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CASE REPORT/CASO CLINICO

Vertical root fracture: a case report and review of the literature

Frattura verticale della radice: un caso clinico e revisione della letteratura

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KEYWORDS
Vertical root fracture;
Fracture line;
Extraction;
Diagnosis;
Treatment.

Abstract
Aim: Vertical root fracture is one of the most complicated conditions in dental practice as the diagnosis of such cases is challenging. Many etiological factors contribute to vertical root fracture including excessive masticatory force and iatrogenic dental procedures. The treatment options can vary from whole tooth extraction to saving the tooth with certain conservative approaches. The evaluation of the surrounding periodontal tissue and the supporting alveolar bone is essential to determine the prognosis of the tooth. The aim of this article is to report an interesting case of vertical root fracture and review how to diagnose and treat vertical root fracture.
Methodology: The Patient was diagnosed with vertical root fracture related to lower right second molar. The fracture line extended from the top of the clinical crown to the apex of the root making the prognosis very poor.

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Results: The treatment involved the extraction of the tooth and scheduling of the patient for prosthetic rehabilitation. As a result, tooth extraction can be considered as the treatment of choice for vertical root fracture especially in posterior teeth.
Conclusion: The combination of comprehensive clinical and radiographic examination is essential to diagnose vertical root fracture. The effectiveness of different treatment options should be evaluated with long-term follow up. Treatment plan need to be discussed with the patient as part of evidence base practice.

PAROLE CHIAVE
Frattura verticale della radice;
linea di frattura;
Estrazione;
Diagnosi;
Trattamento.

Riassunto
Scopo: La frattura verticale di radice è una delle condizioni più complicate da affrontare nella pratica odontoiatrica poichè la diagnosi di tali casi è difficile. Molti fattori eziologici contribuiscono alla frattura verticale, tra cui un'eccessiva forza masticatoria e procedure dentali iatrogene. Le opzioni di trattamento possono variare dall'estrazione al tentative di salvare il dente con alcuni approcci conservativi. La valutazione del tessuto parodontale circostante ed il supporto dell'osso alveolare è essenziale per determinare la prognosi del dente. Lo scopo di questo articolo è quello di descrivere un interessante caso di frattura verticale ed effettuare una revisione della letteratura su come diagnosticare e trattare la frattura verticale di radice.
Metodologia: Al paziente è stata diagnosticata una frattura verticale relativa al secondo molare inferior di destra. La linea di frattura si estendeva dalla parte superiore della corona clinica all'apice della radice rendendo la prognosi molto infausta.
Risultati: il trattamento ha coinvolto l'estrazione del dente e la programmazione del paziente per la susseguente riabilitazione protesica. L'estrazione del dente può essere considerata come il trattamento di scelta per la frattura verticale soprattutto nei denti posteriori. In conclusione, la combinazione fra l'esame clinico e radiografico è fondamentale per una diagnosi di frattura verticale. L'efficacia di diverse opzioni di trattamento deve essere valutata con un lungo periodo di follow up ed il piano di trattamento deve essere discusso con il paziente sulla base di una pratica basate sull'evidenza scientifica.

Introduction

According to the American Association of Endodontics, vertical root fracture (VRF) is "A longitudinally oriented fracture of the root that originates from the apex and propagates to the coronal part".[1] Also, it can be defined as "longitudinally oriented fractures of the root, extending from the root canal to the periodontium".[2] In general, tooth fracture is considered the third most common cause of tooth loss.[3] In addition, VRF composes 2—5% of whole tooth fracture cases.[4] The incidence of VRF is more commonly associated with endodontically than non-endodontically treated teeth.[5] It occurs mainly in patients above forty years of age, and twice higher in males than females.[6,7] The most susceptible teeth in order are premolars, molars, incisors then canines.[8] The incidence of VRF in mandibular molars are two times higher than maxillary molars, some studies claim that the root depressions in the mesial root of mandibular molars and the buccal root of bicuspid premolars lead to more susceptibility for VRF.[5,8]

Literature points out that VRF can be classified by two methods.[9,10] First method is based on the relation of the fracture to the alveolar bone crest either the fracture terminates superior to the alveolar bone crest (supra-osseous), which does not cause any periodontal effect, or terminates inferior to the alveolar bone crest (infra-osseous) compromising the periodontium and the supporting bone.[9] The second method for VRF classification is based on the visibility of the separated fragments either there is a visible separation, which is referred to as complete VRF, or invisible separation called incomplete VRF.[10]

Diagnosis

The difficulty of dealing with VRF is based on fact that the diagnosis is complicated as misdiagnosis of such cases occurs frequently.[11] Multiple radiographic signs can be related to VRF including fracture appearance to the root structure or the surrounding structure.[12,13] Dislodgment of the root fragments, post, canal filling and appearance of double images all are indication for VRF.[12] Also, finding a radiolucent line or space around the root canal filling or the post can be related to VRF.[13] On the other hand, evaluation of the surrounding structure could lead to diagnosis of such cases as different bone defects such as horizontal, vertical, bifurcation and step-like bone loss are associated with VRF.[13] Other findings as widening of periodontal ligaments or resorption around the suspected fracture area can be linked to the presence of VRF.[12,13] Because conventional radiograph has the limitation of being two-dimensional x-ray, the use of advanced radiographic system has been suggested.[14] It has been found that using three-dimensional radiograph system as Cone Beam Computed Tomography (CBCT) shows more information regarding the presence, location and extension of VRF. Even

though the accuracy of CBCT is higher than conventional radiograph, the high radiation dose of this system should be considered.[14,15] Many clinical features could be presented with VRF. Patient may has a discomfort, mild to moderate pain, and some sort of mobility.[12,17] The pain becomes more diffuse and severe with time and it is noticed mainly during biting.[16] The presence of narrow and deep isolated periodontal pocket is a common sign and it can be diagnosed by measurement of the probing depth with periodontal probe. The investigation of any sign of periodontal disease such as bleeding or sinus tract is important.[12] The presence and origin of sinus tract in such cases can be identified by introducing a cone of gutta percha inside the tract and taking x-ray.[12] If the tooth has been treated previously with a restoration or a post, dislodgment of the restoration or the post clinically could refer to the presence of VRF.[16,17] Importance of surgical flap to diagnose some cases has been suggested as achieving a surgical flap procedure will expose more root surface and the facture can be visualized clinically.[2] However, the clinical findings vary from one case to another[18] some cases could be asymptomatic or no mobility reported. The combination of comprehensive clinical and radiographic examination is highly recommended to reach the final diagnosis.

Etiology

Many etiological factors contribute to cause VRF. An anterior tooth VRF is related mainly to traumatic injuries,[19] while fracture in the posterior teeth is more related to the excessive force during mastication and para-functional habits.[17] Also, several iatrogenic dental procedures have been reported as a major cause. For example, during endodontic treatment, weakening of the root structure by un-necessary removal of the canal walls can lead to VRF.[17] Moreover, application of excessive force during lateral condensation of the obturated material or during post placement is considered one of the predisposing factors.[21] In restorative treatment, the behavior of certain materials like amalgam expansion or excessive polymerization shrinkage of resin composite could contribute to VRF.[20,21] Building the tooth in high occlusion either with a restoration or prosthesis can lead to excessive pressure during mastication, and as a result a lot of force will be directed to the remaining tooth structure. In case of weak cusps, the cusps need to be reinforced with full coverage restoration to withstand the occlusal force.[20,21] In addition, after the root canal treatment, the tooth structure is more liable to fracture. Therefore, full coverage restoration is a mandatory treatment to avoid any future fracture or complication.[17,20,21] The incidence of VRF can be reduced by avoiding these predisposing factors. Delivering the appropriate treatment and avoiding of any action that lead to excessive pressure on the tooth structure either internally or externally are recommended to maintain the integrity of the tooth structure.[17]

Treatment

The treatment options can vary from whole tooth extraction to saving the tooth with certain conservative approaches.[22–29] The selected treatment depends on many factors such as the fracture location, the fracture extension and patient opinion.[9] The evaluation of the surrounding periodontal tissue and the supporting alveolar bone is essential to determine the prognosis of such cases.[4] While the extraction of the whole tooth has been recommended for a long time as the treatment of choice, many articles and reviews also explain different treatment modalities. Agarwal et al. reported a VRF case that was treated with hemi-section procedure. The distal root was extracted with the preservation of the mesial root; bone graft procedure was done to overcome the periodontal defect. After two years, the bone formation was acceptable with minor crestal bone loss at the mesial side.[22] Floratos and Kratchman reported many cases using the same techniques, hemi-section, and the results showed normal periodontal ligaments with no pathosis.[23] Using of certain dental materials to bond the tooth fragments has been suggested in many articles. Some materials like cyanoacrylate and glass ionomer cement showed undesirable results. The prognosis of the teeth after many months was poor and the teeth were extracted.[24,25] On the other hand, dual resin composite showed successful outcomes. In a study by Moradi et al., preservation of the tooth with conservative treatment was attempted because the tooth was located in the anterior area, esthetic zone area. The tooth was extracted, fixed using a dual-curing resin cement to hold the two fragments and replanted in the same original position. After 12 months, no abnormalities were reported.[26] Paul et al. showed similar results with 24 months of follow up.[27] Also, mineral trioxide aggregate (MTA) has been suggested to hold the root fragments.[28] Dederich used CO_2 laser to fuse the component of broken tooth structure in VRF and after one year, the bone level and the condition of the tooth were acceptable.[29] In a study by Fidel et al., orthodontic extrusion was used within 16 weeks. Before the orthodontic extrusion, root canal treatment was initiated and filled with calcium hydroxide-base. Then, the tooth was built with post/core system. Follow up of one year showed no abnormalities.[19]

As discussed above, there were a lot of attempts to establish an optimum or specific treatment for VRF. Many studies indicated certain procedures to manage such cases.

Hypothesis and purpose

The hypothesis of this case report study is to indicate that the whole tooth extraction, which can be replaced later by implant or fixed prosthesis, is the most reliable treatment for VRF in posterior teeth. The purpose of this paper is to present unusual clinical situation of VRF, explain the diagnostic challenges and provide management of the case.

Materials and methods

This study was conducted using qualitative approach and it was based on a case report of 55-year-old Indian male patient who came to the intern dental clinic in University of Dammam Dental College. The patient reported pain in the lower right quadrant that started three months ago. However, the pain severity increased in the last two weeks. The patient had hypertension and multiple simple restorations in each quadrant except the one with chief complaint. Radiographic examination showed horizontal bone loss around the lower right second molar, normal supporting structure for the other

Figure 1 Intra oral periapical radiograph shows horizontal bone loss. It is noticeable that there is no radiographic sign for VRF, but the horizontal bone loss can be an indication for that.

teeth (Fig. 1). No periapical inflammation or periodontal ligament widening of any tooth recorded. Clinical examination revealed acceptable oral hygiene; all other teeth in the lower right quadrant were sound. The patient had generalized attrition possibly because of aging. Depending on the history of the pain, it occurred mainly during chewing and eating. Cold test gave normal response in all teeth in the same quadrant except the involved tooth, which revealed a negative response. No history of trauma and mobility was reported. The patient expressed severe pain on percussion and palpation. During the percussion test, the tooth was separated into two parts equally as the fracture line was oriented from the mesial to the distal side involving the whole crown-root system. The fracture was diagnosed as complete vertical root fracture, which had a poor prognosis, especially in this case as the fracture was complete infra osseous fracture extending from the top of the clinical crown to the root apex. After consultation with periodontics department, extraction of the tooth was suggested. The patient signed the consent form for extraction under local anesthesia. The blood pressure was measured and it was within normal limit, 136\90 mmHg. The tooth was removed as two pieces using a remaining root forceps (Figs. 2 and 3). Post-operative instructions were explained to the patient. Ibuprofen, 400 mg tablets, was described in case of post-operative pain. The patient was recalled after one week for follow up and suture removal. After three months, alginate impression was taken for prosthetic rehabilitation. The patient was prepared and scheduled for implant procedure.

Results

After three months, the surgery site showed desirable healing process. The periodontium integrity and bone volume were

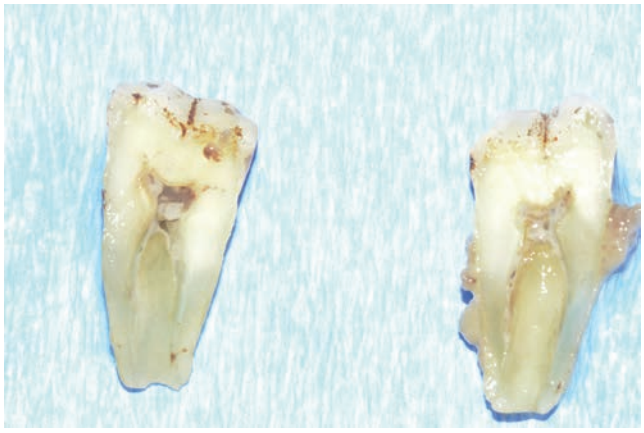

Figure 2 The extracted tooth as two fractured segments. The fracture extended from the mesial to the distal involving the whole crown-root system.

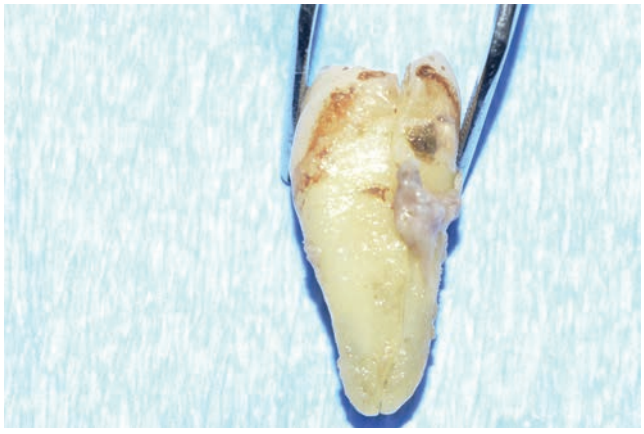

Figure 3 The extracted tooth with repositioned fractured segments.

evaluated, both were acceptable. The prosthodontics consultation was taken to confirm patient eligibility for implant prosthesis. The bone level in the adjacent teeth was ideal, no abnormalities or pathosis were reported. The area was asymptomatic and the patient was satisfied regarding the result of the treatment.

Discussion

VRF is a complicated condition that requires a clinician with wide vision and wise decision.[13] Comprehensive clinical and radiographic examination is recommended to reach the final diagnosis. Many clinicians misdiagnose such cases because of the similarity of VRF symptoms with periodontal diseases or failed endodontic treatment.[30] When wrong diagnosis is made, the extension of the fracture increases with the time making the condition more complicated and the possibility of achieving a conservative treatment rather than whole tooth extraction decreases.[16]

The pain increases and becomes more diffuse as the time duration of undiagnosed VRF increases.[18] In this case, increasing the pain in the last two weeks can be explained by

Table 1 Review of many studies report particular clinical management for vertical root fracture.

Authors	Extension of the fracture	Treatment	Recall time	Result/s
Oliet 1984	#3: mesiodistal fracture extended apical to the crest of the buccal bone to the clinical crown, obliquely through the two buccal roots.	Fragments were held with cyanoacrylate	16 months	Poor prognosis
	#19: mesiodistal fracture extended from the coronal center of the tooth to the mesial and distal roots.		3 months	
	#9: the fracture extended from the coronal portion of the root to the mid-third portion in mesiodistal direction.		15 months	
Vertucci 1985	#13: the fracture extended distally from the buccal root apex to 3 mm from the cervical line.	Removal of the half of the root at the buccal aspect, followed by 20% citric acid application.	36 months	No pathosis, long term follow up needed
Selden 1996	Incomplete vertical root fracture	#12, 19, 30: fracture line was prepared 2-3 mm in depth and 1 mm in width and it was filled with 4-META (amalgambond), then packed with silver glass inomer cement. Also, Bone grafting and guided tissue regeneration were placed #2,13: same above except the filling material as it was with white glass inomer cement #6: same above except the filling material as it was with 4-META (amalgambond) only.	2—12 months	Poor prognosis
Dederich 1999	#20: the fracture line extended from the cervical margin of placed restoration to the osseous defect at the distolabial aspect of the tooth.	CO_2 Laser	12 months	No pathosis, long term follow up needed
Kawai and Masaka 2002	#4: the fracture line was at the junction between the root canal filling and the canal wall with no root separation	The tooth was extracted; fracture line was bonded with resin cement and then replanted with 180-degree rotation.	36 months	No pathosis, long term follow up needed
	#13: the fracture line was observed mesiodistally after removing the crown and the metal post		33 months	
Kudou and Kubota 2003	#13	Fragments were bonded with resin adhesive, replanted with rotation	18 months	No pathosis, long term follow up needed

Table 1 (*Continued*)

Authors	Extension of the fracture	Treatment	Recall time	Result/s
Dua et al., 2004	#29: the fracture line extended mesiodistally from the pulp champer to the root apex	Extraction	—	—
Fidel et al., 2006	#8: the fracture line extended from the mid-incisal edge to the coronal third of the root	Orthodontic extrusion and fiber glass post and light-cured resin	13 months	No pathosis, long term follow up needed
Ozturk and Unal 2008	#8: the fracture line extended from the distal side at CEJ to the mesial side at the apical third of the root	Replantation after bonding the fragments with dual-cured adhesive cement	48 months	No pathosis, long term follow up needed
Arıkan et al., 2008	#8: the fracture line extended among the long axis dividing the tooth to mesial and distal halves	Fragments were bonded with dual-curing adhesive resin cement and then replanted	18 months	No pathosis, long term follow up needed
Ozer et al., 2011	#10: complete VRF around the apical third of the root #9: hairline-like VRF, as it was described by the authors, around the root canal filling without any separation #10: hairline-like VRF in the apical and middle third of the root	Dual-cured adhesive resin cement and replantation	24 months	No pathosis, long term follow up needed
	#6: Complete VRF extended from the root canal filling to the distal wall of the root.	Dual-cured adhesive resin cement, replantation and polyethylene fiber post		
Bhaskar et al., 2011	#14: fracture line was at the cervical third of the mesiobuccal root	Extraction	—	—
Unver et al., 2011	#5: fracture line extended mesiodistally through the long axis of the tooth into the apex	Adhesive resin and replantation	24 months	No pathosis, long term follow up needed
Agarwal et al., 2012	#19: fracture line extended from the middle to the apical third of the distal root	Hemi-section	24 months	No pathosis, long term follow up needed
Floratos and Kratchman 2012	#19: fracture line was located at the buccal surface of the distal root	Distal root resection, filled with MTA and covered by resorbable collagen membrane	12 months	No pathosis, long term follow up needed
	#14: fracture was located at the distobuccal root	Same as above	11 months	
	#14: fracture was located at the mesiobuccal root	Same as above	8 months	
	#3: fracture line was located in the mesial aspect of DB root	Same as above except that the root-end filling was not placed because of the limitation of dentin thickness	24 months	
Da Silva et al., 2012	#6:	The fracture line was prepared and filled with resin composite followed by synthetic hydroxyapatite bone graft	24 months	No pathosis, long term follow up needed

Table 1 (*Continued*)

Authors	Extension of the fracture	Treatment	Recall time	Result/s
Moradi Majd et al., 2012	#9: fracture line extended through the buccal aspect of the tooth from the coronal portion to the apex	Dual-cure resin cement and replantation	12 months	No pathosis, long term follow up needed
Paul and Till 2014	#8: incomplete VRF extended through the buccal surface from the top of the coronal portion to the apex	Calcium-silicate-cement (Biodentine) was used to fill the fracture line preparation and also as a retro-grade filling. Then, the tooth was replanted.	24 months	No pathosis, long term follow up needed
Martins et al., 2015	#13: the VRF was located along the buccal surface of the root #21: the VRF was located along the buccal surface of the root	Extraction	–	–

transition of the fracture from incomplete to complete root fracture. The choice of extraction treatment was made because of the fracture extension. As Figs. 2 and 3 show, the fracture extended from the top of the tooth to the apex of the root making the prognosis very poor. The early diagnosis of such cases is very important, as sometime the VRF can be located in accessible areas and can be treated by more conservative method, but misdiagnosing these cases early can offer more time for the VRF to extend at the stage that saving the tooth is impossible.[16] According to many studies, the patient opinion is the most important factor during the selection of the treatment method.[12] The reason was because other alternative conservative treatment methods consumed more time. In addition, there are no long-term studies regarding these conservative approaches. On the other hand, many studies indicated that extraction was the only predictable treatment for VRF especially in the posterior teeth.[3,17,18,31] Also, it has been discussed that bonding of the root fragments by such materials in the posterior teeth is associated with low success rate in comparison to the anterior teeth. The mastication forces are greater in posterior than anterior teeth. As a result of that, this excessive force will affect the bond holds the fractured fragments.[32] Hemi-section has been suggested as an alternative treatment for multi-rooted teeth instead of whole extraction.[22] Even though that the hemi-section shows excellent results, the success rate among ten years is still low, 68%.[33] Table 1 shows different treatment options to manage VRF. In the present case, the tooth was sound with no history of any previous intervention. The most probable cause of VRF was the excessive force during mastication. The patient reported eating some kind of hard food. In addition, the patient in the present case had a generalized attrition of his teeth which is also considered as an indication for the presence of excessive occlusal load.[5] The extraction was done carefully to preserve the bone volume and periodontium integrity. Prosthetic rehabilitation depends mainly on many factors such as the bone volume and the patient eligibility.[31] In this case, the bone volume was suitable for implant procedure. As a result, the patient was scheduled for implant surgery.

Conclusion and clinical relevance

VRF is one of the most complicated conditions in dental practice. The combination of comprehensive clinical and radiographic examination is essential as the diagnosis of such cases is challenging. While the extraction is considered the most predictable treatment, many alternative options have been suggested. However, the effectiveness of such treatment options should be evaluated with long-term follow up. Treatment plan need to be discussed with the patient as part of evidence base practice. The desirability of saving the tooth should be weighed up against the extraction treatment.

Conflict of interest

Authors have no conflict of interest to declare

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