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Usefulness of cone-beam CT in the evaluation of a spontaneously healed root fracture case

CASE REPORT

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Abstract – Horizontal root fractures (HRF) usually affect anterior teeth of male patients as a result of trauma. The consequences can be complex because of combined damage to different tissues, but it has been reported that root fractures undergo healing in majority cases. Diagnosis of HRF must be based on clinical findings, sensibility tests, and radiographic examination. The cone-beam computed tomography (CBCT) has already been proven to be superior among other radiographic modalities for diagnostic imaging of root fractures. However, CBCT in these cases needs to be used in a careful manner, and only when the radiation exposure should be justified by the potential diagnostic benefits and improvement of the treatment results. This case report describes a case of spontaneously healed horizontal root fracture with displacement of the fragments and discusses the usefulness of CBCT in the follow-up of root fractures cases.

Key words: root fracture; cone-beam computed tomography; root resorption

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Root fractures comprise only 0.5–7% of all dental injuries (1) and are characterized as a break in the continuity of the root. They have a complex healing pattern owing to concomitant damage to dentine, cementum, and pulp (2). Among all types of dental fractures, horizontal root fractures (HRF) are typically of traumatic origin and usually affect maxillary central incisors of male patients as a result of trauma associated with accidents, sports injuries, or fights. They also occur more frequently in fully erupted permanent teeth with closed apices in which the completely formed root is solidly supported in the bone and periodontium (3). The classification and severity of HRF are based on the location of the fracture line (apical third, middle third, and cervical third of the root) and on the degree of dislocation of the coronal fragment (1).

According to the guidelines of the International Association of Dental Traumatology (IADT) (4), the diagnosis of HRF must be based on clinical findings, sensibility tests, and radiographic examination. Clinically, the coronal segment may be mobile, displaced, and/or present a transient discoloration (red or gray). The degree of mobility and displacement is frequently determined by the fracture location (3). On the other hand, the sensibility tests (electric pulp test or cold test) may give negative results initially, indicating transient lack of pulpal response or permanent pulpal damage (4). The unpredictable response of a tooth to pulp testing following trauma should be caused by injury, inflammation, pressure, or tension to apical nerve fibers. For these reasons, follow-up controls are needed to make a definitive pulpal diagnosis.

The radiographic examination on cases of root fracture must be performed carefully. IADT guidelines establish that, as a routine, several projections and angles should be taken (90° horizontal angle, occlusal view, and a lateral view from the mesial or distal aspect of the tooth in question) (4). Variations on these angles may be needed because of the angulation of the fracture (5). It is known that the fracture line will only be detected if the x-ray beam passes directly through the fracture line. Furthermore, the 2-dimensional nature of intraoral radiographs, with the superimposition of other structures, limits its sensitivity (47%) for the detection of root fractures (6).

Since earlier 2000s, with the advent of cone-beam computed tomography (CBCT) dedicated to dental applications, it is possible to perform a CT with less radiation and greater accuracy (7, 8). Actually, CBCT superiority among other radiographic modalities for diagnostic imaging of root fractures has already been demonstrated (9–14). However, CBCT in the diagnosis and, especially, in the management of dentoalveolar trauma needs to be used in a careful manner, only when the conventional image modalities will not be able to help.

The aim of this report is to present one case of spontaneous healed horizontal root fracture with displacement of the fragments and discuss the usefulness of CBCT in the follow-up of root fractures cases.

Case report

A 19-year-old Caucasian woman was referred to the Oral Radiology Center of Piracicaba Dental School (University of Campinas, Piracicaba, Brazil) for a detailed investigation of her anterior lower teeth. The patient reported that she had mandibular fractures and lost her mandibular right central incisor as the result of a traffic accident 2 years ago. On clinical examination, the oral tissue was normal; there was no mobility, fistulae, or pain to percussion or palpation associated with any mandibular anterior teeth (Fig. 1a). The patient denied any history of pain or swelling after the surgical treatment of the mandible fractures.

Periapical radiographs were performed for initial radiographic evaluation of the bone graft in the area of the missing tooth, and analyses of the mandibular anterior teeth roots regarding their integrity. The main purpose of bone grafting was to replace the volume of alveolar bone lost associated with the avulsion of the central incisor and attached buccal cortical plate. A complete horizontal fracture was observed at the level of the apical third of the root with displacement of the apical portion (Fig. 1b). In the fracture line, a slight radiolucent area was seen, which was considered to be an indication of external root resorption. No apparently periapical lesion was seen, and the surrounding bone was normal.

Because of the radiolucency seen on the fracture line of the lower left canine, a CBCT acquisition was performed. In addition, the apical fragment of the root was evaluated to discard any periapical lesion that should have been developing in the area. The CBCT images were acquired using a Picasso trio unit (E-WOO Technology, Giheung-gu, Korea), operated at a standardized exposure of 80 kVp, 4.8 mA, field of view of 5 × 5 cm and voxel size of 0.2 mm. The Metal Artifact filter has been activated to reduce the artifacts from the plates and screws used for fracture reduction. The images were analyzed in all three dimensions using EZ3D2009 software (E-WOO Technology).

The sagittal and coronal images (Fig. 2) revealed the healed horizontal root fracture between the middle and apical thirds of the mandibular left canine. It was possible to observe a small hypo dense area at the apical portion of the superior segment, revealing the presence of external root resorption. On the other hand, there was no evidence of pathology on the apical fragment nor on the surrounding bone. Three-dimensional reconstructed image (Fig. 3) performed on Kodak Dental Imaging Software 3D (Carestream Health, Rochester, NY, USA) showed the healed fracture in detail.

Moreover, a cold pulp test (ROEKO Endo-Frost; Coltène/Whaledent GmbH + Co. KG, Langenau, Germany) and an electric pulp test (Analytic Technology Pulp Tester; Analytic Technology, Redmond, WA, USA) were performed and indicated response from all the mandibular anterior teeth, including the fractured lower left canine.

Discussion

Owing to their infrequent occurrence, HRF are frequently mismanaged and result in either unnecessary root canal treatment or even extractions. In fact, the management of fractured teeth is influenced by several factors, such as stage of root formation, location of fracture, degree of displacement of the coronal fragment, and interval between trauma and treatment (3). Most teeth with root fractures will recover successfully following repositioning of the coronal segment (if displaced) and stabilization for some weeks. Repositioning apparently facilitates pulp revascularization in the coronal part of the pulp (15). In case of middle or apical fracture, recommended treatment calls for stabilization of the tooth with a flexible splint for 4 weeks. If the root fracture is near the cervical area of the tooth, stabilization is beneficial for a longer period of time, up to 4 months (4). On the other hand, according to a previous research, teeth with no or slight loosening of the coronal fragment may not require splinting (15).

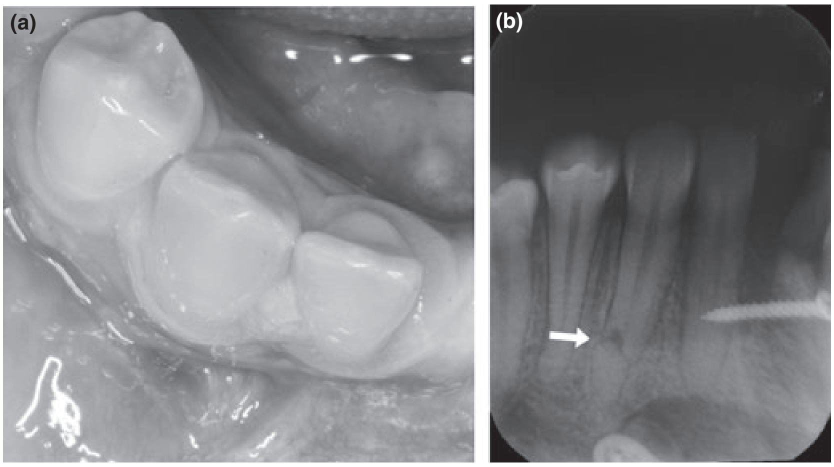

Fig. 1. (a) Intraoral picture showing no evidence of fistulae or tissue change. (b) Periapical radiograph of the patient showing root fracture, with a radiolucent area (arrow), as possible root resorption. Note the well-defined smooth radiopaque outline immediately below the apex of 43 located at the mid line of the inferior periphery of the image field. This is a projection of the anterior extent of the surgical plate used for fracture reduction. The radiolucency extending supero-posteriorly to this area is a representation of a bony defect associated with the trauma.

Fig. 2. Sagittal and coronal cone-beam computed tomography images showing a healed root fracture without evidence of periradicular pathology. An external resorption was detected (arrow) but with signs of cessation.

Fig. 3. Three-dimensional image of root fractures using volumetric rendering software.

Andreasen et al. (16) evaluated the effect of preinjury and injury factors such as sex, age, stage of root development, fracture type, location, and severity of displacement upon the root fracture healing. They observed that 30% of the teeth with root fractures had healed by hard tissue fusion of the fragments. Interposition of periodontal ligament (PDL) and bone between fragments was found in 5%, whereas interposition of PDL alone was found in 43%. Finally, non-healing, with pulp necrosis and inflammatory changes between fragments, was seen in 22%. Cvek et al. (15) found similar results in their research (33%, 8%, 36%, and 23%, respectively). These overall healing rates demonstrate that root fractures have a reasonably good prognosis.

The non-healing cases of root fracture are because of pulp necrosis, which should be caused by a rupture of the neurovascular supply, consequently causing tissue asphyxia, or after an irreversible pulpitis, which will eventually lead to liquefaction necrosis (17). Some authors suggest prophylactic endodontic treatment in teeth with marked dislocation of the coronal fragment or crown fracture with exposed dentin (18). However, the IADT guidelines recommend endodontic treatment only after pulpal necrosis (4). As the incidence of necrosis in these cases is slightly over 20%, clinical and radiographic follow-up have been suggested as the treatment of choice. If after 3 months of follow-up, the tooth still fails to respond to pulp testing and radiographs show radiolucency adjacent to fracture line, endodontic treatment only of the coronal fragment is indicated. Usually, the apical fragment of the root-fractured tooth remains vital (3, 4).

The patient in the case reported denied any kind of splint being used to support the fractured tooth. In fact, she was unaware of the fracture. Two years after the trauma, the tooth was responsive to pulp testing, and clinically, there was no mobility, fistulae, or pain to percussion or palpation. Additionally, in the periapical image, no signs of apical periodontitis or surrounding bone change were seen. These findings led us to a working diagnosis of spontaneous healed root fracture. However, a distinct suspicious radiolucency was observed adjacent to fracture line.

Usually, an intact tooth is resistant to resorption, even if inflammation is present. When an injury damages the protective layer of precementum, inflammation of the pulp or periodontium should induce root resorption (17). Andreasen et al. (1) observed that 60% of the teeth with root fractures exhibited external root resorption. Although asymptomatic in the beginning, root resorption can be followed by serious complications, as the tooth might become symptomatic, mobile, and a periradicular abscess might develop, leading to rapid tooth loss (19).

External root resorption can be categorized as inflammatory, invasive cervical, or replacement resorption. Inflammatory external resorption is characterized by infected or necrotic pulp (20). Invasive cervical resorption is a progressive destruction of tooth structure under the subepithelial attachment, while the pulpal tissue remains unaffected (21). On the other hand, replacement resorption occurs in cases in which trauma has caused damage to PDL cells. As a result, bone might come into direct contact with the root surface, and competitive healing events take place. Healing from the socket wall (creating bone) and healing from adjacent PDL (creating cementum and Sharpey's fibers) occur simultaneously. If <20% of the root surface is involved, a transient ankylosis may occur. Otherwise, a permanent ankylosis is created. In adults, replacement resorption occurs more slowly, often allowing the tooth to function for many years (19, 22).

The diagnosis of root resorption is usually based solely on the radiographic demonstration of the process, by radiolucencies observed in the external root surface and adjacent to the bone (19). The initial radiographic signs can potentially be visualized as early as 2 weeks after trauma (23). However, intraoral radiography is influenced by a number of variables, including geometric distortion, exposure time, receptor sensitivity, and adjacent anatomical interferences, which might camouflage or mimic resorptive defects.

Previous studies demonstrated that CBCT is an excellent resource for diagnosis of dental resorptions, showing superior results when compared with conventional periapical radiographs. CBCT has proven its efficiency in diagnosing external root resorptions by precisely determining the location and the dimensions of resorptions, allowing the establishment of adequate therapeutic measures and, therefore, resulting in a more favorable prognosis (24–26). However, with CBCT, clinical diagnosis of root resorption might be affected by observer performance and viewing conditions as well as hardware and software specifications and beam-hardening artifacts (27).

In 2010, Orhan et al. (5) presented a case regarding the use of CBCT in the detection of possible resorption secondary to a mid-horizontal root fracture. The authors suggested obtaining three-dimensional CBCT images for the detection of possible root resorption in similar cases. CBCT images of our case were acquired to clarify the radiolucency seen on the fracture line and to discard any occult periapical lesion in the area. An external root resorption was detected but with signs of cessation, as the resorption lacunae were filled with newly formed bone without radiographic signs of replacement resorption. However, to confirm this prognosis, it is necessary some follow-up sessions. Although CBCT images are superior in diagnostic efficacy to conventional radiographic images, for follow-up the CBCT images should not necessarily replace conventional methods (5).

The impact that CBCT technology has had on maxillofacial imaging cannot be underestimated, which does not imply that CBCT is appropriate as an imaging modality of first choice in dental practice. Because cone-beam exposure provides a radiation dose to the patient higher than any other imaging procedure in dentistry, it is paramount that practitioners abide by the ALARA principle. The basis of this principle is that the justification of the exposure to the patient is that the total potential diagnostic benefits are greater than the individual detriment radiation exposure might cause (28). In other words, from the radiation protection point of view, the diagnostic information of CBCT must improve the treatment results; without such a benefit, this technique should not be recommended (5). CBCT should not be considered a replacement for standard radiographic applications. Rather, CBCT is a complementary modality for specific applications (28).

In conclusion, our paper demonstrated that CBCT images were confirmatory in diagnosing this case of a spontaneously healed root fracture. Volumetric visualization of the region between the root fragments indicated the presence of healed bone and external root resorption with signs of cessation at the apical portion of the superior segment, whereas conventional imaging only demonstrated a not well-defined radiolucency at the fracture line that could be associated with an occult inflammatory process. Without CBCT confirmation of the clinical impression, there was a likelihood of inappropriate root canal therapy for this tooth. Furthermore, we support the use of small field of view, high resolution CBCT imaging consistent with the ALARA principle.

Conflict of interest

The authors deny any conflict of interest.

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