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CBCT and DOM -Guided management of a complex mandibular second premolar: A case report

Dr. Madhuryak[1], Dr. Pallavi Gopeshetti[2], Dr. Madhu pujar[3]
[1] Department of Conservative Dentistry and Endodontics, Maratha Mandal Dental College, Bauxite, Sadashivnagar, Belgavi, Karnataka, India
[2] Professor, Department of Conservative Dentistry and Endodontics, Maratha Mandal Dental College, Bauxite, Sadashivnagar, Belgavi, Karnataka, India
[3] Professor and Head, Department of Conservative Dentistry and Endodontics, Maratha Mandal Dental College, Bauxite, Sadashivnagar, Belgavi, Karnataka, India
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Abstract
Background: The mandibular second premolar is known for its unpredictable internal anatomy. The simultaneous occurrence of three canals, a C-shaped configuration, and hypertaurodontism—an "anatomical trifecta"—is exceptionally rare and presents significant endodontic challenges.
Case Description: A 15-year-old female presented with symptomatic apical periodontitis in tooth 44. Initial access revealed a vertically elongated pulp chamber and a C2 (semicolon-shaped) canal configuration. Integrated 3D mapping via Cone Beam Computed Tomography (CBCT) and real-time visualization with a Dental Operating Microscope (DOM) were utilized to navigate the complex isthmus and avoid strip perforations in danger zones.
Conclusion: Successful management of highly irregular root systems requires a transition from traditional 2D radiography to a meticulous, technology-driven approach, combining magnification with 3D diagnostic imaging to ensure predictable outcomes.

Keywords: CBCT, C shaped canals, dental operating microscope, mandibular second premolar, taurodont

Introduction
Achieving a successful outcome in endodontics is fundamentally an endeavour aimed at thorough debridement and a precise 3D seal. However, this goal is frequently tested by uncommon root canal morphologies. Among the dentition, the mandibular second premolar (MSP) is particularly notorious for its unpredictable nature, often complex internal anatomy.
Finding a single rare trait in a premolar is noteworthy, but finding three simultaneously is exceptional. The presence of three root canals deviates significantly from the standard Vertucci Type I pattern and is rarely documented in mandibular second premolars [1]. Compounding to this is the C-shaped morphology, a ribbon-like anatomy that heightens the risk of strip perforations and complicates the eradication of bacteria within narrow isthmuses [2]. Furthermore, the inclusion of taurodontism creates a uniquely challenging environment, where an elongated pulp chamber and apically displaced furcation hinder both orifice visualization and precise mechanical instrumentation [3].
By limiting to conventional imaging techniques like radiographs in such complex cases can lead to missed anatomy and clinical failure. This case report highlights how Cone Beam Computed Tomography (CBCT) allowed to map this anatomical triad in three dimensions [4]. Integrating this 3D insight with magnification provided the visual acuity essential for navigating these variations, proving that a meticulous, technology-driven protocol is vital for treating such endodontic variants [5].

Case Report
A 15-year-old female patient reported to the Department of Conservative Dentistry and Endodontics with a chief complaint of pain in the lower right posterior tooth region Since1 week. The patient's medical history was non-contributory. Clinical examination of the mandibular right second premolar (45) revealed extensive deep occlusal caries. The tooth exhibited significant tenderness to vertical percussion, suggesting an inflammatory involvement of periapical tissues. The tooth exhibited no mobility, confirming that the periodontal ligament and attachment apparatus remained functionally intact. On cold test using refrigerant spray (Coltene Whaledent) tooth elicited an immediate and lingering response. Thermal evaluation was further confirmed with heat test using heated gutta-percha which produced a delayed and lingering response, a classic indicator of irreversible pulpal inflammation. Radiographic examination (IOPAR) (Figure 1a) showed radiolucency involving the pulp space in relation to tooth 45 and presence of 2 distinct roots (mesial and distal). A diagnosis of symptomatic irreversible pulpitis with symptomatic apical periodontitis was established. Non-surgical root canal treatment was planned with tooth 45.
Informed consent was obtained before treatment. Caries excavation was performed under local anaesthesia and rubber dam isolation. Upon initiating endodontic access and exploring the pulp chamber floor, C shaped configuration with 3 distinct canals were successfully explored. The canal orifices and floor of the pulp chamber were noted to have significant apical displacement. Due to complex internal morphology patient was referred for CBCT.
In CBCT the mesiobuccal (MB), distobuccal (DB), and distolingual (DL) canals were identified in C2 configuration according to Fan *et al* (2004) classification (Figure 1e). The pulp chamber was elongated suggestive of hypertaurodontism according to Shifman and Shaw (1978)

classification (Figure 1c). Manual scouting and visual inspection under magnification reflected the same.

The canals were negotiated using ISO sizes 10,15 and 20 K-files, and working length was determined using an electronic apex locator (Tri auto ZX 2 plus) and confirmed radiographically (Figure 2b). Cleaning and shaping were performed with protaper gold rotary instruments up to size F2. Irrigation was carried out with 5.25% sodium hypochlorite (safe endo) after each instrument change, sonic activation (super endo) of NaOCl was done. Final irrigation was done with 17% ethylenediaminetetraacetic acid (EDTA).

The canals were dried with sterile paper points, and the master cone fit was verified radiographically. Obturation was performed using apical plug and thermoplastic gutta-percha (Meta Biomed obturator) with bio ceramic sealer (safe endo bioactive RCS). Post-obturation radiograph (Figure 2d) confirmed well-obturated canals and post obturation restoration was done with light-cured composite resin (Figure 2e). Stainless steel crown was given as a definitive interim restoration (Figure 2f).

Discussion

The mandibular second premolar is often called the "Endodontic Enigma" because, while it typically presents with a single canal (Vertucci type I) in approximately 85-95% of cases, its internal anatomy can be incredibly unpredictable. The presence of three root canals (Vertucci type VIII) is considered scarce, with an incidence reported between 0.1% - 1% in Indian population [6, 7]. the vast majority of mandibular second premolars are single-rooted with a prevalence of 98% - 99.9 and presence of two roots is a rare anatomical variation with prevalence of 0.1% to 1.5% in India [8].

Furthermore, the C-shaped canal configuration in premolars is far less common than in mandibular second molars. In the second premolar, the prevalence of C-shaped canals is estimated to be as low as 0.6% - 1% in INDIAN population [9]. According to Fan's classification, a C2 configuration (semicolon shape) indicates that the dentine separates one distinct canal from a C-shaped groove, which poses significant cleaning and shaping challenges due to the narrow isthmus and irregular space [10].

Taurodontism is a developmental anomaly where the pulp chamber is vertically elongated at the expense of the roots, caused by the failure of Hertwig's Epithelial Root Sheath (HERS) to invaginate at the proper horizontal level. Hypertaurodontism in mandibular 2nd premolars occur approximately < 0.5 % of the Indian population [11]. Apical displacement of the pulpal floor complicates endodontic access and localization of the orifices, as they are often positioned very deep within the root [12].

CBCT served as the architectural blueprint overcoming the inherent limitations of 2D periapical radiographs, which often mask internal anatomy through superimposition [13]. CBCT in axial view clarified the transition of root canals across three distinct levels of root. In coronal third of root MB, DB and DL canals were found to be fused forming continuous integrated volume (Figure 1d). In the middle third MB, DB canals were fused while DL canal was separate (Figure 1e). In apical third of root all canals had separate exiting points (Figure 1f). In sagittal view apical displacement of orifices was seen, CBCT dictated exactly where to look for canal orifices (Figure 1c). CBCT helped visualize danger zones in axial section showing thin buccal and lingual walls (Figure 1e).

Dental operating microscope (DOM) provided navigation during instrumentation. Magnification and coaxial illumination were indispensable when dealing with apical displaced floor [14]. DOM allowed for the visual appreciation of C shaped groove. This visual clarity was vital for distinguishing between actual canal orifices and narrow isthmuses connecting canals [15]. DOM allowed precise negotiation of MB, DB and DL canals (Figure 2g). DOM enabled visual verification of the adaptation master cone fit in apical third before proceeding with thermoplasticized gutta-percha for the remaining portion of the canals.

In a C2 configuration, the main canals (MB, DB, DL) are connected by a narrow, ribbon-like isthmus. The fusion of canals in cervical third suggests presence of wide isthmus or web of tissues. Isthmuses contain dense layers of polymicrobial biofilms, often dominated by enterococcus faecalis and anaerobic species [16]. Even after the main canals are cleaned, the isthmus remains the source of reinfection. Instrumentation of main canals often inadvertently pushes dentinal chips and contaminated debris into isthmus plugging and making chemical disinfection even harder. Mechanical instruments are circular and cannot effectively clean these flattened, irregular spaces [17].

To overcome these anatomical challenges sonic activation of NaOCl was utilized. the hydrodynamic pressure and acousting streaming generated is more effective at shearing off biofilms from the isthmus and dissolve organic debris [18]. unlike ultrasonic activation, sonic tips are typically made of flexible, non-cutting polymer which minimizes the risk of accidental dentin removal or strip perforation in such complex cases [19].

Apical plug with a master cone in apical third (3-5mm) using Schilders technique followed by thermoplasticized gutta-percha (injectable technique) for the coronal two-thirds was used to address the large volumetric space of C shaped and taurodontic pulp chamber [20]. An apical plug provides a stable physical barrier that resists displacement. The pressure required for compaction can easily lead to significant overextrusion of hot gutta-percha into periapical tissues, causing irritation and delayed healing. This down pack phase acts as controlled stop against which the rest of the canal can be backfilled with thermoplasticized gutta-percha without risk of extrusion. Warm vertical compaction has demonstrated a significantly higher effectiveness of sealing isthmuses in C shaped canals (95.9 %) compared to cold lateral condensation (87.74%) [21]. Unlike cold techniques, the application of heat in warm vertical compaction reduces the viscosity of gutta-percha, allowing it to adapt better to canal wall irregularities and effectively seal lateral canals and isthmuses [22].

Bioceramic sealers have a very low film thickness and high flowability. They can penetrate into the microscopic irregularities and accessory canals of the C-shaped system through capillary action, which is vital when using a single-cone or hydraulic condensation technique [23]. Unlike resin-based sealers that fail in the presence of moisture, bioceramics are hydrophilic. They utilize the moisture within the dentinal tubules to initiate the setting reaction.

Once set, they form hydroxyapatite, creating a chemical bond between the sealer and the dentin wall [24, 25]. Bioceramic sealers are dimensionally stable and actually exhibit a slight expansion (approximately 0.2%) upon setting, which enhances the hermetic seal in the wide, ribbon-like areas of C-shaped canals. Additionally, their high pH (above 12) during setting provides a potent antimicrobial effect against persistent bacteria like E. faecalis [26].

Conclusion

The successful management of a mandibular second premolar exhibiting the "Endodontic Enigma"—a rare confluence of Taurodontism, a C-shaped (C2) canal configuration, and multiple roots—requires a shift from traditional methods.

The integration of advanced diagnostics and specialized clinical tools is not merely supplementary but essential for a predictable outcome in such complex cases

- **Three-Dimensional Precision:** CBCT is the indispensable "architectural blueprint," eliminating the guesswork of 2D imaging by revealing the specific axial transitions of canals and identifying "danger zones" in thin dentinal walls.
- **Visual Command:** The Dental Operating Microscope (DOM) converts a blind procedure into a controlled navigation, allowing the clinician to differentiate between true orifices and isthmuses, especially when the pulpal floor is apically displaced due to taurodontism.
- **Biological Debridement:** Given the limitations of mechanical instrumentation in ribbon-like spaces, sonic activation of irrigants is critical. It provides the necessary hydrodynamic energy to shear biofilms from isthmuses without the risk of strip perforation.
- **Obturation:** The combination of a controlled apical plug, thermoplasticized gutta-percha, and bioceramic sealers addresses the high volumetric demands of the system. This approach leverages the hydrophilic, expansive, and antimicrobial properties of bioceramics to ensure a stable, three-dimensional seal in areas where cold condensation techniques may fail.

Ultimately, while the internal anatomy of the mandibular second premolar remains unpredictable, the synergy of CBCT, DOM, passive activation and warm vertical compaction help transforming a high-risk anatomical anomaly into a manageable clinical success.

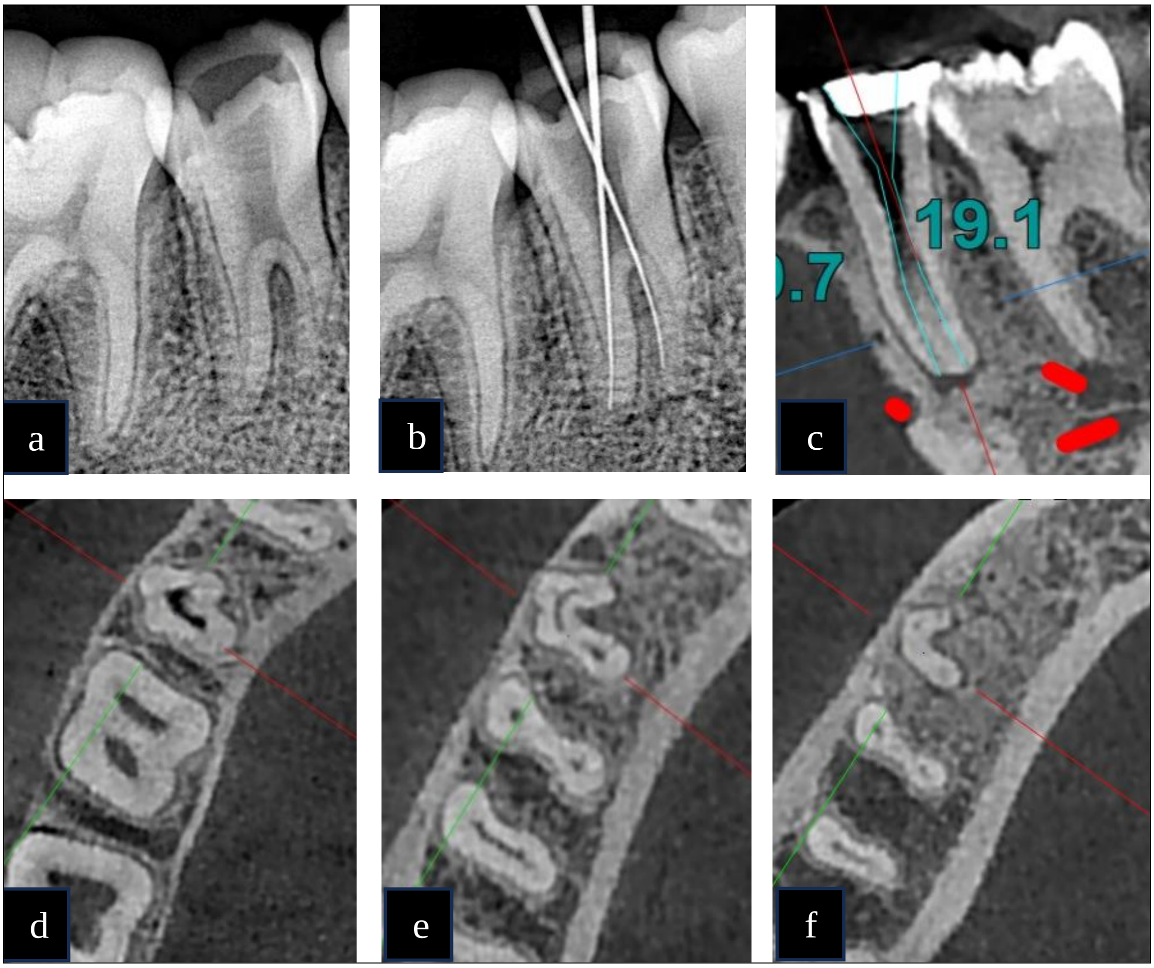

Fig 1:(a) Preoperative radiograph. (b) Exploration of canals prior to CBCT. (c) Sagittal view CBCT showing MB, DB canals with elongated pulp chamber. (d) Axial view CBCT at cervical one third of root showing all canals fused. (e) Axial view CBCT at middle one third of root showing MB, DB canals fused and separate DL canal. (f) Axial view CBCT at apical one third of root showing three exiting points.

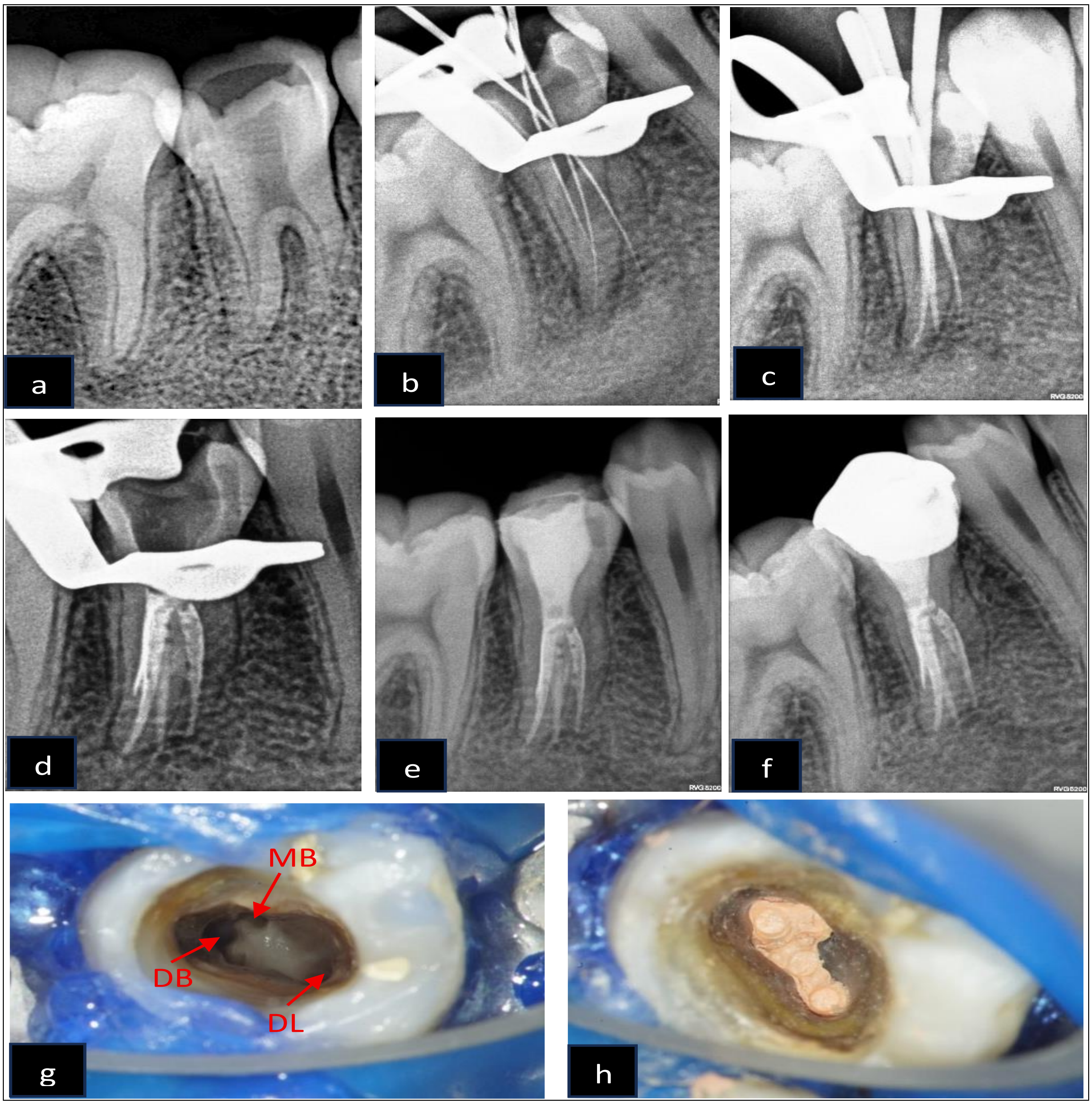

Fig 2: (a) Preoperative radiograph. (b)Working length determination. (c)Master cone fit check. (d)Obturation. (e) Post endodontic restoration. (f) stainless steel crown. (g) Access opening showing MB, DB, DL canals under 0.6 x magnification. (g) Thermoplasticised gutta-percha after obturation.

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