

Cone-beam computed tomography three-dimensional reconstruction aids treatment of three root canals with severe curvature in maxillary first premolar: a case report

Journal of International Medical Research
50(6) 1–6

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DOI: 10.1177/03000605221105361
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Abstract

The maxillary first premolar commonly has one or two root canals; the presence of three canals is rare. These root canals are easily missed during treatment, resulting in failure of root canal therapy. The present report describes a case in which three root canals in the maxillary first premolar were diagnosed by cone-beam computed tomography. The herein-described patient was successfully treated using three-dimensional reconstruction technology to determine the form and direction of curvature of the root canals.

Keywords

Maxillary first premolar, root canal variation, three-dimensional reconstruction, root canal therapy, cone-beam computed tomography, case report

Date received: 28 September 2021; accepted: 18 May 2022

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Introduction

The root canal system of the maxillary first premolar is subject to great variation because of its complex internal anatomical structure. The presence of one or two root canals is common for the maxillary first premolar, but the presence of three is rare.¹ Li et al.² observed the maxillary premolars in Chinese patients by cone-beam computed tomography (CBCT) and found that the incidence of a maxillary first premolar with three root canals was only 0.5%. A complex root canal usually has a low rate of therapeutic success, and a missed root canal usually results in failure of therapy. CBCT three-dimensional (3D) imaging overcomes the limitations of the conventional preoperative X-ray two-dimensional imaging using periapical films and provides comprehensive information regarding the number, form, and curvature of root canal aberrations.³ Preoperative scanning by CBCT improves the clinician's anatomical understanding of the root canals and avoids iatrogenic accidents, such as lateral penetration, bottom penetration, and step formation, thus greatly improving the success rate of root canal therapy for complex structures. The present report describes a patient with three root

canals in the premolar diagnosed at the Affiliated Stomatological Hospital of Nanchang University and provides a reference for the diagnosis and treatment of patients with a similar condition.

Case report

A 22-year-old male student was transferred to the Department of Endodontics, Affiliated Stomatological Hospital of Nanchang University for diagnosis and treatment on 19 September 2019. The main complaint was root canal obstruction during “nerve-killing” treatment for a toothache at another hospital. The patient provided written consent for publication of his data. The study protocol was approved by the ethics review committee of the Affiliated Stomatological Hospital of Nanchang University. The reporting of this study conforms to the CARE guidelines.⁴

Clinical and imaging examinations (Figure 1) revealed white filling in the distal part of tooth 14, with caries under the filling but with no probing pain, percussion pain, or looseness. An X-ray scan of the periapical area was normal, but the canal image was not clear. CBCT conducted in our hospital (Figure 2) showed

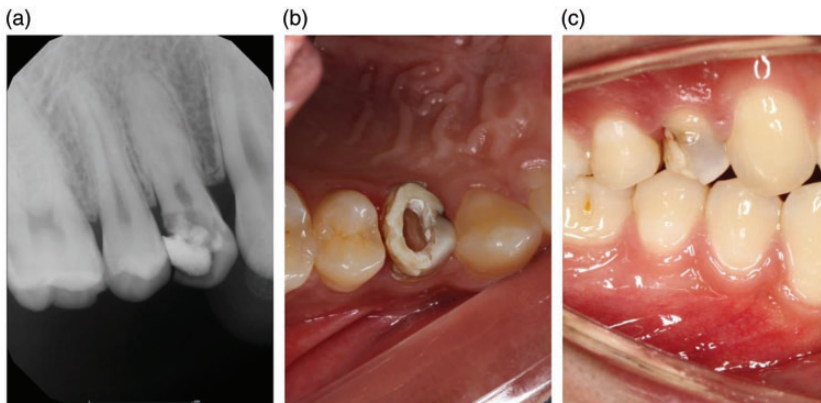


Figure 1. Preoperative examinations. (a) Preoperative X-ray film and (b, c) Preoperative images of the mouth.

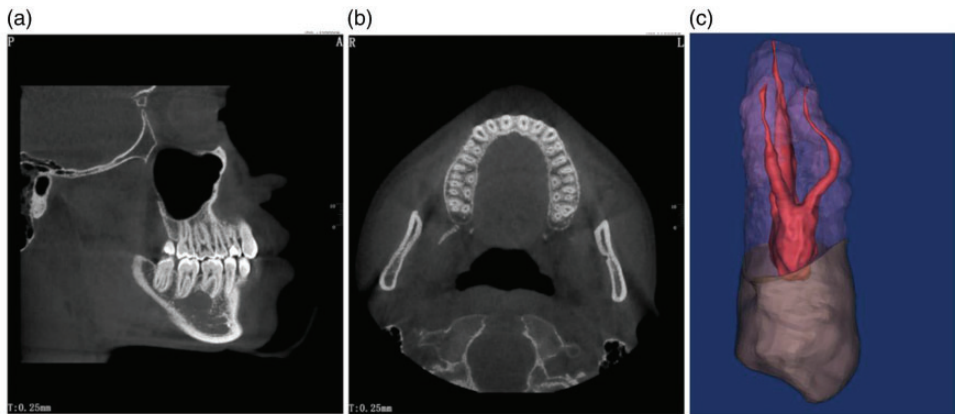


Figure 2. Cone-beam computed tomography (CBCT) and three-dimensional reconstruction. (a) CBCT showed two buccal roots of tooth 14, and the proximal middle root was curved. (b) CBCT showed that tooth 14 had three independent root canals and (c) The measured declination of the mesiobuccal root was 63.04° , and the curvature of the middle of the mesiobuccal root was 84.12° .

three root canals in tooth 14: two on the buccal side and one on the palatal side with a curved mesiobuccal root. The information regarding the pulp cavity and root canal system of tooth 14 were input into 3D imaging software (Mimics; Materialise, Leuven, Belgium) to extract the pulp tissue and build a 3D reconstruction model of the root canal system of tooth 14, allowing us to gain an intuitive understanding of the direction of curvature of the root canals and complexity of the root canal system.⁵ Through this process, the patient was diagnosed with abnormal root development of tooth 14. Root canal therapy and post-crown restoration were carried out on the affected tooth. The patient visited the Endodontics Department three times at 1-week intervals. CBCT was performed and the data were analyzed at the first visit, the root canal was prepared at the second visit, and the root canal was filled at the third visit.

Images obtained during the treatment process are shown in Figure 3. All existing fillings and decay in tooth 14 were removed, the caries were repaired with resin (Filtek Z350; 3M, Saint Paul, MN, USA), and

a rubber dam was applied. The root canals were examined under a microscope (Zumax Medical, Suzhou New District, China), and three were found. A pre-bent stainless steel K-file (Dentsply Sirona, Charlotte, NC, USA) was used to dredge the root canals to 10#, and a root apex locator (VDW, Munich, Germany) was used to measure the length. The root canals were prepared with a nickel-titanium (NiTi) file (Orodeka, Jining, China) with a working length of 15.0 mm for the mesiobuccal root, 15.5 mm for the distal buccal root, and 16.5 mm for the palatal root. All canals were prepared to 35# 04, during which they were washed with 0.5% sodium hypochlorite + 17% ethylenediaminetetraacetic acid by ultrasound (50/60 Hz). An injectable root canal sealer (iRoot SP; Innovative BioCreamix Inc., Vancouver, BC, Canada) and teething gel (Dentsply Sirona) were used to fill the root canals. The root canals were then temporarily sealed, and the patient was transferred to the Department of Prosthodontics for post-crown restoration. On 2 November 2020, the patient underwent a re-examination and reported no

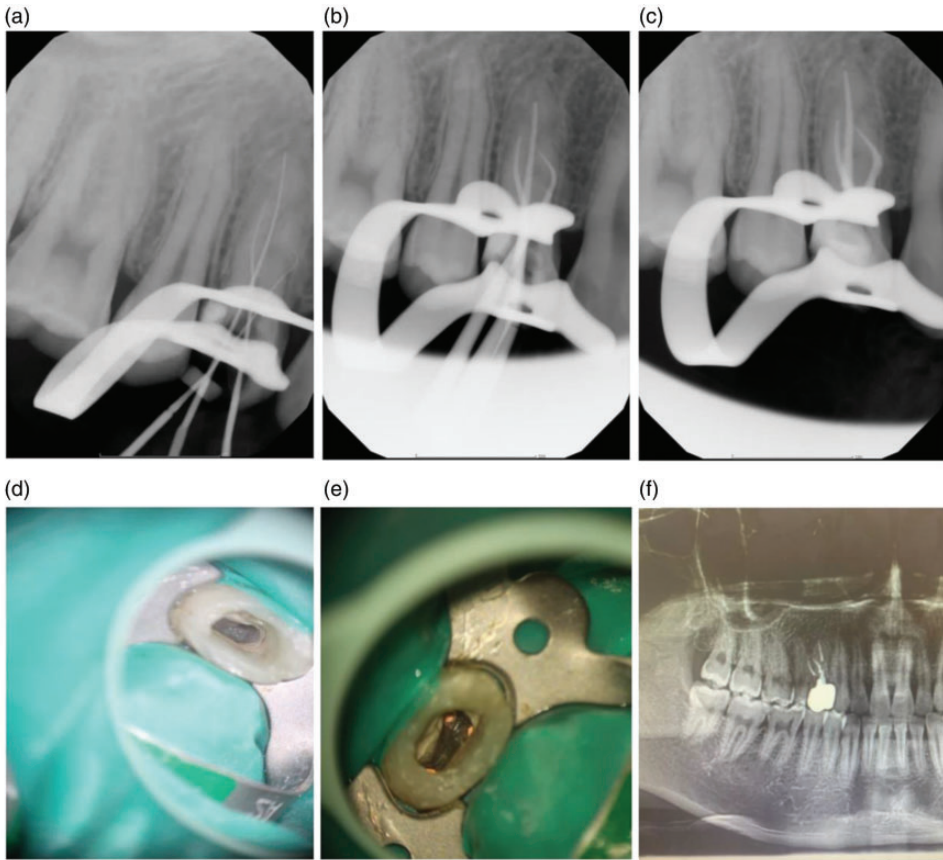


Figure 3. Treatment process and follow-up visit. (a–c) X-ray films during root canal therapy. (d, e) Root canal opening under a microscope and (f) X-ray film of the patient during a follow-up visit.

discomfort. An X-ray examination showed no obvious abnormalities in the root apex.

Discussion

The root canal system may be subject to multiple anatomical variations; hence, a missed root canal usually leads to failure in root canal therapy, especially for a non-vital tooth. Anatomical differences in the maxillary first premolar have been reported in many studies. Vertucci⁶ classified the root canals of the maxillary premolars into eight forms and pointed out that the maxillary first premolar is the only tooth that exhibits all eight root canal forms.

However, the incidence of a maxillary first premolar having three root canals is low, ranging from only 0.4% to 2.6%.¹

Microscopy and X-ray scanning from different angles can detect the anatomical changes during root canal therapy. However, such plain films show only two-dimensional images and may not reflect the complete anatomy of the root canals. Michetti et al.⁷ found that CBCT improves the detection rate of root canals by 40% compared with conventional X-ray films. Furthermore, compared with CBCT, 3D reconstruction enables an intuitive view and provides accurate measurement data.³ In the present case, we collected

3D data from CBCT scans and reconstructed the model to understand the anatomical structure of the root canals in the sagittal, coronal, and fracture planes⁸ and accurately locate the direction and angle of the mesiobuccal root canal of the tooth. This facilitated dredging and thorough cleaning the root canals, thereby improving the success rate of the therapy.

In this case, we accurately located the root canal orifices using 3D reconstruction technology and set the declination of the mesiobuccal root canal to 63.04° according to the method proposed by Yang et al.⁹ The curvature of the mesiobuccal root canal was measured as 84.12° according to the method proposed by Hartmann et al.⁸ The measurement plane in the buccolingual direction is parallel to the long axis of the tooth, and the angle between the mesiobuccal root canal and this plane was measured as 63.04° . Two imaginary planes were drawn from the point of greatest inflection of the mesiobuccal root canal in the buccolingual direction to the root canal orifice and both ends of the apical foramen, and the angle between the two imaginary planes was measured as 84.12° . The measurements were performed with Mimics (Materialise) software. The root canal was severely curved. When such a root canal is dredged and prepared, a controllable memory NiTi file should be used to avoid complications, such as deviation of the root canal and fracture of the instrument. Because the root canal was found to be severely bent, a pre-bent, flexible NiTi file was selected.

A good opening of the pulp cavity and careful exploration of the root canal at the bottom of the pulp cavity also helped to avoid missing the third root canal. In a study by Arisu and Alacam,¹⁰ the buccolingual opening was extended distally to form a T shape for a tooth with three root canals to facilitate exploration of the root canal opening and straight access.

If the mesiodistal distance of the middle one-third of the root is equal to or greater than the mesiodistal distance of one-third of the root neck on a preoperative plain film, the tooth might have three roots.¹¹

In conclusion, although it is rare for a maxillary premolar to have three root canals, an endodontist should always be cautious about the complexity of the root canal system in clinical diagnosis and treatment and should carefully read the imaging information and perform preoperative CBCT when necessary. Additionally, an understanding of the root canal forms and variations is essential for clinicians, and they should therefore have the necessary anatomical knowledge of normal root canals and variants. A microscope should be used during surgery for careful exploration of the root canals to improve the success rate of root canal therapy and preservation of the diseased tooth.

Acknowledgement

The authors would like to thank the patient described in this case report.


Declaration of conflicting interests

The authors declare that there is no conflict of interest.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was supported by a grant from the Science and technology project of Jiangxi Administration of traditional Chinese Medicine (2020B0172).

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