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Evaluation of horizontal/oblique root fractures in the palatal roots of maxillary first molars using cone-beam computed tomography: a report of three cases

CASE REPORT

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Abstract – Diagnosis of root fractures is generally based on clinical and radiographic presentations. This case report aims to detect horizontal/oblique root fractures in posterior teeth using a combination of conventional radiographs and cone-beam computed tomography (CBCT). Three maxillary first molars with horizontal/oblique root fractures in the palatal roots are presented. More detailed information on root fractures can be obtained using CBCT compared with conventional radiography. As such, CBCT might be a useful complementary diagnostic method to conventional radiography in cases of suspected horizontal/oblique root fractures.

In the past, horizontal/oblique root fractures were rarely diagnosed in the absence of endodontic injuries and subsequent treatments, and any diagnosis was mainly based on clinical and radiographic examinations (1, 2). Detection efficiency and correct characterizations of the location and the type of root fracture are essential aspects in assessing the prognosis and in determining appropriate treatments. In clinical practice, conventional and digital intraoral radiography have been the techniques most commonly used to detect root fractures. Although root fractures can be detected via routine dental examination, however, they might not be visible radiographically, especially because periapical radiographs are generally presented as two-dimensional (2D) images of three-dimensional (3D) anatomic structures. Hence, certain clinical and biologic features might not be reflected accurately (3). If the fracture is diagonal, for example, it is unlikely to be observed by a conventional 90-degree angulated periapical X-ray film. Only when the X-ray beam can pass directly through the fracture line does it show up on the radiograph. Therefore, it is often necessary to rely on additional film angulations when root fractures are suspected (4).

Cone-beam computed tomography (CBCT) is a new radiographic method that can be used in the 3D imaging of dental structures (3, 5, 6). The development and rapid commercialization of CBCT technology dedicated to imaging the maxillofacial region increase dental practitioner access to 3D radiographic assessments in clinical dental practice. CBCT imaging provides clinicians with submillimeter spatial resolution images of high diagnostic quality and a reported radiation dose markedly lower than those of conventional CT scans, equivalent to that needed for 4–15 panoramic radiographs (7).

Experimental studies have demonstrated that CBCT is better than conventional radiography in the diagnosis of horizontal root fractures (5, 6). However, there are limited data on the advantages of CBCT, especially where conventional radiographs for the detection of horizontal/oblique root fractures in molars are concerned.

The following cases comparatively analyze images obtained by conventional radiography and CBCT (Sirona Dental Systems GmbH, Bensheim, Germany), focusing on the detection of horizontal/oblique root fractures in the palatal roots of maxillary first molars. CBCT scans were made with exposure volume of $15 \times 15 \times 15$ cm^3 at 0.3/0.5 mm 3D resolution isotropic voxel size and with the unit operated at 85 kV and 5/7 mA. All of the images were evaluated by three observers (two endodontists and one radiologist) at different sessions. Each observer evaluated the CBCT images using the tangential, cross-sectional, and axial sections.

Case reports

Case 1

A 59-year-old man complained of localized swelling in the area of the maxillary left first molar and had been

experiencing pain during mastication in the tooth for about a year. He habitually chewed hard foods. A clinical examination showed a sinus tract, as well as some discharge of pus and exudates in the facial region of the tooth. The tooth was painful to percussion and displayed grade II mobility with a 7-mm periodontal pocket when probed palatally. The tooth was also non-responsive to vitality tests. A radiographic examination showed an area of radiolucency around the furcation area of the tooth, and there was an associated bone loss around the buccal roots (Fig. 1a). Based on the patient's dental history, signs, and symptoms, tooth infractions were strongly suspected. After obtaining informed consent from the patient, the tooth was submitted for CBCT examination. A morphology was obtained from the tangential, cross-sectional, and axial sections (Fig. 1b–d). A cross-sectional view showed an obscure horizontal fracture line at the middle one-third level of the palatal root; the axial CBCT image clearly revealed a fracture in the palatal root of the tooth in an approximately mesiodistal direction. Considering the clinical and radiographic findings, the diagnosis was a combined periodontal–endodontic lesion with a horizontal fracture of the palatal root. Treatment options offered to the patient included extraction or endodontic treatment. The patient chose the latter option, endodontic therapy was carried out, and after instrumentation, the buccal root canals were obturated with gutta-percha cones and AH-plus sealer (Dentsply DeTrey GmbH, Bensheim, Germany) using the lateral condensation technique, calcium hydroxide/iodoform paste (Vitapex; Neo Dental Chemical Products Co. Ltd., Tokyo, Japan) was packed into the lingual canal to the fracture line to induce hard tissue formation, the horizontal fracture in the palatal root was showed by extruded paste (Fig. 1e). The tooth was restored with composite resin, and the patient was scheduled to return for an examination in 1 year.

Case 2

A 50-year-old man presented with sudden pain on mastication in the maxillary right first molar. The pain persisted for 4 days, and the severe pain in the tooth was associated with thermal stimuli. He habitually chewed on hard foods. Clinically, no overt extra-oral or intra-oral swelling was observed, and there were no tooth mobility or pockets around the tooth. However, the tooth was sensitive to percussion and responded positively to a cold spray. A preoperative radiograph showed an unclear fracture line with adjacent bone loss, which raised the suspicion of a root fracture (Fig. 2a). CBCT imaging was conducted for further evaluation. Tangential images presented a horizontal fracture, while cross-sectional views clearly showed a horizontal fracture at the middle one-third level of the palatal root. The apical segment was also lingually displaced. Axial images revealed a root fracture in the palatal root in the mesiodistal direction (Fig. 2b–d). Endodontic therapy (the same as case 1) was carried out.

Case 3

A 62-year-old woman presented with sudden pain on mastication in the maxillary right first molar. The pain persisted for about 7 days. The pain in the tooth was associated with temperature changes. She habitually chewed on hard foods. There was no evidence of swelling or a sinus tract, and no pockets around the tooth were detected. The tooth had a vital pulp and was mostly within normal limits other than slight mobility. A radiographic examination showed a thin translucent line on both the palatal and distobuccal roots (Fig. 3a). To specify the affected roots and to obtain more information to ascertain an appropriate treatment plan, the patient was referred for CBCT imaging. Tangential images revealed a horizontal fracture in the palatal root. Cross-

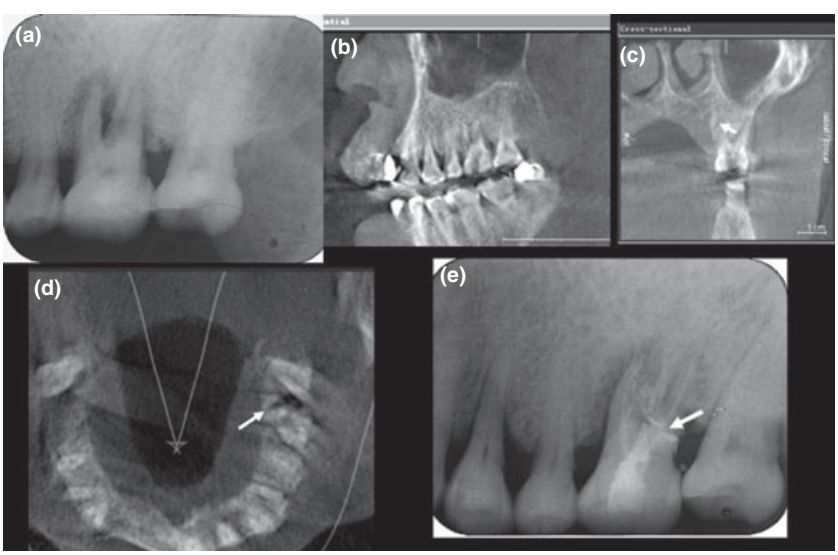

Fig. 1. Case 1: Preoperative radiograph (a) of the maxillary left first molar. Tangential (b), cross-sectional (c), and axial (d) cone-beam computed tomography (CBCT) images. A cross-sectional view showed a obscure horizontal fracture line (c); the axial CBCT image clearly revealed a fracture (d). Postobturation radiograph (e) (arrow indicates the fracture).

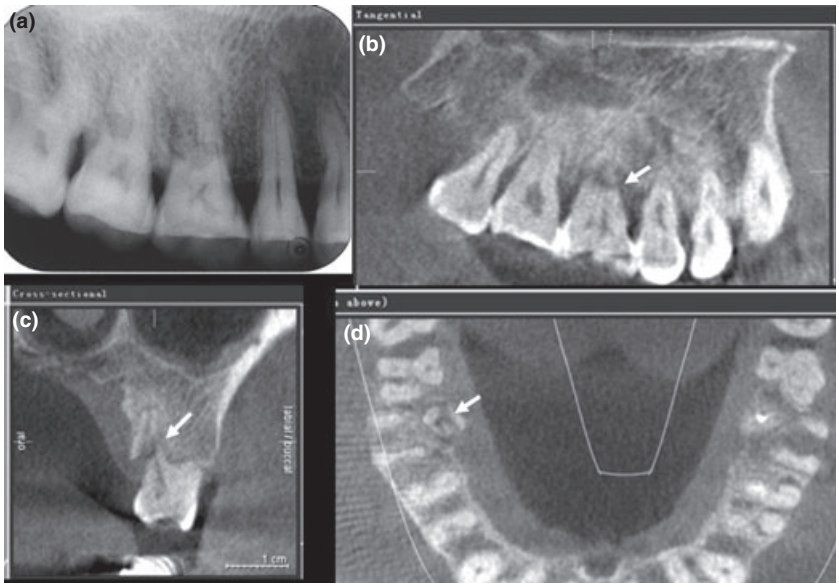

Fig. 2. Case 2: Preoperative radiograph (a) of the maxillary right first molar. Tangential (b), cross-sectional (c), and axial (d) cone-beam computed tomography images (arrow indicates the fracture).

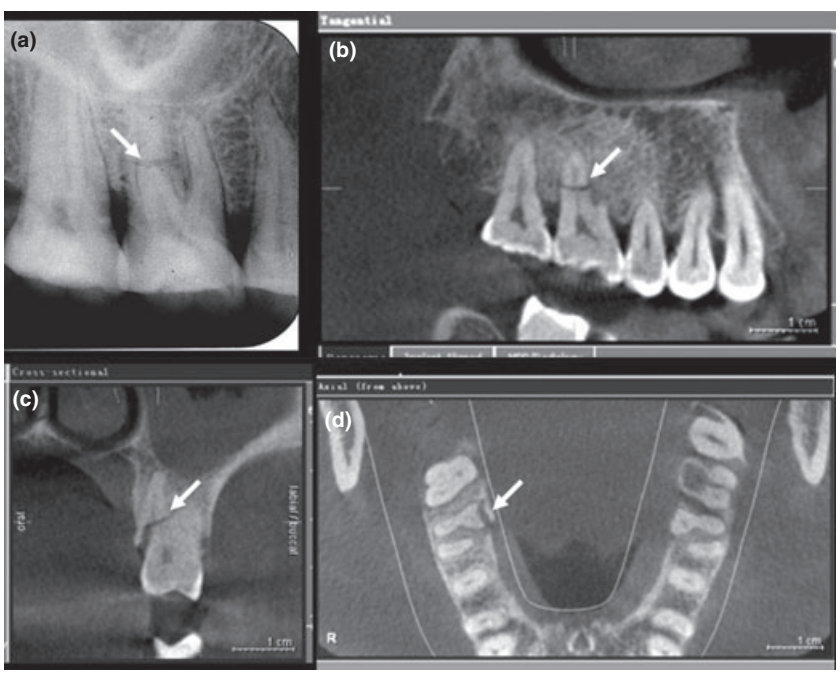

Fig. 3. Case 3: Preoperative radiograph (a) of the maxillary right first molar. Tangential (b), cross-sectional (c), and axial (d) cone-beam computed tomography images (arrow indicates the fracture).

sectional views clearly showed an oblique fracture at the middle one-third level of the palatal root. The apical segment was lingually displaced. Axial images revealed a root fracture in the palatal root in the mesiodistal direction (Fig. 3b–d). The patient did not accept any therapy, and regular periodic examinations will be made.

Discussion

Root fractures in non-endodontically treated posterior teeth are uncommon. Yeh (1) reported four general patterns of fractures seen in radiographs: vertical, horizontal, oblique, and laminar. Fractures result from excessive, repetitive, and heavy masticatory stress applied to teeth. In addition, fractures occur mainly in individuals over 40 years old. Typically, the affected teeth are in the posterior region of the mouth. In this study, all three patients habitually chewed hard foods.

A radiographic examination can detect root fractures. Radiolucent lines between the fragments in root fractures are key factors in the diagnosis (5, 6). However, both two-dimensional digital and two-dimensional conventional

radiographs provide only limited information, especially in cases involving complex background patterns. The patterns of fractures and adjacent anatomic and dental structures can interfere with the detection of lesions; therefore, the clinician should take several radiographs from different angulations (4). CBCT imaging overcomes this major limitation by allowing for the visualization of a third dimension while eliminating the presentation of superimposed structures.

Diagnostic information directly influences clinical decisions. Accurate data lead to better treatment planning and improved outcome predictions. In an *in vitro* study, dental CBCT was shown to be more accurate than digital radiography for detecting simulated vertical root fractures with different thicknesses (8). Two clinical studies have reported that conventional CT and CBCT were superior compared with intraoral radiography in detecting root fractures (9, 10). In the present report, CBCT revealed the fractures clearly in all three cases. These results suggest that CBCT is an excellent option for detecting horizontal/oblique fractures of the maxillary first molars in the palatal roots, as suspected lesions can be assessed in tangential, cross-sectional, and axial views. Moreover, CBCT can provide clinically relevant information that cannot be otherwise gathered from conventional radiography. Hence, CBCT may help clinicians avoid inappropriate treatments.

Despite its advantages, CBCT technology also presents some limitations, such as the high-radiation doses compared with plain-film radiography (7). Endodontic assessment with CBCT should follow the 'as low as reasonably achievable' principle. Images are usually required for planning, treatment evaluation, and follow-up. The choice of CBCT should be related to the patient's clinical needs.

Another limitation is the expensive equipment costs (11). Currently, CBCT is not a popular procedure in many dental offices (12), and CBCT should not necessarily replace conventional radiographic methods. However, in certain complex cases such as those presented in this report, the 3D data sets were more effective than conventional radiographs in accurately diagnosing certain horizontal/oblique root fractures.

Conclusion

In detecting horizontal/oblique root fractures in maxillary first molars, CBCT may serve as an adjunctive diagnostic aid to conventional radiography.

Conflict of interest

The authors deny any conflicts of interest.

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