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Case Report

Non-surgical endodontic management of a maxillary central incisor with vertucci's type V canal configuration: A case report with 3D-printed model analysis

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Abstract

While it's well-known that maxillary central incisors typically have one root canal, this case paper reports the unusual occurrence of an additional root canal alongside the primary canal. The report provides a detailed illustration of the two- and three-dimensional radiographic interpretation, diagnosis, and endodontic management of a symptomatic maxillary central incisor featuring an accessory root, complete with an 18-month follow-up. Importantly, the case underscores the value of utilizing a 3D-printed model for both treatment planning and educational purposes.

Keywords: Root canal therapy, 3D-Printing, Cone beam computed tomography, Endodontic education.

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1. Introduction

The relationship between internal anatomy and access cavity is crucial for the success of endodontic treatment.

True proficiency in cavity preparation requires the clinician to mentally map the tooth's 3D structure, tracing a path from the pulp chamber to the apical foramen.[1]

Before we initiate a root canal treatment, it's crucial to have a thorough understanding of root canal morphology. Most dental literature describes the maxillary central incisor having a single-canal within a single root. Using the clearing technique on human permanent teeth, Vertucci's found that all maxillary central incisors have a single root canal.[2] However, there have been documented cases where they exhibit more complex root anatomy.[3] The present report details the successful non-surgical endodontic treatment of a maxillary central incisor displaying a Vertucci type V canal configuration, highlighting the importance of accurate preoperative assessment in managing such unexpected anatomical variations.

Due to the overlap on 2D images, Intra-oral radiographic images don't accurately depict the true canal configuration. However, digital imaging technologies, such as Cone Beam Computed Tomography (CBCT), have greatly simplified the in-depth study of teeth's anatomical variations. Three-dimensional (3D) printing, a recent advancement in endodontics, has gained significant recognition for its various applications, including: (i) Guided endodontic access, (ii) Treatment of anomalies such as Dens invaginatus and Dens evaginatus, (iii) Guided post removal, (iv) Guided endodontics in periapical surgery, and (v) Tooth autotransplantation.[4] In this case, to better understand the internal anatomy, a 3D-printed model was fabricated using the CBCT files, and the treatment plan was developed accordingly.

2. Case Report

A 40-year-old woman reported to the outpatient clinic of the Department of Conservative Dentistry and Endodontics, complaining of pain in her upper front tooth for the past two

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weeks. The patient reported a history of having fallen 15 years ago.

An intraoral examination revealed an uncomplicated crown fracture of the upper left central incisor (#21) with mild tenderness upon percussion. An Intraoral periapical radiograph (IOPAR) examination showed a periapical radiolucency of approximately 3x3 mm (**Figure 1**A).

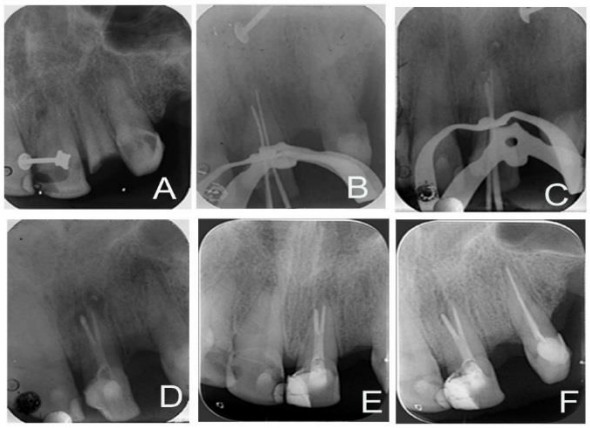

Figure 1: Intra-oral radiographs (Tooth no. 21); **(A):** Pre-operative; **(B):** Working length estimation; **(C):** Master cone selection; **(D):** Immediate post-obturation; (**E):** One year follow-up and **(F):** 18- months follow-up.

A provisional diagnosis of pulpal necrosis with symptomatic apical periodontitis was made. A closer look at the IOPAR revealed the double root appearance. Before the initiation of treatment informed consent was obtained for the endodontic treatment and for Cone Beam Computed Tomography (CBCT) imaging. A limited Field of View (FOV) images were obtained using CBCT scanner (Planmeca Romexis 5.3.5.80, G-XR-136953, Helsinki, Finland) with settings of 90 kV and 10 mA. The images were taken in axial, coronal, and sagittal views (**Figure 2**A,B,C).

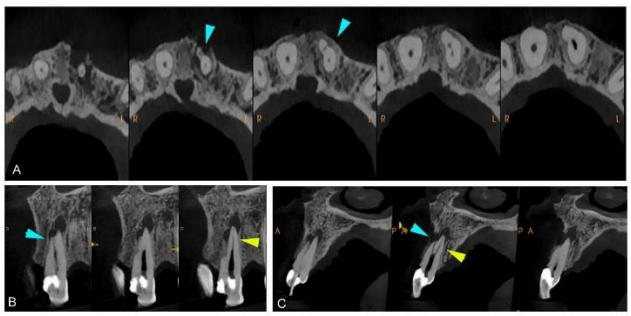

Figure 2: CBCT images **(A):** Axial sections (Blue arrow head indicating the additional root located mesio-labially); **(B):** Coronal sections (Blue arrow head indicating the mesio-labially positioned root and the yellow indicating the disto-palatally positioned canal; **(C**): Sagittal section

The CBCT images confirmed that tooth #21 had a Vertucci Type V root canal anatomy.

To better understand the anatomy of the tooth, a 3D-printed model was created using the following protocols (**Figure 3**A, B):

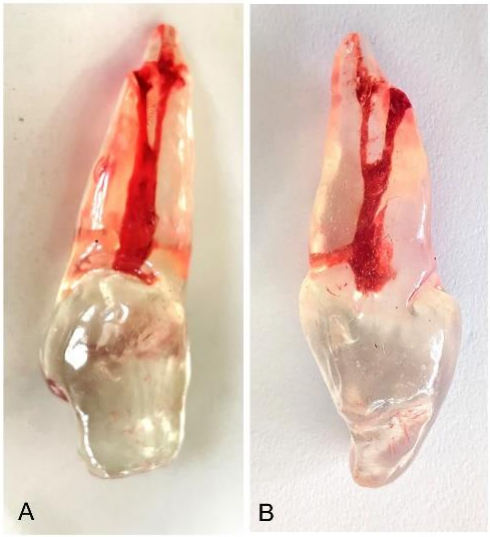

Figure 3: The 3-D printed model; (**A**): Labial view; (**B**): Proximal view.

1. Initial Model Creation**:** An STL (Standard Tessellation Language) file was generated from the CBCT image and viewed in 3D Slicer software (3D slicer, ver 5.0.3R30893/7ea0f43). Using segmentation tools, regions of interest within the CBCT volume were isolated and refined to achieve the desired form. Once the desired structures were segmented, a 3D model was created in the 3D Slicer software.
2. Refinement and Preparation: The generated model was then exported as an STL file and rendered using Meshmixer software (Autodesk Meshmixer version 3.5.474, San Francisco, CA, USA). In Meshmixer, the tooth model was scaled to the desired dimensions, and a display stand was designed. Artifacts and the pulp chamber were isolated, and any error surfaces were corrected.
3. Final Printing**:** The refined model was exported to Lychee Slicer (version 5.2.201, Bordeaux, France). The final 3D-printed tooth model was produced using a Phrozen Sonic Mighty 4K SLA 3D printer (Phrozen, Hsinchu City, Taiwan). This printer utilized photocurable resin and oriented the model appropriately on the print bed. (**Figure 3**A, B)

2.1. Clinical steps

Local anesthesia was administered (2% lidocaine with 1:80,000 epinephrine, Lignox 2% A, Indoco Remedies Ltd., Mumbai) and rubber dam applied. Under a dental operating microscope (Zeiss OPMI pico, Oberkochen, Germany), access cavity was prepared using a round bur (Mani Inc, Tochigi Japan). Canal was negotiated with a 10-K file (Mani, Tochigi-ken, Japan). An electronic apex locator was used to

establish working length. (CanalPro, Coltene-Endo, Cuyahoga Falls, OH, USA) and confirmed by an intra-oral periapical radiograph (IOPAR) (**Figure 1**B).

The canal preparation and irrigation were carried out using 17% EDTA (Endoprep RC, Anabond Stedman Ltd., Tamil Nadu, and India) and 1% sodium hypochlorite (Medlise Chemicals, Kerala). Intracanal calcium hydroxide (RC Cal, Prime Dental Products Pvt. Ltd., Mumbai, India) was placed for two weeks. Once the patient was asymptomatic, the tooth was obturated. The canals were coated with zinc oxide eugenol sealer (Endoseal, Prevest DenPro, India) and the selected master Gutta-percha cones (Dentsply, India) (size 80/2% taper in labial canal and size 60/2% taper in the palatal canal) were placed to the estimated length and downpacked with a System B pluggers (.10 Taper/Medium Size) (Elements Sybrondental, Orange, CA, USA). Thermoplasticized gutta-percha (Elements, Sybrondental, Orange, CA, USA) was used for obturating the remaining part of the canal. (**Figure 1**C and D). The access was restored with composite resin (Ivoclar Vivadent, Schaan, Liechtenstein). At the 12- and 18-month follow-up appointments, the patient remained asymptomatic (**Figure 1**E and F).

3. Discussion

This case study underscores the importance of comprehending the internal anatomy of root canals in both normal teeth and those with anatomical variations. According to a study by da Silva et al., 98% of maxillary anterior teeth have a single canal with consistent root canal anatomy.[3] Iqbal et al. found that a population with diverse ethnic backgrounds exhibited a 97.89% prevalence of Vertucci's type I root canal morphology.[5] While there have been numerous cases of treating multi-rooted central incisors, those with a type V morphology are limited.[6]

Locating and managing all canals is vital during endodontic treatment. Clinicians must watch for signs of additional canals. When assessing the pre-operative radiograph, consider a careful radiographic evaluation, such as a “ghost” apex, a fast break canal (sudden narrowing or disappearance of the pulp space), and an eccentric canal tracing.[7,8] Along with a standard IOPAR, a second radiograph angulated from 20° either mesial or distal angulated horizontally can facilitate identifying additional canals.[8]

Advanced imaging modalities such as CBCT were particularly beneficial in understanding and managing this case with its intricate canal anatomy and morphology.[9,10]

Over the past few decades, 3D printing's manufacturing process has undergone significant evolution, leading to diverse applications in medicine, dentistry, and endodontics. The popular applications among those include guides for access opening and educational models.[11,12] A study by Oza et al., reported the availability of both the 3D printed model and the CBCT scan significantly improved the confidence in performing endodontic microsurgery by clincians.[13]

These complicated cases lead to different treatment approaches and prognoses. Recommendation is to perform a tactile examination of the canal walls using a precurved #10 K-file, and detect “any catch” indicating the presence of an additional canal opening.[14]

The use of Dental operating microscope (DOM) is crucial for effectively navigating complex root canal anatomy. It minimizes the risk of complications, enhances the identification of additional canals, and offers superior precision during treatment. In the present case, the DOM played a vital role in locating the root canal orifices.[15] To achieve optimal root canal closure in the apical, lateral, and accessory canals, the warm vertical gutta percha technique was chosen over cold lateral compaction.

The Vertucci classification remains a longstanding framework for categorizing root canal configurations. However, newer classification proposed by Ahmed et al, offer enhanced specificity and accuracy in understanding root canal anatomy, thereby facilitating more tailored treatment approaches.[16] In the present case according to Ahmed et al, the tooth is denoted as ^{1}21.[1-2-2], indicating a single root, with one orifice, two canals and two foramen.

Ahmed et al.'s classification system provides a clearer approach to studying root canal anatomy, promoting a more detailed understanding of tooth anatomy than simplistic categorizations.[16]

4. Conclusion

Diagnostic breakthroughs and today's endodontic techniques enable us to facilitate accurate diagnoses, develop treatment plans that are specific, and handle even the most challenging and complicated root canal anatomy with relative ease. 3D printed models are good educational tools, and help clinicians map out a successful strategy for managing complex cases.

5. Sources of Funding

None.

6. Conflict of Interest

None.

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