MAXILLARY CENTRAL INCISOR INJURY FOLLOWED FOR 4 YEARS WITH CBCT.

(A case report of maxillary central incisor injury treated and followed for 4 years with cone beam computed tomography .)

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Case report: A 10-year-old girl was cycling home when she collided with another bicycle and fell and hit her face on an asphalt road in early November 9. She presented to our hospital 1 hour after injury. She had no previous systemic medical history.

On oral examination, significant mobility of tooth 11 was noted (Fig. 1(a)). Tooth 21 was also significantly mobile, with a fractured crown and exposed pulp. Clinical diagnosis was subluxation of tooth 11 and subluxation plus crown fracture (with pulp exposure) of tooth 21 (Fig. 2(a, b)). Both teeth showed a negative response to the electric pulp test (EPT). Twelve days later, after fixation of both teeth, tooth 21 was treated with cleaning with 6% sodium hypochlorite for 5 min, followed by pulp capping with calcium hydroxide, coverage of the capped portion with, MMA-resin and filling with composite resin due to loss of fractured crown fragments (Fig. 3(a–d)). even days after injury, she reported a strange feeling at tooth 11 and underwent dental X-ray, which suggested root fracture. Cone beam computed tomography (CBCT) was then performed and root fracture was confirmed (Fig. 4(a–d)). About 3 months after injury, she presented with pain at tooth 21 and underwent cleaning and filling of an infected root canal.

Fig. 2. (a) X-ray image and (b) intra-oral photograph taken immediately after injury.

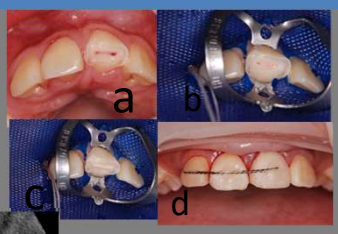

Fig. 3. The tooth was (a) cleaned with 6% sodium hypochlorite for 5 min, followed by (b) pulpotomy with calcium hydroxide, (c) filling with MMA-based resin, and (d) restoration with composite resin.

Fig. 4. (a) Dental X-ray confirms root fracture of tooth 11. CBCT shows (b) no evidence of infection at tooth 21, while a fracture line was observed in tooth 11 on both (c) coronal and (d) sagittal views.

Then about 4 months after injury, tooth 11 showed a positive EPT response, suggesting restored vital reaction of the pulp (Fig. 5). During follow-up, no noteworthy events occurred for tooth 11. Although mobile teeth after traumatic injury are usually fixed for 3-4 weeks, 3-month fixation was required in the present case due to significant mobility of tooth 11. The 3-month period was required until the mobility of the coronal fractured tooth fragment was improved. The patient has been regularly followed to monitor the injured teeth and to provide preventive dental care. Follow-up dental X-ray and CBCT were taken 16 months (Fig. 6 (a–b)) and 4 years (Fig. 7 (a–b)) after injury, respectively.

At the 4-year follow up in November 2013, no evidence of post-root canal filling infection was observed at tooth 21 and no clinical symptoms were observed at tooth 11. However, CBCT images (Figs. 4, 6 and 7) showed progressive separation of the fragments of the fractured root and apex formation from the coronal tooth fragment, as well as evidence of progressive pulp canal obliteration (PCO) and narrowing of the pulp cavity. Nevertheless, the tooth showed a positive EPT response.Close follow up will be continued for as long a period as necessary. The most recent intra-oral photograph is shown in (Fig. 8(a-b)). The patient and her parents were informed of the purpose of the study and gave prior consent to undergoing CBCT on both occasions.

Fig. 5. Response to the electric pulp test (EPT) became positive 3 months after injury.

Fig. 6. (a) Sagittal CBCT image shows apex formation from the coronal tooth fragment and progressive separation of the fracture fragments. (b) Coronal CBCT image shows closure of the root apex of the coronal tooth fragment.

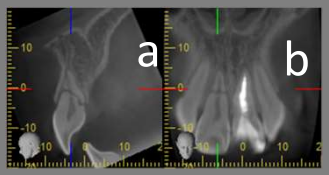

Fig. 7. (a) Sagittal CBCT image shows apex formation from the coronal tooth fragment and closure of the apex. (b) Coronal CBCT image shows further progression of PCO and clearly visualizes the pulp cavity of the coronal tooth fragment.

Fig. 8 (a–c) Intra-oral photographs taken 4 years after injury.

Discussion

Effectiveness of CBCT in diagnosing root fracture.

Many cases of vertical root fracture may not be diagnosed by digital X-ray immediately after injury. In the present case, root fracture was not evident on the X-ray shown in Fig. 2(a). Although a fracture line was observed on another X-ray image shown in Fig. 4 (a), a definitive diagnosis could not be made and CBCT was therefore considered necessary. It has been reported that CBCT is significantly more effective in diagnosing vertical root fracture than conventional digital X-ray, and that the use of CBCT by clinicians has significantly improved the diagnostic accuracy of root fracture (1,2). CBCT is also associated with less variation in interpretation between dentists, which further supports the superiority of CBCT over digital X-ray for diagnosing root fracture (3). When not using CBCT, Bakland et al. (4) have suggested that dental X-ray be taken from various angles, rather than in a single direction, to obtain an accurate diagnosis of tooth fracture.

Significance of the pulpal vital reaction becoming positive 3 months after injury with gradual narrowing of the pulp cavity.

Andreasen et al. (5) classify traumatic horizontal root fracture of the incisor into four types, according to the condition of the coronal tooth fragment: A) concussion (the fracture fragment is not mobile); B) subluxation (the fracture fragment is mobile but not displaced); C) deciduous luxation (the fragment has fallen off); and D) lateral luxation (the fragment is laterally displaced). The present case can be classified as type B, with significant mobility of the coronal tooth fragment. Bakland et al. (4) reported that pulp necrosis occurs in about 15% of cases in the presence of a grown and closed root apex while PCO, as observed in the present case, occurs in only 8.6% of these cases and the pulp remains in a healthy state in 76% of such cases. PCO progressed significantly more in the coronal fracture fragment than in the apical fragment in the present case, and this focal progression pattern of PCO has been observed in many cases.In the present case, significant tooth mobility was associated with a fracture at one-third of the distance from the apex. Welbury et al. (6) suggested that fracture occurring at sites closer to the crown is associated with poorer survival of the pulp and that the loss or displacement of the coronal fracture fragment (type D, lateral luxation) is associated with an increased risk of pulp necrosis. Welbury et al. (6) assert that tooth fixation does not affect the outcome of pulp treatment, while Andreasen et al. (7) identified mobility of a fracture fragment as a negative factor for pulp survival and suggested the importance of appropriate fixation in the presence of tooth luxation or loss. Significant tooth mobility resulting from subluxation, essentially identical to luxation, was observed in the present case. This suggests that damage to the pulp led to PCO-mediated healing of the pulp, instead of complete pulp healing. The absence of significant progression of PCO in the apical fragment of the fractured tooth was probably due to a lack of influence of luxation on the apical fragment.

Significance of gradual separation of the fractured tooth fragments and formation of a new root apex from the coronal tooth fragment.

Andreasen et al. (8) identified four patterns of healing of horizontal root fracture: 1) a healing process involving calcification between fracture fragments, where the gap between fragments is so narrow that a fracture line cannot or can only barely be identified; 2) a healing process in which tooth fragments are separated and hard and soft tissue fills the gap between them; 3) a healing process in which tooth fragments are separated and periodontal ligament-like soft tissue fills the gap and the apex of the coronal tooth fragment becomes rounded, with a radiolucent band observed between fracture fragments; and 4) a healing process characterized by necrosis of the coronal fracture fragment, with soft tissue present between the fragments. A favorable long-term outcome can be expected even in the latter case as long as appropriate root canal therapy is performed (9). Cvek et al. (10) investigated the pattern of healing of root fracture in 208 patients and reported that the healing processes 1–4 described above occurred in 33%, 8%, 36%, and 23% of the patients, respectively, with the healing process 3 being most common. The healing pattern might also vary depending on the patient's sex, age, status of root growth, type and location of fracture, and degree of displacement due to luxation (9).The present patient had healing process 3, where the root apex of the coronal fractured tooth fragment was closed and showed signs of regeneration, rather than becoming rounded as described above. A radiopaque area was observed at the tip of the pulp of the coronal fragment, as shown in Fig. 7 (b,c). To our knowledge, this is the first report of using CBCT for the three-dimensional assessment of the healing process of root fracture. It is likely that this healing process would be visualized as a gradual rounding of the root apex on a two-dimensional image.

Significance of pulp necrosis in tooth 21 observed 3 months after injury.

Crown fracture is divided into 1) enamel fracture, 2) simple crown fracture (without pulp exposure), 3) complicated crown fracture (with pulp exposure), and 4) crown fracture with luxation/subluxation (11). The present case can be classified as type 3 or 4, given the negative EPT response and significant tooth mobility upon initial presentation. Eklund et al. (12) reported in 1976 that pulp necrosis occurred in as many as 48% (36/75) of patients who had subluxation injuries with significant tooth mobility and were treated immediately within 24 h of injury. They also found no significant difference in pulp survival between those treated immediately and those treated after a delay. Tsukihoshi (11) suggested in 2009 that in younger patients, follow up should be continued for at least a few months until the vital reaction of the pulp is restored, regardless of the presence or absence of pulp necrosis. In the present case, however, the vital reaction of the pulp was not restored and the patient complained of pain at the 3-month follow up, leading to treatment of an infected root canal. Tsukihoshi also suggested that most cases of traumatic fracture with luxation injuries result in pulp necrosis and should therefore be treated by root canal therapy immediately following fracture repair. The present patient has been followed for 4 years after root canal filling. No evidence of inflammation has been observed as of November 2013.

Conclusion: The present findings suggest that CBCT is effective for the accurate diagnosis of tooth injury. To decide the treatment of tooth injury, it is important to assess the presence or absence of adequate blood flow to the pulp based on the condition of the apical foramen and the severity of fracture. The outcome of treatment also depends on the growth state of the root, as well as the number and activity of pulp cells, which change with age. The present findings also suggest that the mobility of fracture fragments and the displacement, extension, or rupture of the pulp due to loss of a fragment significantly affect survival of the pulp. These findings suggest that performing appropriate treatment while considering these factors should lead favorable long-term outcomes in patients with tooth injury. Finally, most cases of oral injury can be treated under the coverage of national health insurance in Japan. We believe that providing dental treatment based on a sufficient knowledge of the theoretical and practical aspects of injury and the principles of conservation dentistry will lead to improved QOL for patients.

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