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Endodontic Management of Aberrant Root Canal Anatomy in Maxillary and Mandibular First Premolars: Case Series

Sadel khaoula DDS*, Laslami Kaoutar and Jabri Mouna

Faculty of Dental Medicine, Hassan II University, Casablanca, Morocco.

***Correspondence:**
Sadel khaoula, DDS, Faculty of Dental Medicine, Hassan II University, Casablanca, Morocco.

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ABSTRACT

Aim: *To report and discuss the endodontic management of maxillary and mandibular premolars presenting complex root canal anatomy.*

Background: *Premolars exhibit significant anatomical variability, which may lead to endodontic failure when additional canals are not identified and treated. Successful root canal therapy relies on accurate diagnosis, appropriate access cavity design, thorough chemo-mechanical preparation, and three-dimensional obturation. Therefore, careful assessment of root canal morphology is essential to ensure complete debridement and filling of the entire canal system.*

Case Presentation: *Five cases are presented. Two cases discussed the endodontic treatment and retreatment of maxillary first premolars with three canals. The other three cases concerned mandibular first premolars with two, three and four canals.*

In all cases, it was the in-depth radiographic analysis, combined with adapted access cavity design and meticulous canal exploration under magnification (loupes). Proper chemo-mechanical preparation and three-dimensional filling of the entire root canal system were then performed.

Conclusion: *Maxillary and mandibular premolars present complex and highly variable canal configurations that may compromise treatment outcomes if not properly identified. A thorough understanding of root canal anatomy, combined with appropriate diagnostic and clinical strategies, is essential for achieving successful endodontic outcomes.*

Clinical significance: *These cases highlight the importance of systematic clinical and radiographic evaluation in detecting additional canals and support a structured approach to managing premolars with complex root canal anatomy.*

Keywords

Mandibular premolar, Maxillary premolar, Root canal anatomy, Root canal variation, Complex anatomy.

Introduction

the ultimate goal of any endodontic treatment is to disinfect and seal three-dimensionally the root canal system. However, achieving this goal is often challenging due to the inherent complexity and variability of root canal anatomy. The risk of missing anatomy during root canal treatment is high in all categories of teeth but the likelihood of finding aberrant canal configurations is higher in premolars and molars [1].

Premolars -particularly mandibular premolars- are considered among the most difficult to treat endodontically. Studies such as Vertucci Root Canal Morphology Study have demonstrated that although a single canal configuration is most common, multiple canal systems, including bifurcations and trifurcations, may occur [2]. Also, it has been shown that the event of multiple canals in mandibular 1st premolars is between 11.53% and 46%, and the

potentiality of a 2nd root canal has been reported to range between 0.4% to 48.1% using cone beam computed tomography (CBCT) [3].
Similarly, Cleghorn Mandibular Premolar Anatomy Review revealed that a single canal was present in 75.8% of the teeth. Two or more canals were found in 24.2% of the mandibular premolar studied, emphasizing the clinical importance of identifying these variations to avoid treatment failure [4].

Maxillary first premolars exhibit significant anatomical variability, with the majority presenting two canals; however, the presence of a third canal has been reported in a small but clinically relevant percentage of cases. A recent CBCT-based study by Cebeci and Akmansoy showed that 4.14% of first premolars exhibited one root–one canal, 24.20% had one root–two canals, 70.70% had two roots–two canals, and only 0.95% had three roots–three canals [5].

Failure to detect such variations is a known cause of persistent infection and endodontic failure. Therefore, a comprehensive understanding of root canal anatomy, combined with meticulous clinical and advanced radiographic evaluation, is essential for successful endodontic management [5].

This article presents five clinical cases illustrating different aberrant anatomical configurations in premolars and discusses their endodontic management implications.

Anatomical Variations in Premolars: Clinical Significance

Atypical dental anatomy refers to variations in the shape, size, and number of roots and canals within a tooth. These variations can make root canal treatment more challenging and complex. Failure to identify and address these variations can result in inadequate debridement, persistent infection, postoperative pain, and ultimately treatment failure.

A thorough understanding of pulp cavity morphology is essential for successful endodontic therapy. Clinicians must always consider the possibility of additional canals, particularly in premolars, where anatomical variability is common. The ability to detect and manage these variations relies on a combination of anatomical knowledge, diagnostic tools, and clinical expertise [6].

Root Canal Configuration Classifications

Understanding root canal morphology is facilitated by classification systems that describe the possible anatomical configurations.

Weine's Classification

Introduced in 1969, Weine's classification describes four main canal configurations:

Type I: A single canal extending from the pulp chamber to the apex

Type II: Two canals leaving the chamber and merging into one before the apex

Type III: Two separate canals extending from the chamber to the apex

Type IV: One canal dividing into two distinct canals toward the apex [7] (Figure 1).

Vertucci's Classification

Type I: (1) Single canal extends from the pulp chamber to the apex.

Type II: (2–1) Two separate canals leave the pulp chamber and join short of the apex to form one canal.

Type III: (1–2–1) One canal leaves the pulp chamber and divides into two in the root; the two then merge to exit as one canal.

Type IV: (2) Two separate distinct canals extend from the pulp chamber to the apex.

Type V: (1–2) One canal leaves the pulp chamber and divides short of the apex into two separate distinct canals with separate apical foramina.

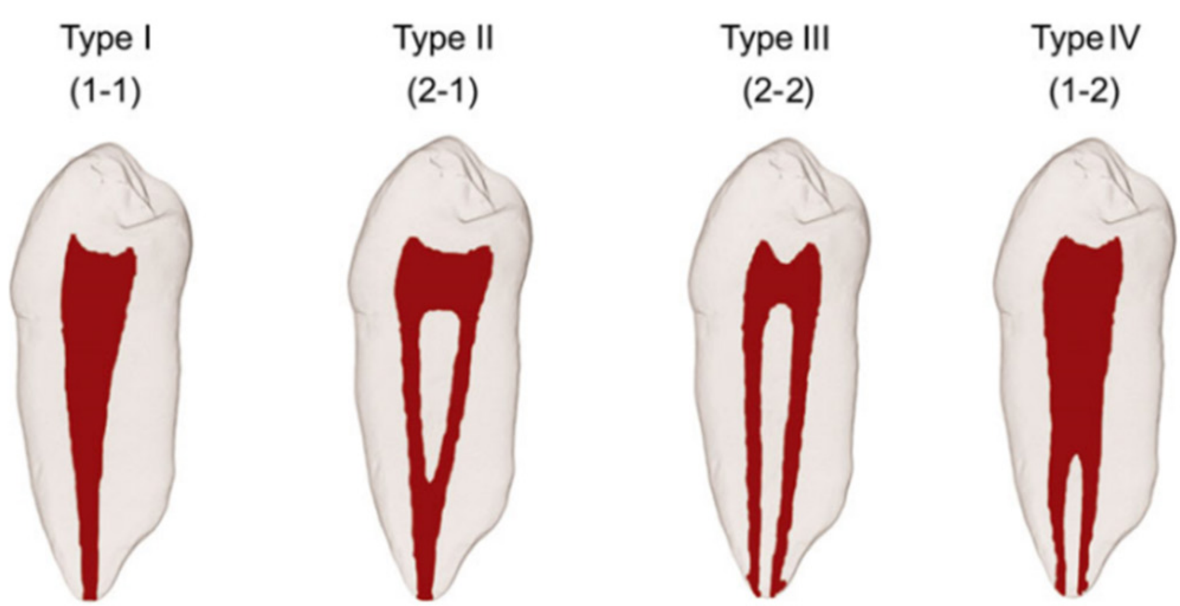

Figure 1: Diagrammatic representations of Weine's classification for root canal morphology [8].

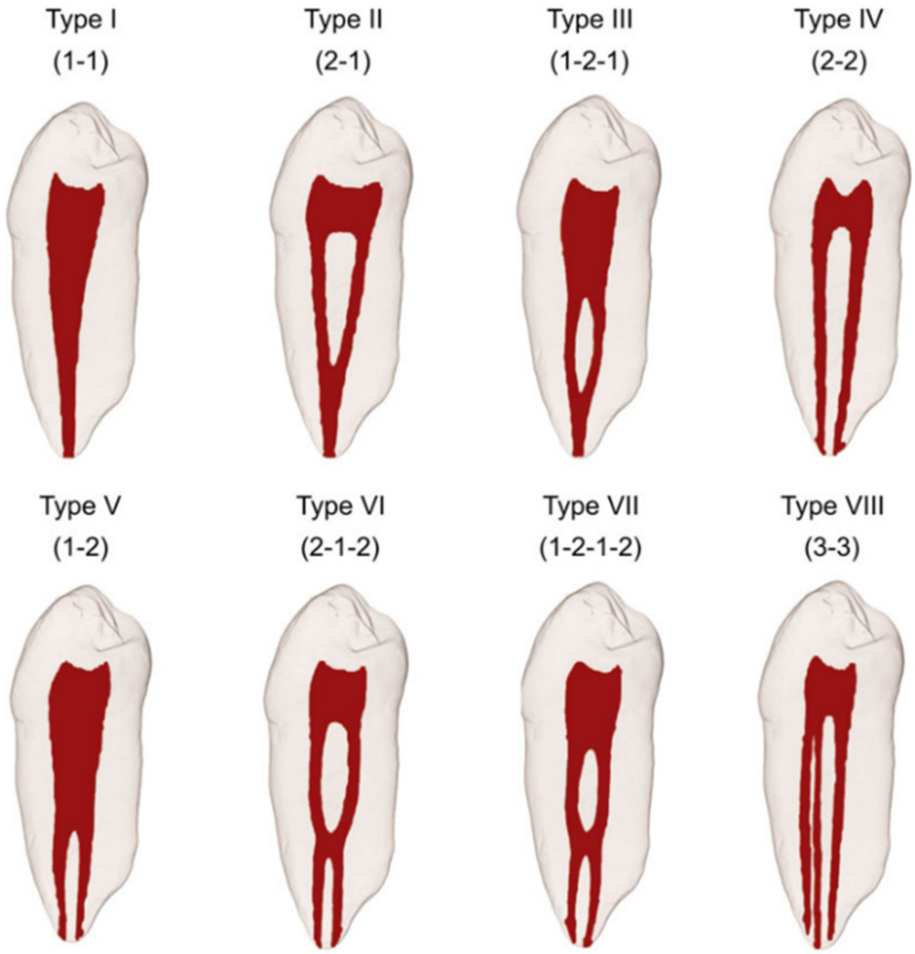

Figure 2: Diagrammatic representations of Vertucci's classification for root canal morphology [8].

Type VI: (2–1–2) Two separate canals leave the pulp chamber, merge in the body of the root, and redivide short of the apex to exit as two distinct canals.

Type VII: (1–2–1–2) One canal leaves the pulp chamber, divides and then rejoins in the body of the root, and finally redivides into two distinct canals short of the apex.

Type VIII: (3) Three separate distinct canals extend from the pulp chamber to the apex/ (Figure 2).

These classifications provide a framework for anticipating anatomical variations, particularly in premolars [9].

Key Considerations in The Diagnostic Approach of Aberrant Anatomy

Accurate diagnosis of atypical anatomy requires a careful correlation between clinical findings and radiographic interpretation.

Clinical indicators

Before access cavity preparation, certain anatomical features may suggest the presence of additional canals, such as an increased mesiodistal dimension in maxillary premolars [10].

During access cavity preparation, good visibility is a must. The use of magnification (dental loupes or operating microscope) combined with appropriate instruments -such as micro-openers and ultrasonic tips- facilitates the identification of canal orifices (Figure 3).

Tactile feedback during instrumentation also plays a critical role. The sensation of a "catch" on the canal wall, deviation of the instrument, or persistent bleeding despite instrumentation may indicate the presence of additional canals.

Radiographic indicators

In straight-on radiographs, if the mesiodistal width of the midroot image of the maxillary premolar is equal to or greater than the image of the crown of the tooth, then there is a high probability that the tooth has three canals [10].

Then it's important to visualize the position of the pulp chamber. This requires the evaluation of orthogonal and eccentric radiographs, enabling examination at coronal, cervical and root levels.

In a two-dimensional, *peri-apical* radiographs, key radiographic signs suggestive of additional canals include:

- Abrupt loss of canal continuity: "Fast break"

Figure 3: Dental loupes – microscope – ultrasonic tips – micro-openers.

- Radiolucent lines suggesting canal division (Figure 4)
- Non-centered file position [11]

The use of cone-beam computed tomography (CBCT) provides three-dimensional visualization and significantly enhances the detection of complex canal systems. It is particularly useful in cases where conventional radiography is inconclusive [12].

Figure 4: Preoperative periapical radiograph showing premolars with suggestive signs of complex root canal anatomy, including a fast break and possible canal division in the middle third.

Access Cavity Design and Canal Localization

The access cavity in maxillary premolars is usually ovoid in shape in the bucco-palatal direction. Three-rooted maxillary premolars look anatomically similar to molars and have been referred to in the literature as "mini/ small molars". When there are three canals present, their location is similar to that of maxillary molars having a mesiobuccal, distobuccal and palatal canal.

So, the access cavity has to be modified to:

- Extend buccolingually
- Eliminate dentinal overhangs
- Allow direct visualization of all canal orifices

Failure to adequately modify the access cavity is a common cause of missed canals.

The internal anatomy of the tooth dictates the external contour of the access cavity. This concept is supported by the laws described by Krasner and Rankow:

- **Law of symmetry 1:** Except for maxillary molars, the orifices of the canals are equidistant from a line drawn in a mesiodistal direction through the pulp chamber floor.
- **Law of symmetry 2:** Except for maxillary molars, the orifices of the canals lie on a line perpendicular to a line drawn in a mesiodistal direction across the center of the floor of the pulp chamber.
- **Law of Color Change:** The color of the pulp chamber floor is always darker than the walls.
- **Law of orifices location 1:** The orifices of the root canals are always located at the junction of the walls and the floor.
- **Law of orifices location 2:** The orifices of the root canals are located at the angles in the floor-wall junction.
- **Law of orifices location 3:** The orifices of the root canals are located at the terminus of the root developmental fusion lines [13].

In certain cases, a "dynamic access cavity" approach may be required, involving slight enlargement of the cavity to achieve straight-line access and facilitate instrumentation.

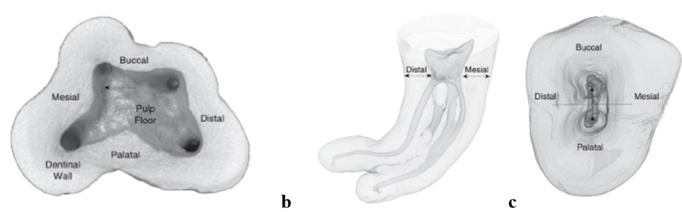

Figure 5: Krasner and Rankow guidelines (a): Law of Color Change, (b): Law of orifices location, (c): Law of symmetry.

Clinical Management of Premolars with Complex Anatomy

After recognizing root canal anatomy and identifying anatomical variations, the next step is clinical management, which we will develop using selected clinical cases.

Maxillary First Premolar

In most cases, the first maxillary premolar has 2 roots and 2 distinct canals. However, in 5% of cases, it may have 3 roots and 3 canals [2].

A Cone-beam computed tomography evaluation of the root morphology of the maxillary and mandibular premolars in a Moroccan subpopulation reported that only 2,7% of maxillary premolars presented a Vertucci type VIII root canal configuration [14].

Case no 1: Endodontic treatment of a three rooted premolar

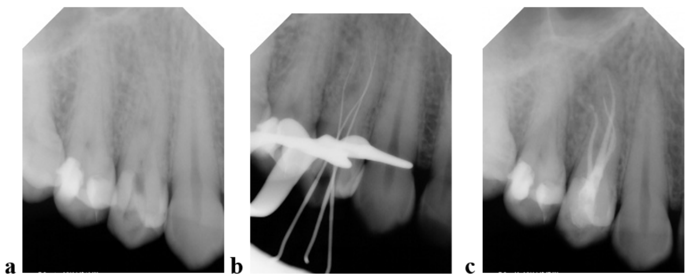

Figure 6: (a) pre-operative radiograph (b) working length radiograph (c) obturation.

A patient presented to the Department of Conservative Dentistry and Endodontics with a chief complaint of pain in the maxillary posterior region. Clinical examination revealed a previously restored maxillary first premolar exhibiting symptoms consistent with severe pulpitis.

Preoperative periapical radiographic assessment revealed several indicators of complex root canal anatomy, including a loss of continuity of the main canal ("fast break"), an unclear canal trajectory in the middle third, and the presence of multiple radiolucent lines within the root, raising suspicion of additional canal (Figure 6a).

Following administration of local anesthesia, the tooth was isolated under rubber dam, and the existing restoration was removed. A conventional ovoid access cavity was then created using a diamond round bur. Initial exploration of the pulp chamber using a size 10 K-file revealed 2 canal orifices- one palatal and one lingual- with an unusual trajectory of the buccal canal and an eccentric positioning of the K file, further supporting the presence of a buccal additional canal.

Then, careful inspection of the pulp chamber floor under magnification, combined with modification of the access cavity into a more triangular shape to achieve straight-line access, allowed the identification of three distinct canal orifices: mesiobuccal, distobuccal, and palatal. Canal scouting of the extra canal was performed using small K-files (sizes 08 and 10).

Once the presence of three canals was confirmed, endodontic management was adapted accordingly. Canal negotiation proved initially challenging due to the narrow diameter and possible curvature of the canals. A glide path was carefully established using small stainless-steel files prior to rotary instrumentation. The working length was determined using an apex locator (VDW) (Figure 6b).

2.5% sodium hypochlorite and 17% ethylene diamine tetra-acetic acid were used as irrigants during instrumentation, and a final manual activation of irrigants using gutta-percha points to enhance penetration into inaccessible areas of the complex canal system.

Following complete biomechanical preparation, the canals were dried with sterile paper points and obturated using single-cone hydraulic cold obturation method using Ceraseal (Meta-biomed) as a sealer. The postoperative radiograph showed satisfactory obturation (Figure 6c).

Case no 2: Retreatment of a maxillary premolar with three canals

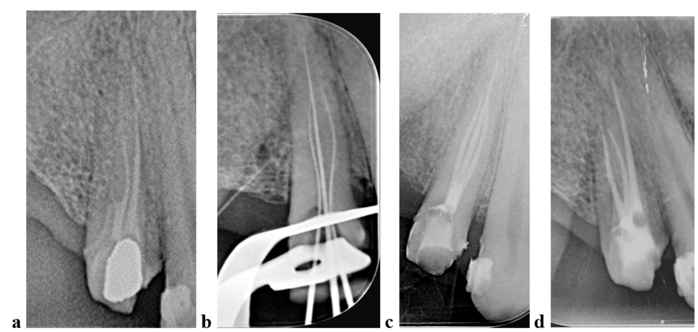

Figure 7: (a) pre-operative radiograph (b) working length radiograph (c) mastercone radiograph (d) obturation completed.

A 40-year-old female patient was referred to the department of conservative odontology and Endodontics in Casablanca for the retreatment of a maxillary first premolar prior to a crown. A root canal treatment had been previously performed.

The tooth was asymptomatic and had an amalgam restoration in place.

The pre-operative radiograph shows a poor endodontic treatment. The fusion of the sealer associated with an equality between the coronal and root M-D diameters suggests the presence of a 2nd buccal canal (Figure 7a).

Local anesthesia was administered. The tooth was isolated with a rubber dam and the amalgam restoration was removed using a diamond-coated round bur.

The oval access cavity was modified with a thin diamond flame bur to expose the disto-buccal orifice.

The oval access cavity design was rectified using a fine diamond-cone-rounded bur. Gutta percha was removed from palatal and Mesio-buccal canals using retreatment files and the Disto-buccal orifice was identified.

The DB canal was negotiated with a 10 K-file and coronal flaring completed. Working length determination using periapical radiographs and electronic apex locator (Figure 7b).

The glide path was prepared in all canals until a 20 K-file.

The mesiobuccal and distobuccal canals were prepared until a 4%/25 file. The palatal canal was larger and then prepared to a 6%/25.

Irrigation of the canals was performed using a 2,5% NaOCl solution and a manual activation.

Obturation was completed using matching taper gutta-percha cones and eugenol zinc oxide cement using the cold lateral condensation technique (Figure 7c, 7d).

The entire procedure was completed in two sessions. The patient was referred to the department of prosthodontics for a full coverage crown.

Mandibular First Premolar

The mandibular first premolar generally has a short, conical root. But its root canal system is also highly variable and can also have several anatomical variations, such as 2 (1.5%) or 3 (0.5%) canals [2].

The presence of a second canal, particularly a lingual canal, has been reported in approximately 11% of cases. Failure to detect and treat such variations is a common cause of endodontic failure.

Case no 3 : Mandibular First Premolar with WEINE Type II Configuration

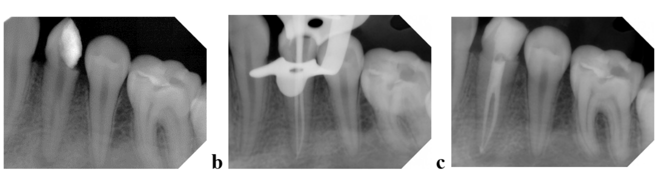

Figure 8: (a) pre-operative radiograph (b) mastercone radiograph (c) obturation completed

An 18-year-old male patient presented to the Department of Conservative Odontology and Endodontics in Casablanca with a chief complaint of spontaneous pain in the left mandibular region.

Clinical examination revealed a provisional restoration on the left mandibular first premolar. The tooth was sensitive to percussion.

Periapical radiographic examination revealed the presence of an apical radiolucency suggestive of periapical pathology, a bifurcation in the middle third of the root and an unclear image in the apical third, raising suspicion of complex canal anatomy (Figure 8a).

Access cavity preparation was modified to enhance detection of additional canals. The access was extended in the buccolingual direction to achieve an ovoid shape, allowing better visualization and exploration of the pulp chamber floor.

A small red flame bur was used to refine the access and locate the canal orifices. A second (lingual) canal was identified, branching from the main canal at an acute angle.

After establishing working length, chemomechanical preparation was performed using a rotary instrumentation system. Irrigation protocols were followed throughout the procedure (Figure 8b).

Obturation was completed using cold lateral condensation with gutta-percha and an epoxy resin-based sealer, ensuring a three-dimensional seal of the canal system (Figure 8c).

Case no 4: Mandibular First Premolar with canal trifurcation

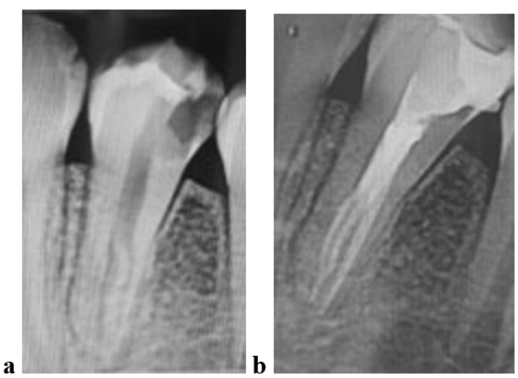

Figure 9: (a) pre-operative radiograph (b) obturation completed.

This case report describes the endodontic management of a mandibular first premolar presenting a rare trifurcated canal configuration. The case highlights the importance of careful clinical exploration and appropriate instrumentation strategies in managing complex root canal anatomies.

A 14-year-old patient presented with spontaneous nocturnal pain in the lower left region. Clinical examination revealed deep proximal caries, with exaggerated and lingering response to cold and tenderness to percussion, suggesting severe pulpitis with apical involvement.

Radiographic examination suggested the presence of multiple canals with unclear canal anatomy in the middle and apical thirds (Figure 9a).

Endodontic treatment was initiated under rubber dam isolation.

Access cavity preparation initially revealed a single canal in the coronal third. Further exploration demonstrated division into three distinct canals in the middle third: two buccal canals (mesiobuccal and distobuccal) and one lingual canal.

The lingual canal was the easiest to locate, being the widest and straightest. The mesiobuccal and distobuccal canals required careful negotiation using small stainless steel hand files (K-files sizes 08 and 10; MicroMega) to establish a reproducible glide path.

Working length was established using an apex locator (VDW) and confirmed radiographically.

Canal negotiation was achieved using K-files (sizes 08 and 10), followed by rotary instrumentation using a crown-down technique to final size 25 with 4% taper in the mesiobuccal and distobuccal canals and size 25 with 6% taper in the lingual canal.

Final irrigation was performed with 2.5% sodium hypochlorite and 17% EDTA combined with manual activation. Obturation was completed using lateral condensation with gutta-percha and zinc oxide eugenol sealer (Figure 9b).

Preoperative periapical radiographic examination revealed a radiolucent lesion approaching the pulp chamber, a periapical radiolucency consistent with apical pathology and evidence suggestive of complex root canal anatomy, with apparent division of the main canal in the middle third into more than two canals (Figure 10a).

Following administration of local anesthesia, the tooth was isolated under rubber dam, caries was removed and access cavity preparation was performed. Initial canal scouting with a size 10 K-file revealed difficulty in achieving straight-line access, raising suspicion of multiple canals.

Further exploration confirmed the presence of three canals. Working length determination was performed using an electronic apex locator and confirmed radiographically. Cleaning and shaping were carried out using rotary nickel-titanium instruments with a crown-down technique.

Copious irrigation was performed using 2.5% sodium hypochlorite with ultrasonic activation to enhance debridement of the complex canal system. After adequate biomechanical preparation, the canals were dried with paper points.

Obturation was performed using gutta-percha and a bioceramic sealer with the lateral condensation technique (Figure 10b).

The postoperative radiograph confirmed adequate filling of all canals, including the previously identified three canals and an additional fourth one (Figure 10c).

The patient was scheduled for follow-up and referred for definitive coronal restoration (Figure 10d).

Conclusion

Premolars exhibit significant anatomical variability and should always be approached with a high index of suspicion. Radiographic interpretation alone may be insufficient; meticulous clinical exploration is essential to detect additional canals, as missed canals remain a major cause of endodontic failure.

Case no 5: Mandibular First Premolar with 4 canals

Figure 10: (a) pre-operative radiograph (b) mastercone radiograph (c) obturation completed (d) 2 months follow-up.
A patient presented with pain in the lower posterior region. Clinical examination revealed a deep carious lesion affecting the mandibular premolar. The tooth was sensitive to percussion, suggesting pulpal and periapical involvement.

Adjunctive tools such as horizontal tube shift radiography, CBCT, and magnification significantly enhance the identification of complex canal systems and should be considered in doubtful cases. When multiple canals are present, treatment strategies must be adapted to ensure complete debridement and obturation while minimizing iatrogenic risks.

Clinicians should also be aware of possible bilateral symmetry in canal morphology.

Successful management relies on accurate diagnosis, thorough exploration, and appropriate adaptation of endodontic techniques. Recognition of these variations is critical to achieving predictable and long-term treatment success.

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