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CASE REPORT/CASO CLINICO

Clinical management of horizontal root fractures aided by the use of cone-beam computed tomography

Trattamento clinico-chirurgico di fratture radicolari orizzontali con l'ausilio di tomografia computerizzata a fascio conico

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KEYWORDS
Dental trauma;
Root fracture;
Cone-beam computed tomography;
Diagnosis;
Treatment.

Abstract
Aim: To present a a therapeutic approach in a case series of teeth that suffered some root fracture at different thirds with a follow-up period of 24 months.
Summary: Dental trauma occurs with great frequency to the maxillary incisors, and, sometimes, horizontal root fractures are caused. The classification and severity of horizontal root fractures are based on the location of the fracture line and on the degree of dislocation of the coronal fragment. Diagnosis of horizontal root fractures is based on clinical findings, sensibility tests, and principally in radiographic and cone-beam computed tomography (CBCT) examination. The following cases report describes the diagnosis and treatment of four maxillary central incisors with horizontal root fractures. In three of the cases described, the healing occurred through the interposition of connective tissue where radiographically was possible to observe a radiolucent at the level of the fracture line and the rounding of the fragment angles. In one case, the healing occurred by calcified tissue, which can be seen radiographically in the fracture line, but the

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fragments are in close contact. In addition to a proper treatment plan, the International Association of Dental Traumatology (IADT) stresses the importance of patient compliance with follow-up, and daily care visits for better healing after dental trauma. Knowledge of existing protocols for this type of injury and periodic monitoring of cases has shown the success of the treatment so far.

Key-learning points:

(1) The diagnosis of root fractures requires a detailed examination, both clinical and radiographic.
(2) The IADT developed a guideline in order to propose an effective treatment plan.
(3) The CBCT facilitates the visualization of lines fracture.
(4) An immediate approach after horizontal root fractures comprises reduction, splints and occlusal adjustment.

PAROLE CHIAVE
Trauma dentale;
Frattura radicolare;
Tomografia computerizzata a fascio Conico;
Diagnosi;
Trattamento.

Riassunto

Obiettivi: Presentare un approccio terapeutico con una serie di casi di denti che hanno subito una frattura radicale a diversi livelli con un periodo di follow-up di 24 mesi.

Riassunto: Il trauma dentale si presenta con una grande frequenza negli incisivi mascellari e, a volte, si possono verificano fratture di radice orizzontale. La classificazione e la gravità delle fratture di radice orizzontale si basano sulla posizione della linea di frattura e sul grado di dislocazione del frammento coronale. La diagnosi delle fratture di radice orizzontale è basata sui riscontri clinici, test di sensibilità e principalmente un esame radiografico intraorale e CBCT. I casi affrontati descrivono la diagnosi e il trattamento di quattro incisivi centrali mascellari con fratture di radice orizzontale. In tre dei casi descritti, la guarigione si è verificata attraverso l'interposizione di tessuto connettivo in cui radiograficamente è stato possibile osservare un radiotrasparenza a livello della linea di frattura e l'arrotondamento degli angoli dei frammenti. In un caso, la guarigione è stata caratterizzata da tessuto calcificato, che può essere visto radiograficamente nella linea di frattura, ma i frammenti sono in stretto contatto. Oltre ad un adeguato piano di trattamento, l'Associazione Internazionale della Traumatologia Dentale (IADT) sottolinea l'importanza delle visite di follow-up e del mantenimento quotidiano per una migliore guarigione dopo traumi dentali. La conoscenza dei protocolli esistenti per questo tipo di lesioni e il monitoraggio periodico dei casi ha mostrato finora un buon successo del trattamento.

Punti chiave di apprendimento:

1.La diagnosi di fratture radice richiede un esame dettagliato, clinico e radiografico.
2.L'Associazione Internazionale della Traumatologia Dentale (IADT) ha sviluppato una linea guida per proporre un efficace piano di trattamento.
3.La CBCT facilita la visualizzazione delle linee di frattura.
4.Un approccio immediato dopo le fratture di radice orizzontale comprende riduzione, splintaggio e regolazione occlusale.

Introduction

Dental root fractures occur mainly in the anterior area of the maxilla, frequently due to a frontal impact, predominantly as a result of automobile accidents, violence and sporting activities.[1] The incidence of fractures in permanent teeth occurs at a rate of 0.5—7% of all traumatic injuries of teeth.[2] This traumatic event is most observable in the maxillary central and lateral teeth, and rarely in mandibular incisors.[3] The classification and severity of horizontal root fractures are based on the location of the fracture line, i.e., cervical, medium, or apical; and on the degree of dislocation of the coronal fragment.[2]

The clinical management of a root fracture depends on its pulp vitality, dislocation of the fragments, and the location/extent of the fracture line. Root fracture healing that can occur through hard tissue deposition or by the interposition of connective and hard tissue between the fragments is dependent on two conditions: pulp integrity and invasion or no bacteria in the fracture line.[4,5]

The degree of mobility is related to the level of the fracture, but the diagnosis depends on the radiographic examination for differentiation trauma of dislocation. It is convenient to hold two or multiple radiographs with variation in the vertical angle of incidence of the beam[6] or complementation with another dimensional view by using cone-beam computed tomography (CBCT), especially the oro-facial dimension.[7—10]

A series of clinical reports have shown important information regarding long-term survival of teeth with horizontal

root fractures.[11–18] Within this context, the location of the root fracture had a substantial and relevant effect on tooth survival.[19,20]

The following cases report describes the diagnosis and treatment of four maxillary central incisors with horizontal root fractures.

Case reports

Case 1

A 9-year-old female patient was presented with reporting dento-alveolar trauma to the anterior teeth resulting from a fall in which the patient's mouth struck the floor. The patient sought emergency care 10 days after the accident.

Clinical examination revealed that the right maxillary central incisor presented remarkable mobility, no sensitivity to percussion, a positive sensitivity test, and a soft color discrepancy. A slight extrusion of the right maxillary central incisor was noted (Fig. 1a). Radiographic examination revealed the periodontal ligament and lamina dura with normal appearance; however, a horizontal root fracture was evident (Fig. 1b). Further analysis by a CBCT revealed a horizontal root fracture of the middle third and apical at the buccal portion progressing to the middle third in palatal direction. A displacement of the fragments became apparent through the parasagittal view (Fig. 1c–e).

The treatment involved the placement of the semi-rigid splint performed with 0.03-mm stainless steel braided wire, fixed with light-cured composite resin from lateral to lateral, and kept for 4 months (Fig. 1f and g). Furthermore, a light incisal wear of the right upper incisor was performed.

The clinical and radiographic follow-up was performed periodically, and 2 years after the trauma, the right maxillary central incisor was asymptomatic and presented positive pulp sensitivity (Fig. 1h and i). Radiographic examination showed no change in radiolucent line between fragments, but the outer edges of the fragments were rounded and do not show pathological changes in both the coronal and the apical segment.

Case 2

Because of a motorcycle accident, a 39-year-old female presented with facial trauma 10 days before. Clinical examination reveals mobility in the maxillary right central incisor, and complicated crown fracture in the maxillary right lateral incisor with pulp exposure and uncomplicated fracture in the maxillary left central incisor (Fig. 2a). The pulp sensitivity tests gave an exaggerated response in traumatized teeth. The periodontal tissues had no change, yet the lip mucosa was lacerated due to the trauma. A periapical radiograph showed horizontal root fracture in the middle third of the maxillary right central incisor (Fig. 2b).

A further analysis provided by CBCT revealed through the coronal and axial section, an oblique fracture with a root path apical portion in their buccal aspect, progressing to the third middle in palatal direction (Fig. 2c–e). A large displacement of the fragments became apparent through complementary parasagittal cut.

The treatment involved endodontic therapy in the maxillary right lateral incisor, followed by stabilization with a flexible splint for 4 months.

Clinical and radiographic follow-up was performed every month. After 24 months, the maxillary right central incisor was asymptomatic with negative response to pulp test (Fig. 2f and g). The periodontal tissues showed no sign of inflammation or fistula. Radiographically, we observed the calcification of the apical segment and the beginning of that process in the coronal segment. Radiographic examination showed no change in radiolucent line between fragments, but the outer edges of the fragments were rounded.

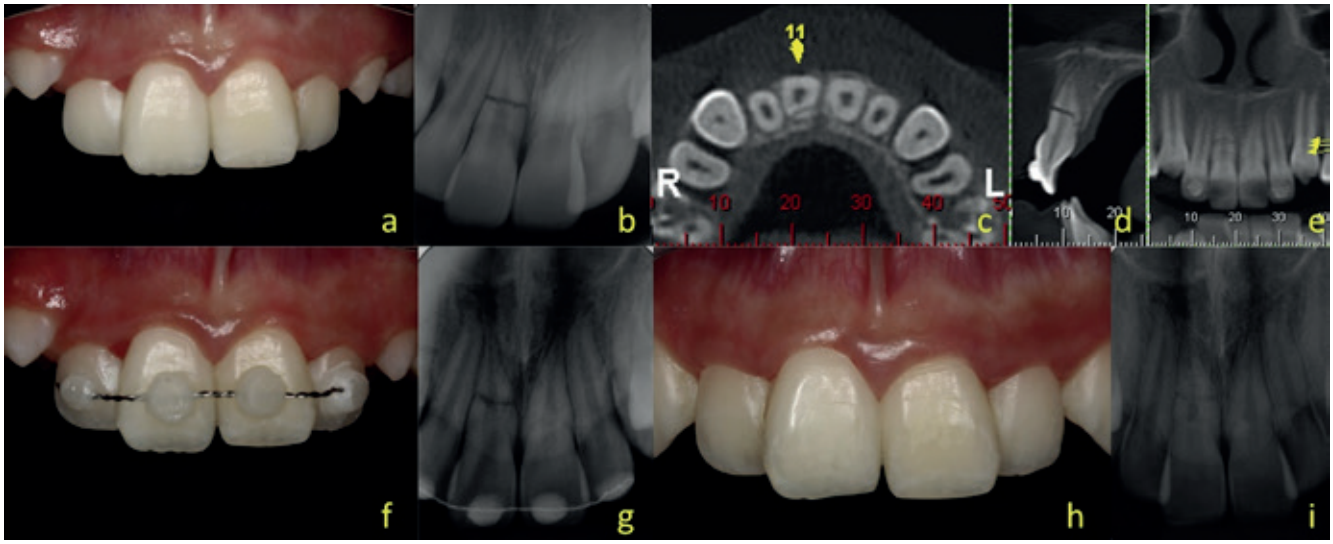

Figure 1 (a) Initial intraoral view of the case 1. (b) A preoperative radiograph showing horizontal root fracture at the apical third of the left maxillary central incisor. (c) CBCT showing the sagittal (d) axial (e) and panoramic view. (f) Semi-rigid splint performed. (g) Periapical radiograph at 4-months. (h) Buccal clinical aspect at 2-year follow-up. (i) Radiographic examination at 24-months.

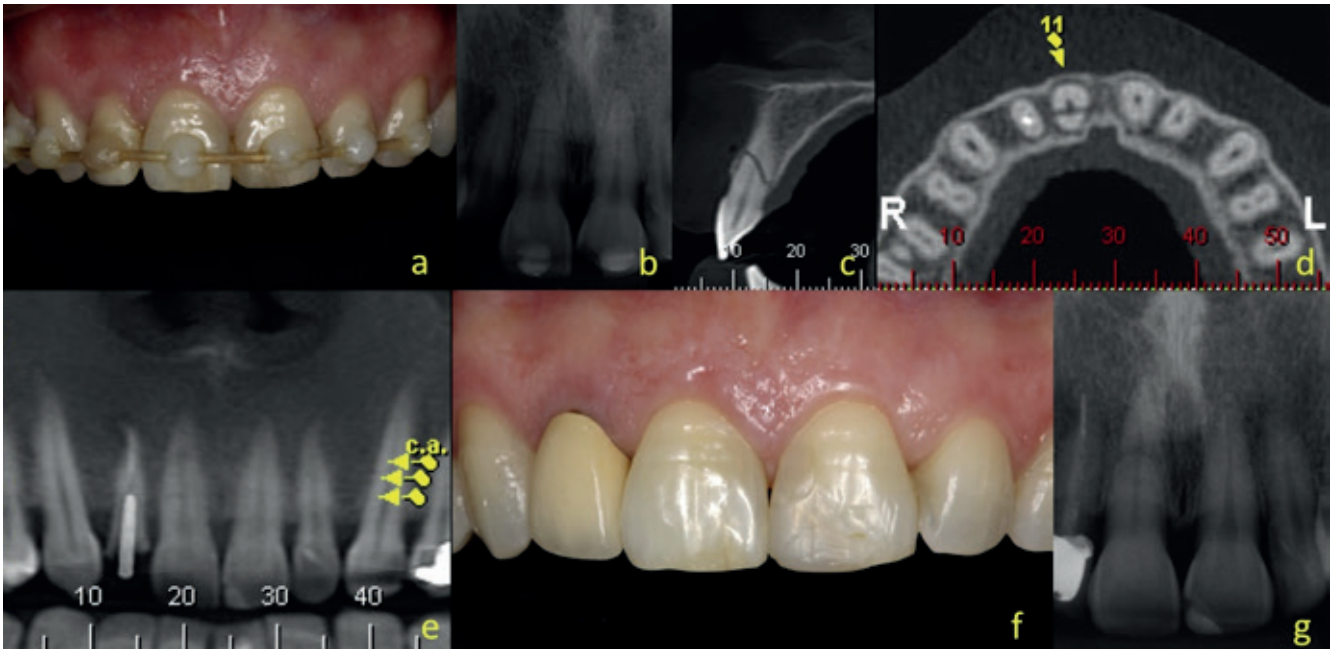

Figure 2 (a) Image obtained 10 days after the trauma. (b) Periapical radiograph suggesting root fracture at the apical third of the right maxillary central incisor. (c) CBCT showing the sagittal. (d) axial (e) and panoramic view. (f) 2-year follow-up evidencing healthy clinical appearance. (g) Periapical radiograph at 2-year follow-up displays healing of the horizontal root fracture.

Case 3

A 16-year-old male patient was referred to the Department of Clinics with pain in the region of the upper incisors. The patient reported a bicycle accident two days ago and an accomplishment of flexible splint fixated with light-cured composite resin from canine to canine in the teeth (Fig. 3a).

Clinical examination revealed a crown fracture of the maxillary left lateral incisor, small mobility, and a smooth color alteration in maxillary left central incisor. The pulp

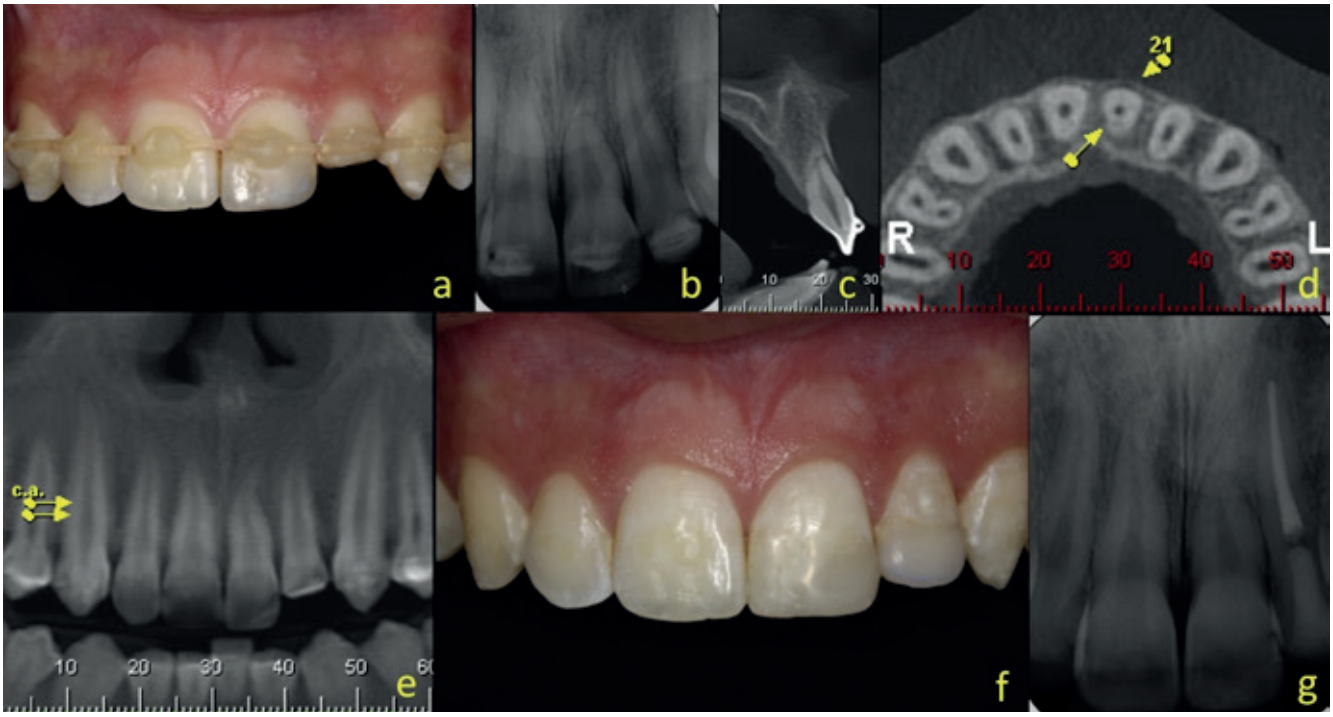

Figure 3 (a) Initial intraoral view of the case 3. (b) A preoperative radiograph showing horizontal root fracture at the apical third of the left maxillary central incisor. (c) CBCT showing the sagittal (d) axial (e) and panoramic view. (f) Clinical follow-up after 2-years. (g) Periapical radiograph at 2-year follow-up showing the interposition of hard tissue between the fragments.

sensitivity test appeared vital to thermal stimulation. Radiographic examination revealed horizontal root fracture in the apical third of the left maxillary central incisor (Fig. 3b).

Cone-beam computed tomography revealed oblique root fracture with an apical trajectory in its buccal portion, progressing to the third middle in palatal direction (Fig. 3c—e). A discrete displacement of the fragments became apparent through the parasagittal cut.

The patient was wearing the flexible splint for 4 months, and the maxillary left lateral incisor was submitted to endodontic treatment. After 24 months, the maxillary left central incisor presented a positive response to pulp test and normal mobility. The radiographic follow-up showed no change in radiolucent line between fragments, suggesting healing of the apical root fracture with the interposition of hard tissue between the fragments (Fig. 3f and g).

Case 4

The maxillary left central incisor of a 24-year-old male suffered an impact due to a physical attack 2 years ago. The clinical examination revealed the presence of a slight discoloration of the maxillary left central incisor (Fig. 4a). The patient reported a root fracture in the maxillary left central incisor. He reported an attempt to find a dentist five days after such trauma, and emergency care had been repositioning a flexible splint with 0.7-mm orthodontic wire for a period of 3 months.

The clinical examination evidenced a small mobility and a positive response to thermal stimulation in the maxillary left central incisor. The periodontal tissues adjacent to the traumatized tooth area had no alteration. The periapical radiographic showed oblique root fracture in the apical third of the tooth maxillary left central incisor (Fig. 4b).

Cone-beam computed tomography revealed an oblique root fracture evolving into the middle third in palatal direction (Fig. 4c—e). A serious displacement of the fragments was evident by cutting the parasagittal about 3 months after the dental trauma.

The treatment consisted of clinical and radiographic follow-up. Furthermore, an occlusal relief through slight wear on the palate of the maxillary left central incisor and buccal of the mandibular left central incisor was performed.

After 35 months, the maxillary left central incisor was asymptomatic with no mobility or pain with longitudinal percussion, and the patient did not report any clinical symptoms (Fig. 4f and g). The soft tissues showed no sign of inflammation or fistulae. Radiographic examination showed no change in the radiolucent line between fragments, but the outer edges of the fragments were rounded and had no pathological alteration in both the coronal and the apical segments. The fragments were separated by the interposition of hard and soft tissue between the fragments on the periapical radiographs.

Discussion

Root fractures are commonly identified after some dental trauma; however, they are often asymptomatic and discovered in routine tests. In clinical cases presented, patients sought care a few days or shortly after trauma, favoring the development of a treatment plan and a better prognosis.

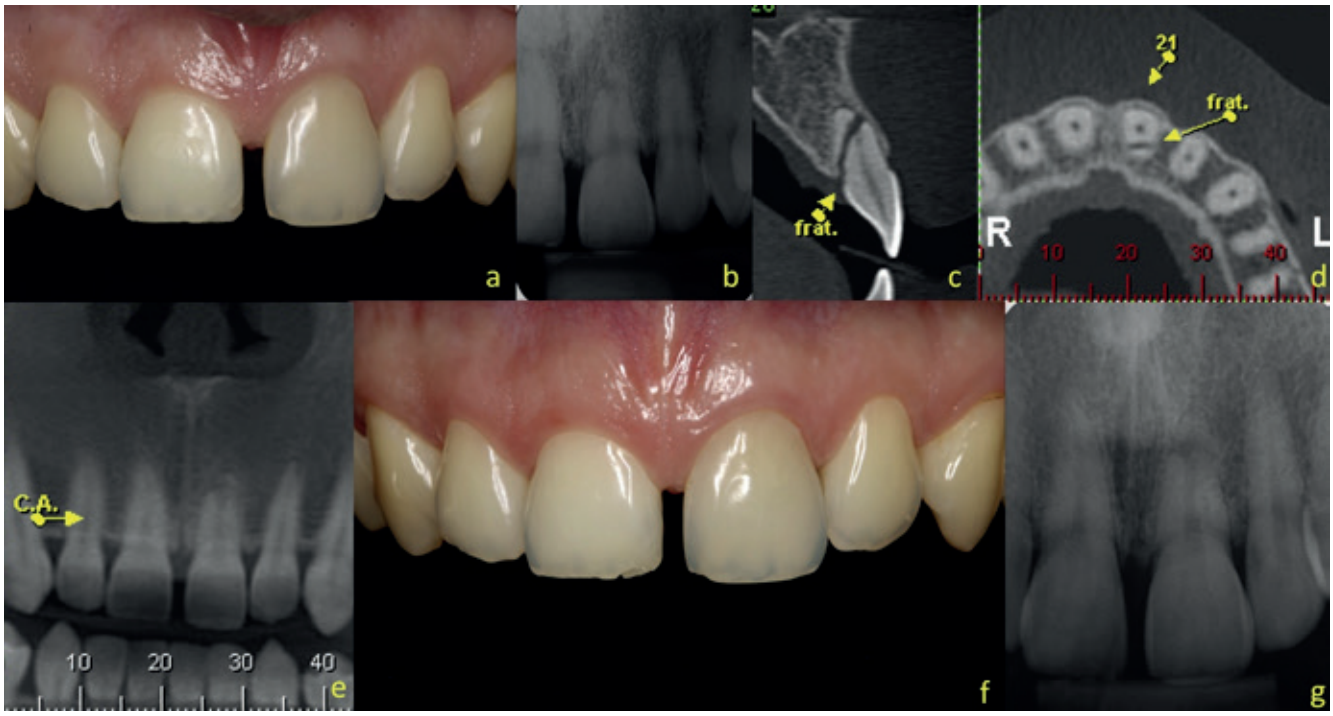

Figure 4 (a) Slight discoloration of the maxillary left central incisor. (b) A preoperative radiograph showing horizontal root fracture at the apical third of the left maxillary central incisor. (c) CBCT showing the sagittal (d) axial (e) and panoramic view. (f) Periapical radiograph at 2-year follow-up showing the interposition of soft tissue between the fragments. (g) Clinical aspect at 2-year follow-up.

Most root fractures occur in the middle-third of the root, followed by apical and coronal third.[21] In addition, it occurs most often in permanent teeth with closed apices where the fully formed root is solidly supported by the periodontal tissues.[18,22]

In the occurrence of root fracture, the healing events are initiated locally, through the periodontal ligament and pulp tissue, and led in two possible ways. If the pulp is intact, a union with calcified hard tissue is formed between the fragments[2,18]; however, when the pulp is cut or severely damaged, a revascularization procedure starts; and while revascularization is ongoing, cells derived from the periodontal ligament join the two fragments through the interposition of connective tissue.[18,23] Didactically, the sequelae of root fractures may be divided into four categories: (i) healing with calcified tissue, (ii) healing with interproximal connective tissue, (iii) healing with interproximal bone and connective tissue, and (iv) interproximal inflammatory tissue without healing.[22,24,25]

In the reported cases, most of the patients were young, and the affected region was the upper incisor, confirming with the literature,[2] as well as oblique root fracture with an apical trajectory in its buccal portion, progressing to the third middle in palatal direction. The causes of injury observed in this report were varied; among them were motorcycle accidents, falls, and alleged physical assault. In most cases, radicular fractures and an apical medium require a conservative replacement treatment, such as crown fragment reposition for a period of time and occlusal immediate relief, together with a long-term preservation in well-established guidelines for the dental management of traumatic injuries.[9] These clinical characteristics were all conducted in the case shown, yielding a positive response to this treatment.

Across all four cases reported that there was no adverse change during the clinical and radiographic preservation, or any indication of a necrotic pulp. What we could see, in subsequent radiographs, was the reabsorption of the sharp angles of the fragments due to the consequence of remodeling, similar as reported in other report.[24]

In three of the cases described, the healing occurred through the interposition of connective tissue where radiographically was possible to observe a radiolucent at the level of the fracture line and the rounding of the fragment angles. In clinical case 3, the healing occurred by calcified tissue, which can be seen radiographically in the fracture line, but the fragments are in close contact. The International Association of Dental Traumatology (IADT) developed a consensus in 2012,[9] guiding the conduct that the dentist should take before dental trauma in order to propose an effective treatment plan. The guidelines represent the best current evidence, based on data from the literature and a large experience of professionals.[9]

In the cases of horizontal root fractures, the consensus suggests that the diagnosis is based on clinical and radiographic findings, such as mobility or crown displacement, and in response to percussion tests; the gingival sulcus bleeding; pulp sensitivity testing (which may have negative initially, due to permanent or temporary damage pulp); and even color change of dental crown. To detect fractures in the apical or middle third, through radiographs, necessities of the variation of the incidence of vertical angle was suggested.[9,26]

In addition to a proper treatment plan, IADT stresses the importance of patient compliance with follow-up, and daily care visits for better healing after dental trauma. The patient and the patient's parents should be instructed on the care of tooth trauma in sports and maintaining a proper oral hygiene, ordered with optimal healing. It is suitable to use an antibacterial agent such as chlorhexidine gluconate-free alcohol 0.1% at 1—2 weeks, as an adjuvant in the oral environment suitability.[9]

We can have a better understanding of the long-term survival of teeth with root fractures when we analyze the Andreasen et al. study,[19] which considered the fracture line position as influential in healing modalities in 492 cases, followed for 10 years after the injury. With these results, we can observe that the apical fractures have the best prognosis; while cervical, the worst. Thus, it is clear that more apical the trace of root fractures, the greater the chances for healing and repair.

The diagnosis of radicular fractures require a detailed examination, both clinical and radiographic, in order to obtain accurate results. In this respect, the X-rays are very important tests to demonstrate structures that are not possible to be observed on clinical examination. However, they generate a two-dimensional image, especially in limited representation of three-dimensional structures, which may hamper diagnosis.[27—29]

Faced with the need for a better diagnostic imaging, a CBCT has gained ground in dentistry, as allowing a clear view without overlay images, which facilitates the visualization of lines fracture.[10,27] Through CBCT, it is possible to observe the degree of separation of the fragments, the direction of the fracture line, the presence of bone lesions, and also the occurrence of engagement of the adjacent structures.[10,27]

Periodic monitoring of cases has shown the success of the treatment so far. In all of them, there is an absence of symptoms, negative response to percussion tests, and no excessive mobility or no mobility. Of the four cases, three respond positively to pulp sensitivity testing, and one of them has not; however, so far no bone or periodontal change was observed in all of them.

Conclusion

The root fractures in anterior teeth are present in the emergency dental clinic and, being an unexpected occurrence, require staff professionalism and good technical preparation. Knowledge of existing protocols for this type of injury is the first step to successful treatment in the middle third and apical.

Conflict of interest

The authors deny any conflicts of interest.

The authors warrants that the article is totally original, does not infringe upon any copyright or other proprietary right of any third party, is not under consideration for publication by any other journal, and has not been submitted or published previously. The authors confirm that they have reviewed and approved the final version of the manuscript and the revised English language was certificate by PaperCheck Language ProofReading and Editing Services.

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