using 3.5× magnification loupes, three distinct canal orifices were identified. The orifices were located in a triangular configuration.

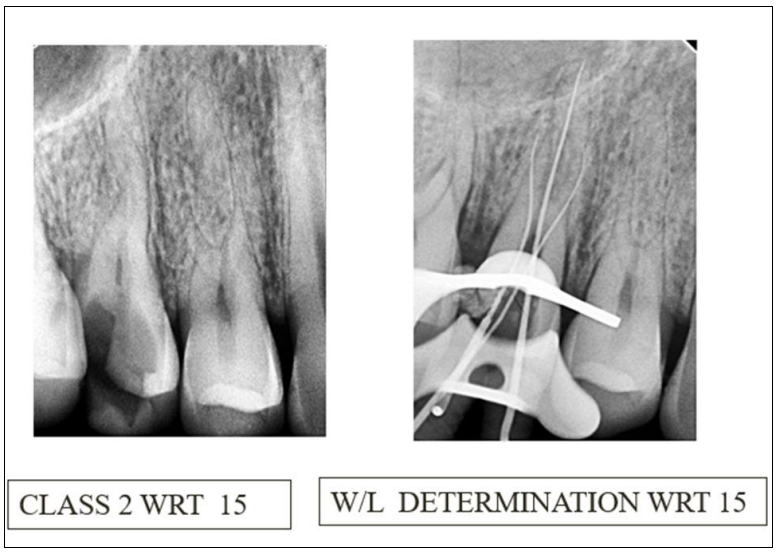
Cleaning and Shaping: Working lengths were determined using an apex locator and confirmed radiographically. (FIG.2) Biomechanical preparation was performed using a rotary NiTi system (Protaper Gold, Dentsply Sirona) upto f2 in palatal canals and F1 in both mesiobuccal and distobuccal canals. This was followed by copious irrigation using 5.25% sodium hypochlorite and 17% EDTA. The mastercones were taken to confirm radiographically (Fig 3)

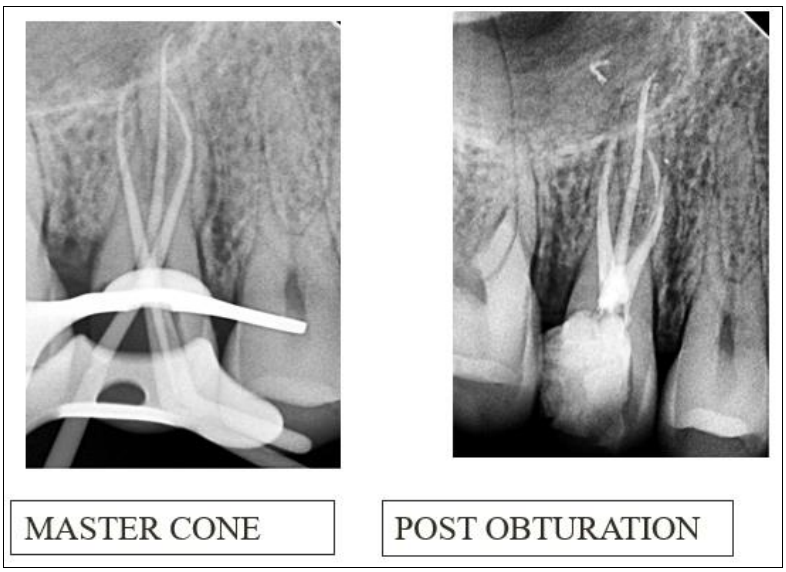
Obturation

On drying the canals with sterile paper points, obturation was completed using warm vertical condensation with gutta-percha cones and AH Plus sealer (Dentsply). A post-operative radiograph confirmed the dense fill in all three canals (Fig. 4).

Restoration

The post endodontic restoration was carried out with bulk filled resin composite. The patient was advised for full-coverage restoration after the completion of endodontic treatment.





Discussion

A growing number of studies conducted in recent years have demonstrated the complex nature of PM Root canal systems, exhibiting a wide range of anatomical variants such as numerous roots, varied canal forms, and root surface sulci. The significant failure rate in premolar RCTs is a result of these complex variances, which make it difficult to achieve ideal cleaning and shape. Investigations on the symmetry of root canals can reveal information about the possible anatomical traits of adjacent homonymous teeth because symmetry is a universal feature [1].

The maxillary first premolars in this case report have three roots, a condition that has been found to happen in 0-3% of cases in earlier research. Between 0% and 1.6% of people have 3-rooted maxillary second premolars. According to research, the majority of maxillary premolars with three roots have one palatal root and two buccal roots. The three-rooted maxillary premolars in the current study also had one palatal root and two buccal roots, with the buccal root splitting in the middle third. These structural differences should be understood by clinicians because they could make treatment more difficult [2].

When conducting RCTs on PMs, clinicians need to have a solid understanding of the complex structure, diverse composition, and symmetry of the RMCC system. Using imaging methods such as CBCT can yield distinct, accurate, and trustworthy visual representations, facilitating a thorough understanding of the RMCC system's anatomical characteristics. Medical personnel can successfully complete RCTs with the help of these essential visual tools.

This article's goals were to evaluate the body of research on the morphology of the maxillary first premolars' roots and root canals and to talk about the clinical implications of both their internal and exterior morphology for different dental operations.

Genes linked to canal structure are situated on the X chromosome, prompting research efforts to explore how gender disparities affect the root canal morphology. Al-Zubaidi *et al.* reported a higher incidence of single-root maxillary PM1s in women (56.5% vs. 29.3%), while men exhibited a higher prevalence of maxillary PM1s with double roots (67.2% vs. 51.1%). Differently, Alghamdi *et al.* observed a greater prevalence of single-root mandibular PM2s in men (98.8% vs. 97.8%).

According to the current review, most apical foramina did not align with the tips of the apical roots. According to reports, it can be difficult to identify foramen deviation on radiography, especially when the opening is on the buccal or lingual root surfaces.

Since electronic apex locators have been shown to be very accurate in locating the apical foramen, it is advised to use them to validate the radiographic working length. Although

they can occur at any level of the root, the lateral canals are more frequently found in the apical third. They may occasionally be filled with obturating materials during canal obturation, but they are rarely debrided during cleaning and shaping. The outcome of endodontic treatment and the preservation of periodontal health may be impacted by these canals' potential to serve as pathways for the spread of inflammatory breakdown products from the dental pulp to the periodontal tissues or vice versa [4]

Because it may be challenging to properly debride and fill these areas, the presence of apical deltas and isthmus may also be clinically significant and may increase the risk of endodontic failure. Reaching these uninstrumented areas of the root canal system may be facilitated by using ultrasonics to activate the irrigant and by providing adequate irrigation during nonsurgical therapy.

The majority of canal abnormalities, including as lateral canals and apical deltas, are eliminated during surgical root canal therapy by resecting the apical part of the root. To seal the apical end of the root, all apical foramina and isthmi on the resected root surface need to be prepared and filled [4-5].

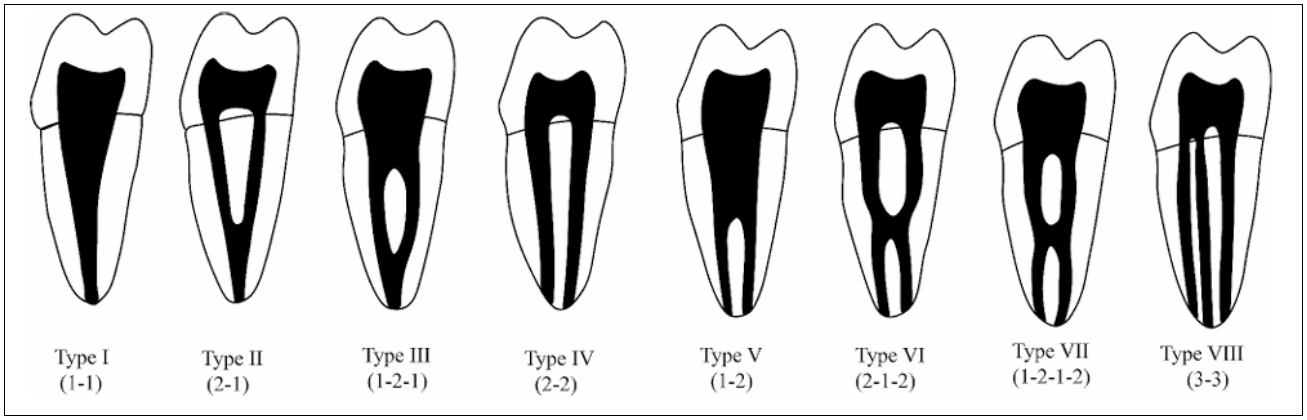


Fig 1: Vertucci's Classification for Premolars

1. The Number of Roots,
2. The Number of Canals, And
3. The Classification Of Root Canal Configurations Based On The Vertucci Method

Incidence of More than Two Canals in Maxillary Premolars - Case Reports

Table 1: Case Report Table (Recent & Historical Studies)

Authors (Country) & Year	Journal (Vol:No)	Tooth	Canals	Key Findings & Conclusion
Khan *et al.* (Pakistan, 2024) [12]	Journal of Rawalpindi Medical College (2024)	Max first premolar	3 canals, 3 roots	Three separate canals; importance of radiographic diligence
Singh *et al.* (Nepal, 2022) [19]	J. Nepalese Assoc. Pediatric Dentistry (2022)	Max first premolar	3 canals, 3 roots	Rare triple-rooted premolar; careful clinical/radiographic examination needed
Beyraghshamshir *et al.* (Iran, 2020) [20]	Iranian Endodontic Journal (15:4, 2020)	Max first & second premolars	3 canals	Two clinical cases; CBCT/magnification aided detection
Karamifar & Tondari (Iran, 2021) [13]	Iranian Endodontic Journal (16:2, 2021)	Max second premolar	4 canals	Four separate canals detected with microscope; extremely rare
Jiannan *et al.* (China, 2024)	Case Reports in Dentistry (2024)	Max premolar (unspecified)	3 roots, 4 canals	First report of 3 roots + 4 canals configuration
Bugea *et al.* (Italy, 2022)	Bioengineering (Basel) (2022)	Max premolars	4 canals	Case series: multiple premolars with four canals; emphasizes CBCT imaging
Olczak (Poland, 2021) [22]	Pomeranian J. Life Sci. (2021)	Max first premolar	3 canals	CBCT confirmed; 8-yr follow-up showed sustained success
Uğur *et al.* (Turkey, 2017) [23]	J. Istanbul Univ Fac Dent (2017)	Two max first premolars	3 canals each	Two cases in same report; both showed three-canalled anatomy
Relvas *et al.* (Brazil, 2013) [24]	Case Rep Dent (2013)	Max first premolar	3 canals	Used microscope + NiTi rotary; 1-yr follow-up symptom-free
Cantatore *et al.* (2003)	Int Endod J	Max first/second premolar	3 canals	Classic early reports of three-canal premolars
Sulaiman *et al.* (Nigeria, 2013)	Annals Ibadan Postgrad Med (2013)	Max first premolar	3 canals	Highlights need to investigate unusual anatomy
Chauhan & Singh (India, 2012)	J. Clin & Exp Dent (2012)	Max second premolar	3 roots/canals	Bilateral occurrence; rare second premolar anomaly
Kartal *et al.* (Turkey, 1998) [5]	J Endod (1998)	Max first premolar	~1- 6%	Population-based morphological data
Pecora *et al.* (Brazil, 1991)	Braz Dent J (1992)	Max second premolar	~0.3% with 3 canals	Very low incidence heightens significance of cases
Vertucci & Gegauff (USA, 1984) [7]	Int Endod J	Max first premolar	~4% incidence	Early morphology benchmark data

Conclusion

Maxillary premolars with three roots often mimic the morphology of maxillary molars. Christie *et al.* classified them into three types based on root morphology [4]. The detection of such variations is essential for complete debridement and obturation. Failure to identify additional canals may lead to persistent infection [5]. CBCT serves as a critical tool for 3D assessment of complex anatomy, especially when conventional radiographs are inconclusive [3]. This case report highlights the importance of thorough radiographic and clinical evaluation to detect anatomical variations. Use of CBCT and magnification significantly improves the outcome of endodontic therapy in teeth with complex root canal systems [6].

Most maxillary first premolars have one root (41.7%) or two (56.6%), with the three-rooted variety being uncommon (1.7%). Most maxillary first premolars (86.6%) have two root canals, regardless of the number of roots. 3. Type IV root canals account for 64.8% of these teeth, with types II and I coming in second and third, respectively, at 13.5% and 11.4%. 7. Clinical case reports revealed that while developmental abnormalities are uncommon in these teeth, the most frequent anatomic variation is the presence of a third root. To improve the results of both surgical and nonsurgical dental operations, the physician should be well-versed in the internal and external morphology of maxillary first premolars and how they relate to neighbouring anatomic structures [4].

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