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Curved Root Canal Management in Endodontics: Case Series

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ABSTRACT: The non-surgical management of curved root canals requires a harmonious combination of advanced diagnostic tools, skilled clinical execution, and appropriate selection of instruments to navigate complex canal anatomies. A meticulous pre-operative assessment using two-dimensional imaging is fundamental for understanding canal morphology and anticipating procedural challenges. The clinician's proficiency in utilizing both manual and rotary instruments plays a vital role in negotiating severe curvatures while achieving effective cleaning and disinfection of the root canal system. Equally essential is the application of canal assessment criteria to determine treatment difficulty and guide the intervention strategy.

This case series presents the endodontic management of three anatomically curved and challenging cases, emphasizing the significance of diagnostic precision, operator expertise, and evidence-based instrumentation protocols in achieving predictable and biologically favourable outcomes.

I. INTRODUCTION

The primary aim of root canal therapy is to thoroughly clean, shape, and three-dimensionally obturate the canal system to eliminate infection, prevent reinfection, and ensure long-term periapical healing and tooth function.[1] Effective instrumentation forms the cornerstone of root canal therapy as it enables the removal of necrotic tissues and microbial biofilms, creates a proper canal taper to allow efficient irrigation and disinfection, and prepares an ideal shape for obturation.[2]

However, these objectives become considerably harder to achieve in teeth with pronounced root curvatures. Narrow and curved canals can increase the risk of procedural mishaps during canal preparation.[3] Common complications include ledge formation, canal transportation, zipping, perforations, instrument separation, asymmetric dentin removal, and distortion of the original canal anatomy (Roane et al., Schäfer &Dammaschke).[3]

The following section outlines three case reports demonstrating the endodontic management of severely curved canals.

II. CASE REPORTS

CASE 1

A 55-year-old male patient presented to the outpatient department with pain in the upper left posterior region. Clinical examination revealed a deep cervical abrasion approximating the pulp in tooth #24, which was tender on percussion. Pulp sensibility testing elicited no response. A pre-operative intraoral periapical (IOPA) radiograph showed taurodontic roots associated with tooth #24, periapical radiolucency, an impacted permanent left canine, and a retained deciduous canine. Based on the findings, a diagnosis of **pulp necrosis with symptomatic apical periodontitis** was made (AAE 2023).

The degree of curvature was determined using the **Schneider method**, which indicated a moderately curved palatal canal. After obtaining informed consent, local anesthesia (2% lignocaine with 1:80,000 adrenaline; Lignox 2%) was administered. The tooth was isolated using rubber dam, and access was gained under **4× magnification and illumination** (Admetec Ergo, Admetec Ltd., Haifa) using a #4 round bur (Mani Inc., Japan). Initial canal negotiation was performed using pre-curved #8 and #10 K-files. The coronal pre-flaring was done rotary orifice opener (25/.12) HyFlex EDM (Coltene, Switzerland). A **micro-glide path** ensures a smooth, reproducible path for rotary files, which is important in maintaining the original canal anatomy, thus avoiding canal transportation and ledging. It improves file navigation and also prevents instrument separation. After negotiating the canal by careful watch winding motion, the working length determination was done with an electronic apex locator (Airpex, Eighteeth Apex Locator, China) and was confirmed radiographically using the long-cone paralleling technique with a #10 K-file. The initial rotary instrumentation was done using HyFlex EDM 10/.05 (Coltene, Switzerland). Sequential Instrumentation was progressed up to a master apical size 25, taper 0.04 (HyFlex CM, Coltene) in both buccal and palatal canals. The apical portions of the canal were prepared by short amplitude filing. Special attention was paid to frequent recapitulation and irrigation of the canals to avoid blockage and removal of tissue debris. The canals were irrigated

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using 5.25% sodium hypochlorite and saline and the smear layer was removed with 17% EDTA (PrevestDenPro, J&K). A master cone radiograph was taken with 4% 25 gutta-percha cones (HyFlex CM Spitzen, Coltene). **Single-cone obturation** was carried out using a **bioceramic sealer** (BIO-C Repair MTA, Angelus, Brazil). The access cavity was restored with **resin-modified glass ionomer** (Prevest Fusion i-Seal, J&K), followed by **core build-up with light-cure composite**(Tokuyama Palfique LX5).The patient was reviewed periodically over six months and remained asymptomatic throughout.

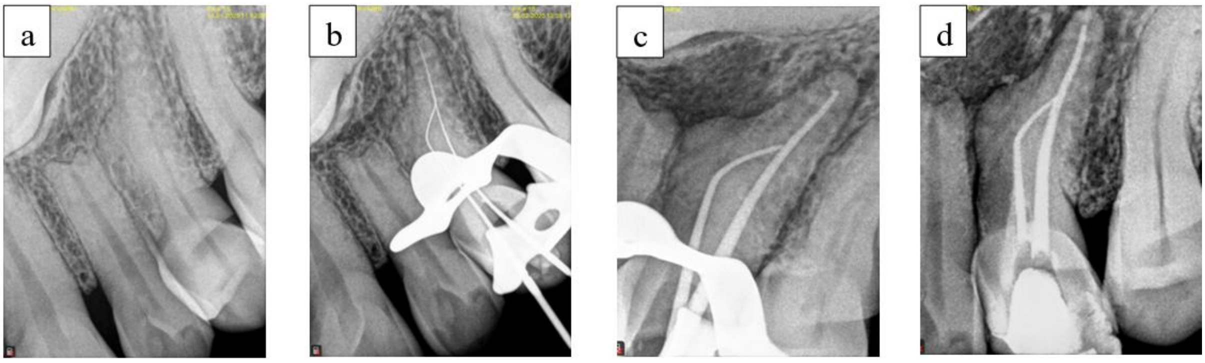

FIG1. a) Pre-operative IOPA x-ray. b) working length IOPA x-ray. c) Master apical cone x-ray. d) post-operative x-ray.

CASE 2

A 46-year-old female patient reported to the dental outpatient department with a chief complaint of pain in the lower right posterior region. Clinical examination revealed deep dentinal caries in tooth #48, with teeth #46 and #47 missing. Pulp sensibility testing showed a lingering response, and the tooth was tender on percussion. A pre-operative intraoral periapical (IOPA) radiograph revealed a curved mesial root associated with tooth #48. Based on these findings, a diagnosis of **symptomatic irreversible pulpitis with symptomatic apical periodontitis** was established.

A comprehensive treatment plan was designed for the prosthetic rehabilitation of the mandibular posterior segment using a fixed partial denture involving teeth #45, 46, 47, and 48. Before initiating endodontic therapy, the curvature of the mesial root was assessed using **Schneider's method**, which revealed a pronounced curvature in the mesial canal. After obtaining informed consent, local anesthesia (2% lignocaine with 1:80,000 adrenaline; Lignox 2%) was administered.

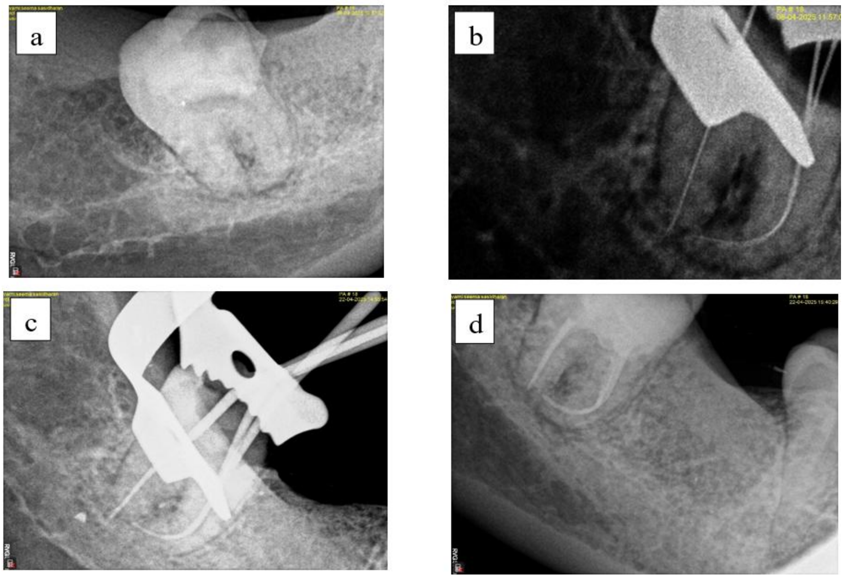

FIG 2. a) Pre-operative IOPA x-ray. b) working length IOPA x-ray c) Master apical cone IOPA x-ray d) Post-operative IOPA x-ray.

Following **rubber dam isolation** under magnification and illumination (Admetec Ergo 4×), endodontic access was prepared using a #4 round bur (Mani, Japan). Initial canal negotiation was carried out using #8 and #10 K-files

The coronal pre-flaring was done rotaryorifice opener (25/.12) HyFlex EDM (Coltene, Switzerland). A micro-glide path ensures a smooth, reproducible path for rotary files, which is important in maintaining the original canal anatomy, thus avoiding canal transportation and ledging. It improves file navigation and also prevents instrument separation. After negotiating the canal by careful watch winding motion, the working length determination was done with an electronic apex locator (Airpex, Eighteeth Apex Locator, China) and confirmed radiographically using the long-cone paralleling technique with a #10 K-file.The initial rotary instrumentation was done using HyFlex EDM 10/.05 (Coltene, Switzerland). Sequential Instrumentation was progressed up to a master apical size 25, taper 0.04 (HyFlex CM, Coltene) in both buccal and palatal canals. The apical portions of the canal were prepared by short amplitude filing. Special attention was paid to frequent recapitulation and irrigation of the canals to avoid blockage and removal of tissue debris. The canals were irrigated with 5.25% sodium hypochlorite, and the smear layer was removed using 17% EDTA (PrevestDenPro, India).

A **master cone radiograph** was obtained with 4% 25 gutta-percha cones (HyFlex CM Spitzen, Coltene). **Single-cone obturation** was completed using a **bioceramic sealer** (BIO-C Repair MTA, Angelus, Brazil). The access cavity was sealed with **resin-modified glass ionomer** (Prevest Fusion i-Seal, J&K), and **core build-up** was performed with **light-cure composite resin** (Tokuyama Palfique LX5).

The patient was reviewed periodically over a six-month follow-up period and remained asymptomatic. Regular follow-up visits were advised and maintained.

CASE 3

A 50-year-old male patient presented to the dental outpatient department with pain in the upper left posterior region. Clinical examination revealed deep dentinal caries approximating the pulp in tooth #25. Pulp sensibility testing produced a negative response, and an intraoral periapical (IOPA) radiograph demonstrated periapical radiolucency with a bayonet-shaped (S-shaped) canal curvature. The tooth was tender on percussion. Based on the clinical and radiographic findings, a diagnosis of **pulp necrosis with symptomatic apical periodontitis** was established.

Before initiating endodontic therapy, the curvature of the canals was evaluated using **Schneider's method**, which revealed severe curvatures in both the buccal and palatal canals. After obtaining informed consent, local anaesthesia (2% lignocaine with 1:80,000 adrenaline; Lignox 2%) was administered.

Following **rubber dam isolation**, access to the pulp chamber was achieved under **magnification and illumination** (Admetec 4×) using a #4 round bur (Mani, Japan). The initial negotiation of the canals was performed with #8 and #10 K-files. The **working length** was established using an electronic apex locator (Airpex, Eighteeth Apex Locator, China) and confirmed radiographically via the long-cone paralleling technique with a #10 K-file.

A preliminary glide path was created with a #10 K-file, followed by a **micro-glide path** using HyFlex EDM 10/.05 (Coltene, Switzerland).After establishing micro-glide path,the coronal pre-flaring was carried out using Ni-Ti orifice opener (25/.12)HyFlex EDM (Coltene, Switzerland). Coronal pre-flaring was done to reduce the influence of coronal curvature on the apical curvature.The rotary files were advanced in a pecking motion to prevent instrument separation. Sequential Instrumentation was progressed up to a master apical size 25, taper 0.04 (HyFlex CM, Coltene) in both buccal and palatal canals. The apical portions of the canal were prepared by short amplitude filing. Special attention was paid to frequent recapitulation and irrigation of the canals to avoid blockage and removal of tissue debris. The canals were irrigated with **5.25% sodium hypochlorite**, and the **smear layer** was removed using **17% EDTA** (PrevestDenPro, J&K).

A **master cone radiograph** was taken using 4% 25 gutta-percha cones (HyFlex CM Spitzen, Coltene). **Single-cone obturation** was performed with **bioceramic sealer** (BIO-C Repair MTA, Angelus, Brazil). The **access cavity** was sealed with **resin-modified glass ionomer** (Prevest Fusion i-Seal, J&K), and **core build-up** was completed using **light-cure composite resin** (Tokuyama Palfique LX5).

The patient was monitored periodically over a six-month follow-up period and remained asymptomatic throughout. Regular follow-up is ongoing.

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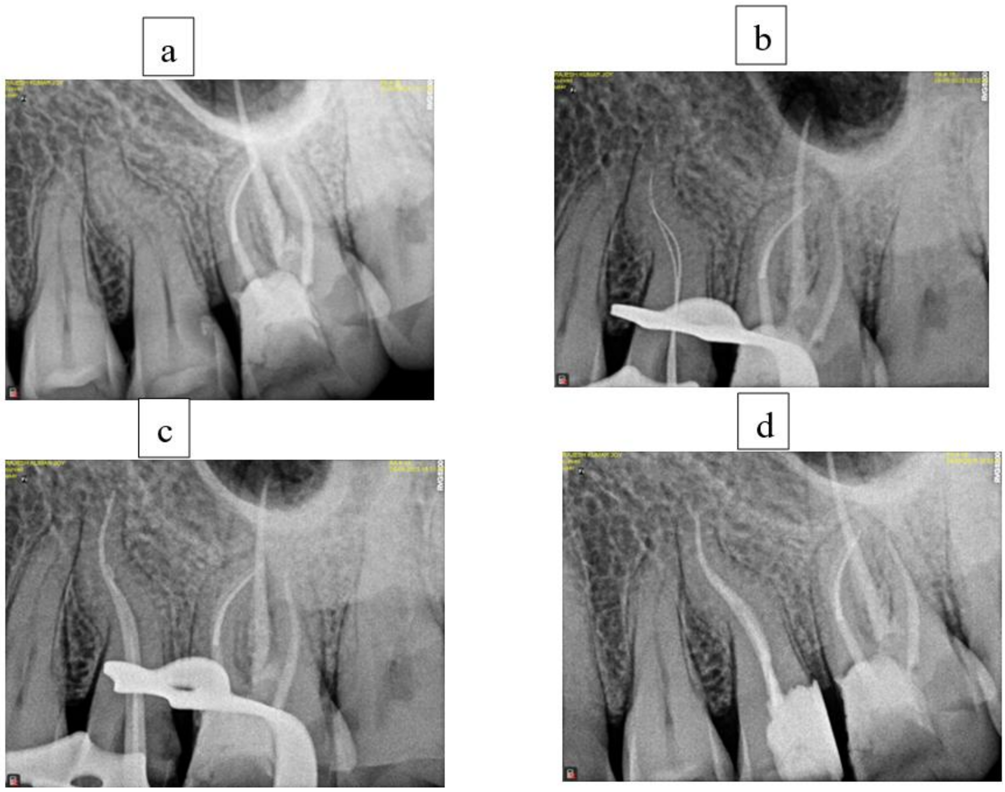

FIG 3. a) Pre-operative IOPA x-ray b) working length IOPA x-ray c) Master cone IOPA x-ray d) Post-operative IOPA x-ray

III. DISCUSSION

Schilder (1974) emphasized that effective root canal therapy involves thorough cleaning of the canal system to eliminate organic remnants and shaping the canals to facilitate a three-dimensional obturation. These objectives are readily achieved in wide and relatively straight canals; however, the same may not hold for narrow or markedly curved root canals. In clinical practice, canal morphology rarely follows a straight path—curvatures may be apical, gradual, sickle-shaped, moderate-severe, bayonet,or S-shaped, or even dilacerated in nature.[4]

According to Schäfer and Dammaschke, instrumentation within curved canals generates torsional stress and cyclic fatigue, producing uneven forces that can lead to canal transportation, ledge formation, apical perforation, or instrument separation.[5] To anticipate these challenges, **multiple intraoral periapical radiographs** taken from different horizontal angulations can help reveal canal morphology adequately for treatment planning. The advent of **cone-beam computed tomography (CBCT)** has further enhanced the clinician's ability to visualize complex canal geometries in three dimensions, thereby improving accuracy and safety during instrumentation.

Several methods exist for assessing root canal curvature in both 2D and 3D planes. Conventional periapical radiographs provide only a two-dimensional view, allowing evaluation of mesiodistal curvatures but not buccolingual deviations.[6] In contrast, **CBCT imaging** overcomes these limitations by offering a more detailed, three-dimensional perspective of the canal anatomy.[7]

Among various measurement systems, **Schneider's method** remains the most widely adopted, classifying canals as:

- **Straight:** ≤ 5°
- **Moderate:** 10–20°
- **Severe:** 25–70° [8]

The **initial step in endodontic therapy** is establishing a smooth, unobstructed pathway from the canal orifice to the apical constriction. This task is particularly challenging in curved canals due to anatomical complexities and potential blockages. Using fine hand files in the early stages helps preserve canal patency and minimize procedural complications such as ledging or transportation. **Coronal pre-flaring** and creation of a **glide path** further reduce the likelihood of instrument separation.[9]

Hand **K-files** provide greater tactile feedback and control in narrow or complex canals, whereas **motor-driven glide-path files** expedite the process and decrease operator fatigue, though they may pose a higher risk of instrument fracture in tight curvatures. After locating the canal orifice, #06–#10 K-files are typically used with a watch-winding motion and suitable lubricants for initial negotiation (Ingle, 1961). For canals with pronounced curvatures, files beyond size #15 are best used with the **balanced-force technique**, while the **step-back approach** is preferred for challenging anatomies.[9,10]

Before introducing rotary instrumentation, a reproducible glide path must be secured. **McSpadden** outlined nine principles for shaping curved canals,[3] though not all can be applied to extreme curvatures. Consequently, newer and modified techniques have been proposed, including the **Zone Technique**, **Reciprocating Technique**, **Tactile Controlled Activation (TCA)**, and **Arithmetic Crown-Down Dynamic Tactile Instrumentation**.[3]

In the **Zone Technique** (McSpadden, 2007), two key principles are followed: (1) the coronal portion of the canal—above the curvature—should be sufficiently enlarged to prevent file engagement, and (2) the file diameter should remain small enough to rotate safely within the curvature. The **Reciprocating Technique** uses a single file that alternates between counter-clockwise cutting and clockwise release motions, reducing torsional stress and eliminating the need for prior glide-path preparation.

The **Tactile Controlled Activation (TCA) Technique** involves engaging the file in a patent canal until tactile resistance is felt, followed by a single activation stroke using an engine-driven file, enabling controlled enlargement.

The **Arithmetic Crown-Down Technique** combines features of both the Zone and TCA techniques, optimizing efficiency and minimizing procedural errors in complex canal systems.

Effective **disinfection** is equally important, as severe canal curvature can restrict apical enlargement and limit irrigant penetration. Factors such as needle gauge, insertion depth, and activation method influence irrigant delivery; finer needles can reach deeper apical regions but require increased pressure.[11] In curved canals, effective alternatives for irrigant activation include **manual dynamic agitation** using gutta-percha cones or advanced **multisonic activation systems**. Heating **sodium hypochlorite** solutions may lower their viscosity, improving flow and antibacterial efficacy within constricted canals.[12,13]

IV. CONCLUSION

Management of curved root canals demands a systematic and well-coordinated approach that integrates a thorough understanding of internal tooth anatomy, utilization of advanced imaging modalities like CBCT, and refined clinical skill. Treatment begins with the negotiation of the canals using small stainless-steel hand files (#6, #8, and #10) to establish a reproducible glide path, followed by shaping with flexible nickel-titanium instruments specifically designed for curved anatomy. The adoption of modern instrumentation techniques, optimized irrigation protocols, and controlled torque and speed parameters significantly reduces procedural complications such as canal transportation, zipping, ledge formation, and instrument fracture. Ultimately, successful management depends on the clinician's precision, adaptability, and adherence to evidence-based endodontic principles to preserve canal integrity and ensure long-term clinical success.

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