Case Report

Journal of Dental and Maxillofacial Surgery

Multidisciplinary Approach in a Child with Complex Trauma of Maxillary Permanent Central Incisors

Lucisano MP*, Corrêa Leite RGL¹, Nelson-Filho P¹, Minto AMP², Ferraz JAB³, Cesco RT¹, de Carvalho FK¹ and Queiroz AM¹

¹Department of Pediatric Dentistry, School of Dentistry of Ribeirão Preto, University of São Paulo, Ribeirão Preto, SP, Brazil

²Department of Restorative Dentistry, School of Dentistry, University of Franca, Franca, SP, Brazil

³Department of Endodontics, School of Dentistry, University of Ribeirão Preto, UNAERP, Ribeirão Preto, SP, Brazil

***Correspondence:** Dr. Marília Pacífico Lucisano, Department of Child Clinic, School of Dentistry of Ribeirão Preto, University of São Paulo, Avenida do Café s / n, Monte Alegre, 14040-904, Ribeirão Preto, SP, Brazil, Tel: +55-16-3315-4143; Fax: +55-16-3633-0999; E-mail: marilia.lucisano@forp.usp.br

Received date: May 02, 2019; Accepted date: May 13, 2019; Published date: May 20, 2019

Abstract

The present case report describes a multidisciplinary approach involving endodontic, restorative, surgical and periodontal treatment and rehabilitation of a central incisor with crown-root fracture (CRF) in an 11-year-old child. Although in the future possible sequelae and complications should be considered since it is an extensive trauma, the prognosis of the present case is favourable, with the occurrence of repair, evidenced by clinical, radiographic and tomographic success, after one year and six months of follow-up. It was concluded that the association of prolonged flexible splint, biological endodontic treatment, gingivoplasty and restorative/rehabilitative procedures seem to be an adequate and conservative management for CRF cases.

Keywords: Dental trauma, Crown-root fracture, Pediatric dentistry, Multidisciplinary approach

Introduction

Dental trauma can result in different types of damage to teeth and support structures [1]. The upper incisors are the teeth most commonly affected by trauma and, most of the times, the coronal portion is damaged [2]. The crown-root fracture (CRF) involves enamel, dentin and root cementum [1,2], presenting a prevalence of 5% in the permanent dentition [3]. The CRFs are classified as non-complicated and complicated, according to the presence or absence of pulp involvement [4].

Depending on the force and direction of the impact, the fracture line may begin at some point of the crown and extend longitudinally, reaching the subgingival area and alveolar crest [1]. According to Olsburgh et al. [5], an inflammatory reaction occurs in the gingival tissue at the

level of the fracture line, below the cementum-enamel junction, with the presence of leukocytes and fibroblasts. Clinically, a mobility of the coronal fragment attached to the gingiva, with or without pulp exposure is observed [1]. It is difficult to detect the fracture line on the radiographic examination due to limitations inherent in the technique [6], since the oblique line is almost perpendicular to the central beam of x-rays.

In this context, the importance of Cone Beam Computed Tomography (CBCT) in the diagnosis of root fractures, especially oblique and vertical fractures, is highlighted. This three-dimensional image reconstruction method allows direct visualization of the fracture line and overcomes the problems of distortion and overlap of anatomical structures of conventional two-dimensional methods [7]. Therefore, the CBCT can be a useful tool in determining

the fracture line and in the planning of the best conduct to be taken. In addition, it makes an early diagnosis possible, guaranteeing a better prognosis of the case [8].

Oblique CRFs which extend below the gingival margin and the alveolar ridge are difficult to restore [2]. During the planning of the best conduct to be followed, one must consider some factors such as the location and level of invasion of the biological space; pulp involvement; root development stage; dental eruption stage and presence of the fragment adequately adapted to the dental remnant [9]. Efforts should be directed to avoid loss of dental elements, especially in young patients, and to restore their shape and function, preventing the occurrence of deformities or injuries to soft tissues, which may occur through aggression of the biological space with restorative procedures [10].

The subgingival location of the fracture makes obtaining a restoration with an ideal sealing by adhesive procedures extremely difficult or impracticable [2]. Thus, the treatment of these cases is a challenge to the dental surgeon and requires a multidisciplinary approach, involving Endodontics, Orthodontics, Periodontics and Prosthodontics. The main objective should be to expose the fracture margins supragingivally so that all clinical procedures can be performed without contamination with moisture or blood. In addition, the prognosis of the tooth can be improved by better control of the patient's biofilm [5].

Treatment options for a crown-root fracture with the invasion of biological space include extraction, surgical crown lengthening, surgical extrusion, and orthodontic extrusion [2,11]. In cases of young patients, extraction should be the last option because the rehabilitation through the placement of implants is unfeasible.

Therefore, the present case report describes a conservative multidisciplinary approach to the management and treatment of an extensive case of trauma involving the upper central incisors in a child.

Case Report

The patient M.E.B.M., female, 11 years old, was referred to the Pediatric Dentistry Clinic of the School of Dentistry of Ribeirão Preto, University of São Paulo, Brazil, reporting pain in the upper anterior incisors. During anamnesis, it was reported that the patient had suffered a bike fall a year before and that the permanent right upper central incisor [11] presented mobility, which impaired her feeding and

the permanent left upper central incisor [12] was broken. After the trauma, coronal access, pulpectomy and sealing were the only dental procedures performed in a public health care unit. In addition, it was reported that the patient was experiencing psycho-emotional problems due to the aesthetic that was compromised and significantly affecting her self-esteem, including bullying episodes in school.

The presence of severe mobility in the permanent right upper central incisor [11] and extensive crown fracture in the permanent left upper central incisor [12] were clinically confirmed, as demonstrated in figure 1A. Both teeth responded negatively to the pulp sensitivity test and positively to the percussion. On radiographic examination, shown in figure 1B, a fracture line was observed in the cervical region of tooth 11, teeth 11 and 21 presented an intracanal dressing in the pulp chamber of unknown nature and tooth 21 presented a radiolucent image in the periapical region. The remnants upper and lower incisors did not show any significant clinical or radiographic signs.

In CBCT images examination, shown in figure 1C, an S-fracture was found in tooth 11, which was located at the level of cervical enamel (subgingivally) on the vestibular surface and at an intraosseous level in the cervical third of the root by palatal surface. In addition, periapical lesion on tooth 21 was present, whereas root resorptions and bone rarefaction in the lateral region of the root were absent.

A conservative treatment on tooth 11 was chosen to be performed, as the child could not receive an implant due to age. All possible consequences of the treatment plan elaborated were clarified to the patient and her legal guardian, who accepted and authorized by signing an Informed Consent Form. During all stages of the treatment, there was collaboration, dedication and commitment on the part of the family, which contributed to a favourable prognosis of the present case.

Clinical procedures

The first clinical procedure was the class IV restoration with light cure composite (Filtek Z250 XT, 3M ESPE, St. Paul, MN, USA) of the tooth 21, partly recovering the aesthetics and creating a suitable surface for the placement of the splint, as shown in figure 2A. A flexible splint 0.4 mm diameter orthodontic wire and composite was then performed from canine to canine and preserved for 8 months, to promote consolidation of the fracture in the palatal region. In this same session, the endodontic treatment was initiated on teeth 11 and 21. During the procedure, an absorbent paper cone was found inside the canal of the element 11,

which was causing a foul smell and an inflammatory and infectious process, including a purulent exudate. The origin of the paper cone was unknown since it had been placed inside the canal during the service performed in a public health care unit, about a year ago.

Figure 1: (A) - Extensive crown fracture in tooth 21 and gingival inflammation in the tooth 11. (B) - Initial periapical radiograph evidencing fracture line in the cervical region of tooth 11 (arrow) and periapical radiolucent image in tooth 21 (arrow). (C) - CBCT images showing an S fracture in tooth 11 (arrow) and a periapical lesion on tooth 11 (arrow).

Figure 2: (A) - Clinical view evidencing restored tooth 21, gingival hyperplasia and the flexible splint with orthodontic wire and composite. (B) - Radiographic image of teeth 11 and 21 with a calcium hydroxide based paste intracanal dressing. (C) - Radiographic image of teeth 11 and 21 after root canal obturation.

Endodontic treatment of both teeth included removal of temporary crown sealing neutralization of the septic root canal content, with manual files from greater to lesser caliber, until reaching provisional working length, and irrigation with 2.5% sodium hypochlorite; determination of the working length at 0.5mm short of the apical foramen, using an electronic apex locator (Root ZXII, J Morita Corp., Kyoto, Japan) and biomechanical preparation of root canals using the ProTaper NiTi rotary Universal System (Dentsply Maillefer, Ballaigues, Switzerland) powered by the X-Smart endodontic micromotor (Dentsply Maillefer), under constant irrigation with 2.5% sodium hypochlorite at each instrument change. After application of EDTA, new irrigation and drying of the canals with absorbent paper tips, an intracanal dressing was placed with calcium hydroxide based paste (Calen® - S.S. White Artigos Dentários Ltda., Rio de Janeiro - RJ - Brazil) and the access cavities were provisionally sealed with glass ionomer cement (Vidrion R® - SS White Artigos Dentários Ltda., Rio de Janeiro - RJ - Brazil). Figure 2B shows the radiographic image of root canals filled with the intracanal dressing.

After two changes of the intracanal dressing, every 30 days, it was removed and the root canals were filled with cones of gutta-percha and AH Plus root canal sealer (Dentsply-De Trey, Konstanz-Germany), shown in figure 2C, using the lateral condensation technique. After application of a layer of calcium hydroxide Dycal (Dentsply - De Trey) cement and glass ionomer cement, the access cavities were restored with composite (Filtek Z250 XT).

During the period of stabilization, gingival hyperplasia was observed in the anterior region, due to the absence of adequate oral hygiene, which was made difficult by the presence of the splint. Oral hygiene guidelines and instructions, as well as mouthwash prescription with 0.12% chlorhexidine, were necessary to control gingival inflammation.

After controlling of the inflammatory process and subsequent regression of gingival hyperplasia, periodontal surgical treatment was performed in the buccal region of the tooth 11, as demonstrated in figure 3A, which involved the following steps: intrapapillary local anesthesia, gingivoplasty performed with a 15-scalpel blade and periodontal curette, with exposure of the fracture line and tooth wear with bur (Figure 3B). Labial frenectomy and suture were also performed, as shown in figure 3C. In the next session, after gingival tissue healing, a restoration with a light cure composite of the fracture line was performed in the vestibular surface. The clinical view after surgical and

restorative procedures can be seen in the figure 3D.

Figure 3: Periodontal surgery for exposure of the fracture line. (A) - Periodontal probing. (B) - Tooth wear with bur. (C) - Labial frenectomy and suture. Gingival contour at the level of the vestibular fracture. (D) - Gingival healing 10 days after surgery.

The splint was removed subsequently, as demonstrated in figure 4A. However, a slight mobility on tooth 11 and gingival inflammation in the region corresponding to the vestibular fracture line were still present. The fracture of the palatal surface was completely repaired, as visualized in the radiographic examination. Figure 4B shows radiographic signs indicative of bone repair.

Thus, it was decided to plan an indirect restoration with the placement of an intraradicular post on tooth 11, involving the fracture line, which would improve the repair of the gingival tissue, as well as confer stability to the dental element. It was decided to also perform indirect restoration with an intraradicular post on the tooth 21, which had an extensive coronary fracture, so the post improved both aesthetics and retention. After preparation of the root canals, the glass fiber posts were cemented with dual resin cement (Relyx U200 (3M ESPE)) inside the root canals of both teeth. Subsequently, the elements were prepared to receive full composite resin crowns, as shown in figure 4C. It is noteworthy that the fracture line located on the vestibular surface of tooth 11 was included in the preparation. Temporary crowns were prepared and cemented in each tooth. Gingival healing and tissue adaptation were expected to take 60 days, evidenced in figure 4D.

After this period, the final composite crowns were cemented with dual resin cement (Relyx U200), offering a very satisfactory aesthetic result.

Figure 4: (A) - Clinical view after removal of the splint, where gingival inflammation is present. (B) - Periapical radiography, showing absence of pathological signs. (C) - Preparation for a crown placement. (D) - Sixty days after temporary crowns cementation, evidencing gingival tissue adaptation and healing.

At the end of the therapeutic approach, a new clinical (Figure 5A), radiographic (Figure 5B) and tomographic examination (Figure 5C) were carried out to evaluate all dental and periodontal tissues. In this examination, the deposition of mineralized tissue in the region of the fracture line located on the palatal surface of the tooth 11, the covering of the vestibular fracture line by the composite crown, the satisfactory root canal obturation, the correct adaptation of the composite crowns, absence of external root resorptions, continuity of lamina dura, and health of gingival tissue were observed.

Figure 5: Two months after the end of treatment. (A) - Clinical view showing periodontal health and satisfactory adaptation of the crowns. (B) - Radiographic image showing absence of pathological signs. (C) - Tomographic image evidencing repair of the root fracture of the tooth 11, with the presence of intact lamina dura.

After a year and six months of follow-up, in addition to reports of satisfaction and improvement of the patient's

self-esteem, both clinical and radiographic exams showed periodontal health, with regular gingival contour and no signs of tissue inflammation, satisfactory adaptation of the crown and an excellent aesthetic result, as can be seen in figure 6.

Figure 6: One year and six months after the end of treatment. (A) - Clinical view showing periodontal health. (B) - Palatal clinical view showing periodontal health. (C) - Clinical view showing a satisfactory aesthetic outcome. (D)-Radiographic image evidencing absence of pathological signs.

Discussion

The present case report describes a conservative multidisciplinary approach involving endodontic, restorative, surgical and periodontal treatment and rehabilitation of a central upper incisor with crown-root fracture (CRF) of an 11-year-old child. Tooth loss in a young patient is very undesirable since this situation causes serious aesthetic and functional damages. Facing a severe dental trauma, a conservative treatment should be attempted. Then, the multidisciplinary approach described in the case report presents great clinical relevance.

It is well established in the literature that the prognosis of a tooth that presents fracture in the cervical third is unfavourable and that its permanence in the oral cavity in the long term is significantly diminished, when compared to teeth that present fracture in the middle or apical third of the root [3,13]. This fact is due to the presence of mobile coronal fragment, which facilitates bacterial contamination of the fracture line from the gingival sulcus, damaging the occurrence of the repair process with mineralized tissue [3,14]. This situation makes factors such as root development, pulp sensitivity and repositioning of the displaced fragments, described as crucial to the repair, not to exert so much influence in the cases of fractures

located in the cervical third [15]. On the other hand, in this type of fracture, the smaller length of the pulp tissue in the coronal fragment presents a slightly greater chance of undergoing revascularization [13], although this factor did not influence the present case, which already had a long-lasting necrotic process throughout the root extension.

However, it has been demonstrated that cervical fractures can be repaired and a conservative approach, including relatively long periods of stabilization, has been recommended [16,17], being the conduct basis in this case. Considering that one of the objectives was the consolidation of the cervical fracture in the palatal region, the flexible stabilization splint was maintained for a period of 8 months, based on the recommendation of the International Association of Dental Traumatology [18] that if the root fracture is close to the cervical area of the tooth, the splint should remain for longer periods (up to 4 months). In this case, the stabilization was indispensable to control the excessive mobility of the coronal fragment.

At the same time, the importance of endodontic therapy performed with the use of calcium hydroxide paste $[\text{Ca}(\text{OH})_2]$ as an intracanal dressing between sessions needs to be emphasized. The healing of the fracture lines can exhibit several patterns, including repair with interposition of mineralized tissue, bone and connective tissue interposition (with separation of the fragments), interposition of connective tissue (around the ends of the fracture) and absence of repair with presence of a granulomatous tissue caused by the infection [19,20]. In the present case, based on the final tomography (CBCT) image, we suggest that the consolidation has occurred with connective tissue interposition, which although is not an ideal repair, is also acceptable.

$\text{Ca}(\text{OH})_2$ has been indicated for several endodontic procedures, including the treatment of horizontal and vertical root fractures [12,21,22]. Its antimicrobial potential and its ability to stimulate the formation of mineralized tissue, properties attributed to its high pH, makes this material an excellent repair inducer [22], and being widely accepted as an intracanal medication in the Endodontics and Traumatology areas [23]. Its action mechanism is based on the release of calcium and hydroxyl ions, the last one being the most important because it provides an alkaline environment, which stimulates repair and activate calcification. The alkaline pH prevents dentin's dissolution of the mineral components by neutralizing the lactic acid generated by the osteoclasts and also activates the alkaline phosphatase that plays an important role in

the formation of mineralized tissue [21,24]. In parallel, calcium ions are part of the immune response and may activate the calcium-dependent adenosine triphosphatase reaction, also associated with mineralization [21]. Thus, the beneficial effects generated by the use of this medicament in the present case are verified, which probably contributed to the success of the treatment, controlling the infectious process and stimulating the repair of the intraosseous fracture line in the palatal region.

On the other hand, the involvement of the coronal portion at the level of subgingival enamel on the vestibular surface made it necessary to expose the fracture line supragingivally to enable the performance of restorative procedures under ideal conditions of non-contamination, this being the second main objective expected of this case. This condition was achieved through gingivoplasty, which is a relatively simple and conservative method and offered a prompt result, allowing the restoration to be performed in the same session [5]. In the present case, it was not necessary to perform the osteotomy, which favoured the repair and aesthetics and did not cause any difference in the contour of the soft tissues in relation to the adjacent teeth.

It should be emphasized that the approach adopted, besides preserving the tooth and the coronal fragment, avoided the need for orthodontic or surgical extrusion of the root fragment, which are treatment options proposed for CRF cases and that aim to expose all the margins of the traumatized tooth in a more coronal (supragingival) position, through orthodontic movement or root luxation, respectively [5]. Orthodontic extrusion is a more time-consuming treatment and requires gingivoplasty, since the periodontal tissues, including bone and gum, accompany the tooth coronally. On the other hand, although it is a relatively fast procedure, the surgical extrusion can cause bone loss around the root and offers risk of external root resorption [5]. In addition to these disadvantages, both types of extrusions require analysis of some clinical criteria: the root length supported by bone should be sufficient to maintain a crown-root ratio of at least 1:1 [25]; the root length should also be considered in relation to the size of the intraradicular post that will be placed posteriorly; and the thickness of the dentin should be adequate to avoid risk of fracture [5]. These disadvantages and critical factors were avoided by the approach taken in the present case.

The final step of the treatment consisted in the aesthetic and functional rehabilitation of elements 11 and 21 by the placement of intraradicular glass fiber posts and composite crowns, which besides offering an excellent aesthetic J Den Max Surg, 2(1): 147-154 (2019)

result, gives greater resistance and retention, mainly to the tooth that underwent CRF, and allows the stress to be distributed evenly along the root [2].

Considering all these aspects, it is noted that CBCT examination is fundamental to obtain a precise diagnosis, to help in the elaboration of the treatment plan and to follow the process of root fractures repair [26]. The images obtained through CBCT allow the visualization of the tooth from multiple planes at different angles and orientations, in extremely fine cuts and with high contrast, providing a three-dimensional reconstruction of the area of interest [7]. Through the initial CBCT, it was possible to accurately observe all fracture characteristics and determine the treatment plans. The final tomographic examination showed fracture repair at the intraosseous level through the interposition of connective tissue, an absence of bone rarefaction and absence of root resorption, indicating a favourable prognosis of the case. The success of the case has also been clinically demonstrated by the absence of signs and symptoms of infection, by the healthy appearance of the soft tissues and by the recovery of function and aesthetics after one year and six months of follow-up.

However, periodical clinical and radiographic follow-up must be performed and the occurrence of possible sequelae and complications should be considered, since it was an extensive and complex trauma of the dental and periodontal tissues.

Conclusion

The cases of severe trauma with the presence of FCR require a multidisciplinary approach, which should consider periodontal health, aesthetic and functional aspects. The association of flexible splint stabilization for prolonged periods, biological endodontic treatment, conservative gingivoplasty and restorative/rehabilitative procedures seems to be an adequate and conservative management for FCR cases in young patients.

References

1. Das B, Muthu MS. Surgical extrusion as a treatment option for crown-root fracture in permanent anterior teeth: a systematic review. *Dent Traumatol.* 2013; 29:423-431. DOI: <https://doi.org/10.1111/edt.12054>
2. Bajaj P, Chordiya R, Rudagi K, Patil N. Multidisciplinary approach to the management of complicated crown-root fracture: a case report. *J Int Oral Health.* 2015; 7:88-91. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/25954080>

3. Andreasen J.O. and Andreasen F.M. Crown-root fractures. Textbook and color atlas of traumatic injuries to the teeth, 3rd edn. *Trove*. 1994; 257-277. Available from: https://trove.nla.gov.au/k/23780613?q&sort=holdings+desc&_id=1557817552189&versionId=28766884
4. Kirzioğlu Z, Karayilmaz H. Surgical extrusion of a crown-root fractured immature permanent incisor: 36 month follow-up. *Dent Traumatol*. 2007; 23:380-385. DOI: <https://doi.org/10.1111/j.1600-9657.2006.00467.x>
5. Olsburgh S, Jacoby T, Krejci I. Crown fractures in the permanent dentition: pulpal and restorative considerations. *Dent Traumatol*. 2002; 18:103-115. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/12110103>
6. Sackett D.L., Straus S.E., Richardson W.S., Rosenberg W. and Haynes R.B. Evidence-based medicine: how to practice and teach EBM, 2nd edn. Edinburgh: *Churchill Livingstone*. 2000; Available from: <https://www.amazon.co.uk/Evidence-Based-Medicine-Practice-Teach-CD-ROM/dp/0443062404>
7. Talwar S, Utneja S, Nawal RR, Kaushik A, Srivastava D, Oberoy SS. Role of Cone-beam Computed Tomography in Diagnosis of Vertical Root Fractures: A Systematic Review and Meta-analysis. *J Endod*. 2016; 42:12-24. DOI: <https://doi.org/10.1016/j.joen.2015.09.012>
8. Kajan ZD, Taromsari M. Value of cone beam CT in detection of dental root fractures. *Dentomaxillofac Radiol*. 2012; 41:3-10. DOI: <https://doi.org/10.1259/dmfr/25194588>
9. Baratieri L.N., Monteiro S. Jr., Caldeira de Andrada M.A. et al. Tooth fragment reattachment (Chapter 6). In: Baratieri L.N., Monteiro S. Jr., Caldeira de Andrada M.A. et al. Direct adhesive restorations on fractured anterior teeth. Translated from the 2nd Brazilian edn. Sao Paulo: *Quintessence Books*. 1998; 134-205. Available from: <https://www.worldcat.org/title/estetica-restauracoes-adesivas-diretas-em-dentes-anteriores-fraturados/oclc/69961549?referer=di&ht=edition>
10. Padbury A Jr, Eber R, Wang HL. Interactions between the gingiva and the margin of restorations. *J Clin Periodontol*. 2003; 30:379-385. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/12716328>
11. Fournier A. Orthodontic management of subgingivally fractured teeth. *J Clin Orthod*. 1981; 15:502-503. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/6948825>
12. Maki K, Nishioka T, Seo R, Kimura M. Management of a root fracture in an immature permanent tooth. *J Clin Pediatr Dent*. 2005; 30:127-130. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/16491966>
13. Cvek M, Mejàre I, Andreasen JO. Healing and prognosis of teeth with intra-alveolar fractures involving the cervical part of the root. *Dent Traumatol*. 2002; 18:57-65. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/12184212>
14. Feiglin B. Clinical management of transverse root fractures. *Dent Clin North Am*. 1995; 39:53-78. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/7890108>
15. Cvek M, Andreasen JO, Borum MK. Healing of 208 intraalveolar root fractures in patients aged 7-17 years. *Dent Traumatol*. 2001; 17:53-62. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/11475947>
16. Andreasen JO, Hjørting-Hansen E. Intraalveolar root fractures. radiographic and histologic study of 50 cases. *J Oral Surg*. 1967; 25:414-426. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/5231441>
17. Yates JA. Root fractures in permanent teeth: a clinical review. *Int Endod J*. 1992; 25:50-157. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/1399064>
18. Diangelis AJ, Andreasen JO, Ebeleseder KA, Kenny DJ, Trope M, et al. International Association of Dental Traumatology. Guidelines for the Management of Traumatic Dental Injuries: 1. Fractures and Luxations of Permanent Teeth. *Dent Traumatol*. 2016; 28:2-12. DOI: <https://doi.org/10.1111/j.1600-9657.2011.01103.x>
19. Wilson R, Manfrin T, Holland R. Repair characteristics of horizontal root fracture: a case report. *Dent Traumatol*. 2002; 18:98-102. DOI: <https://doi.org/10.1034/j.1600-9657.2002.00071.x>
20. Kucukyilmaz E, Botsali MS, Keser G. Treatments of horizontal root fractures: Four case reports. *J Pediatr Dent*. 2013; 1:19-23. DOI: <https://doi.org/10.4103/2321-6646.113852>
21. Carrotte P. Endodontics: Part 9. Calcium hydroxide, root resorption, endo-periolesions. *Br Dent J*. 2004; 197:735-743. DOI: <https://doi.org/10.1038/sj.bdj.4811897>
22. Mohammadi Z, Dummer PM. Properties and applications of calcium hydroxide in endodontics and dental traumatology. *Int Endod J*. 2011; 44:697-730. DOI: <https://doi.org/10.1111/j.1365-2591.2011.01886.x>
23. Kawashima N, Wadachi R, Suda H, Yeng T, Parashos P. Root canal medicaments. *Int Dent J*. 2009; 59:5-11. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/19323305>
24. Estrela C, Sydney GB, Bammann LL, FelipeJúnior O. Mechanism of action of calcium and hydroxyl ions of calcium hydroxide on tissue and bacteria. *Braz Dent J*. 1995; 6:85-90. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/8688662>
25. Simon JH. Root extrusion. rationale and techniques. *J Den Max Surg*. 2(1): 147-154 (2019)

Dent Clin North Am. 1984; 28:909-921. PMID: <https://www.ncbi.nlm.nih.gov/pubmed/6594285>

26. FagundesDdos S, de Mendonça IL, de Albuquerque MT, Inojosa Ide F. Spontaneous healing responses detected by cone-beam computed tomography of horizontal root fractures: a report of two cases. *Dent Traumatol.* 2014; 30:484-487. DOI: <https://doi.org/10.1111/edt.12117>

Copyright: © **Lucisano et al.** This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.