

VERTICAL ROOT FRACTURES- A NARRATIVE REVIEW

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INTRODUCTION

According to the American Association of Endodontists “A “true” vertical root fracture is defined as a complete or incomplete fracture initiated from the root at any level, usually directed buccolingually”.¹ It starts from an internal dentinal crack, and develops over time, due to masticatory forces and occlusal loads. Fractures or splits represent the third most common reason for tooth loss.² However, the primary pathogenic cause is not always clear as it develops over a long period. Average time between root filling and the appearance of a vertical root fracture (VRF) has been estimated to be between 39 months ² and 52.5 months ³ with a range of three days to 14 years.

Incidence

Gher et al. have reported a low incidence of 2.3%.² Highest incidence has been observed in endodontically treated teeth and in patients older than 40 years of age.⁴ But, VRF can also be observed in vital teeth. Teeth with flat or thin roots of smaller mesiodistal diameter and an oval diameter in a buccolingual direction, such as those in maxillary and mandibular premolars; mesiobuccal roots of maxillary and mesial roots of mandibular molars; and mandibular incisors, are more susceptible to fracture.⁵ Testori et al.⁶ reported premolars to have the highest incidence of VRF in endodontically treated teeth; however, Chan et al.⁷ reported first molars to be the teeth most frequently fractured. On the other hand, canines had the lowest incidence. VRF is rare in vital anterior teeth, possibly because the direction of masticatory force is usually more lateral than vertical. VRF in vital teeth occurs more frequently in males due to factors such as stronger masticatory force, increased attrition, habitual chewing of hard food and less pliable supporting bone.⁷

Prevalence

Vertical root fracture is more commonly associated with root filled teeth.^{4,5,7,8} In a retrospective cross-sectional study of 736 extracted teeth, Yoshino et al.⁸ found that 31.7% of teeth were extracted due to VRF, of which 93.6% were root filled teeth. Sugaya et al.⁹ performed a retrospective analysis on 304 teeth with VRFs that had been detected clinically and/or radiographically. The authors reported that 97% of the detected VRFs were found in root filled teeth, whilst 2.3% were detected in teeth with vital pulps and 0.7% in teeth with non-vital pulps which were not root filled. he reported prevalence of VRFs in root filled teeth ranges from 4% to 32%.^{10,11,8} This wide range in the frequency of VRF may be due to heterogeneity in the method of evaluation of VRFs found in clinical studies. The variations include differences in the diagnosis and categorization of VRF (e.g., misdiagnosis of an isolated periodontal pocketing associated with a VRF as periodontal disease), which makes it difficult to appreciate the true prevalence of VRF in the general population. In some cases, although VRF has been attributed as the reason for extraction of root filled teeth, the VRF may have been present prior to endodontic treatment.

Diagnosis of a vertical root fracture

VRF poses a diagnostic challenge because often times the fracture line may not be visible until it extends to the cervical region. Early radiographic detection is also difficult. Signs and symptoms are similar to those found in failed root canal treatment or in periodontal disease.¹²⁻¹⁵ Early and correct diagnosis is imperative, as bone resorption around a fractured root continues with time until the tooth/root is removed or lost. Delay in diagnosis will result in limited success rate of any treatment modality due to loss of supporting bone and presence of a weakened periodontium.

History

Teeth with vertical root fractures often present with a history of discomfort or soreness, usually associated with a chronic infection. The pain is usually mild to moderate in intensity. Patient's with vertically fractured teeth can also present with a history of pain on mastication. Occasionally the patient can be aware of a sharp, cracking sound during the condensation of gutta percha, or the cementation of a post.¹²⁻¹⁵

Clinical manifestations

The clinical signs and symptoms vary according to the position of the fracture, tooth type, time elapsed since fracture, periodontal condition of the tooth and the architecture of the bone adjacent to the fracture, and are difficult to detect or reproduce during patient examination. However, bleeding during condensation of a root filling material, and an apparent. ¹²⁻¹⁵ Lack of resistance within the canal during condensation, leading to an almost unlimited ability to condense gutta percha into the canal are signs that a vertical root fracture is present. ¹²⁻¹⁵ Rapid deterioration of endodontic status of a tooth after a long time without symptoms, or reappearance of radiolucencies after healing has previously taken place, is indicative of fracture. ¹²⁻¹⁵ Other pathognomonic clinical manifestations are as follows:

Pain and swelling

Local chronic inflammation due to infection leads to discomfort and soreness, mild to moderate pain, pain on biting, and swelling of soft tissue. The swelling is usually broad based, and mid root in position compared to apical location in peri apical abscess. Palpation will often show swelling and tenderness over the root itself. ¹²⁻¹⁵

Sinus tract

A sinus tract is commonly found in VRF cases (13-42%). In VRF, sinus tract is located close to the gingival margin as opposed to non vital teeth where sinus tracts are located more apically. The presence of two sinus tracts at both buccal and lingual aspects or multiple sinus tracts is almost pathognomonic for a VRF. 12-15

Periodontal pockets

Deep, narrow, isolated periodontal pockets are commonly found in vertically fractured roots. Deep probing in one position around the circumference of tooth in presence of otherwise normal attachment usually indicates that the tooth is fractured, as opposed with periodontal disease, where the pocketing is generalized around a large part of the tooth. Deep probing in two positions on opposite sides of the infection is almost pathognomonic for the presence of a fracture. 12-15

Radiographic manifestations

Fracture lines

Separation of root fragments makes fracture clearly visible. Proliferation of granulation tissue between the separated fragments often results in the rapid movement of the fragment away from the remaining root. 15

Radiolucent lines along the root fillings or post

Appearance of a vertical space adjacent to the root filling material in an otherwise well obturated canal, or a space between the edge of a root canal, which may be coated with cement, and the post itself may be indicative of VRF. 15

Radiolucent halos

‘Halo like’ radiolucency running around whole of the root surface is a classic sign of VRF.15 The radiolucent area may travel almost completely up the side of the root, resulting in a “J type” lesion.

Step like bone defects

Obliquely oriented fractures often lead to a characteristic step like bone defect which may mimic endodontic lesions resulting from causes like post perforations and vertical grooves. 15

Isolated horizontal bone loss in posterior teeth

Mesio distally oriented vertical fractures can cause bilateral horizontal bone loss in an isolated tooth.15

Unexplained bifurcation bone loss

Furcation bone loss may occur in molars with fracture, in absence of apical pathosis or overt periodontal disease and without any apparent reason e.g., perforation.

V shaped diffuse bone loss

Diffuse V shaped radiolucency i.e., wider coronally, narrowing towards the apex is a common radiographic image in vertically fractured buccal roots of maxillary molars or the roots of lower molars.14,15 Confined to a single root or a single tooth in the mouth, it is almost pathognomonic. In 90% of teeth with VRF extracted during exploratory surgery, buccal bone dehiscence along the entire root length was noted. In 10% of the maxillary premolars and mesial roots of mandibular molars, fenestration type of bone loss was noted. The radiologic signs are highly non specific and not detectable during early stages, in which there are subtle fissures with no separation. 14,15 These develop late as sequelae of chronic inflammation induced by the fracture. Only approximately one third of fractures may be visualized directly at dental radiography. 14,15

Cone beam computerized tomography versus conventional radiographs

Two-dimensional radiographs are encountered with problems such as superimposition and distortion in which case 3-D imaging modalities such as Cone beam-computed tomography (CBCT) images could assist in the verification of VRFs. 16 However, radiopaque intracanal materials may result in artifacts or obscure the fracture line, thus limiting its diagnostic value. 17 An in vivo study analyzed the accuracy of high-resolution CBCT used for detecting VRFs and concluded that the tool was non-diagnostic. Intracanal metal posts and multirooted teeth limited the diagnostic outcome. 17 Thus, CBCT is more useful in the diagnosis of non-endodontically treated VRFs, otherwise materials must be removed before performing the CBCT. There is still no consensus on the accuracy of CBCT in detecting endodontically treated VRFs. The voxel size also plays an important role in the observation of fracture lines. In a study assessing VRFETT via micro-computed tomography, a 9-micrometer voxel size was recommended for accurately observing a VRF.18 The smallest currently used voxel size for CBCT is not comparable to that used for micro-computed tomography. 17 Thus, limitations remain when detecting VRFs via CBCT.

Laser in diagnosis

Kimura et al. 19 have suggested that root fracture could be diagnosed by DIAGNOdent with methylene blue (MB) dye solution. In a further study, they proposed that the use of detergent allows better penetration of dye thereby enhancing the detection of root fractures.²⁰

Surgical exploration

Surgical intervention is suggested when a VRF is highly suspected but cannot be confirmed through other examinations.^{14,15} During surgery, a sharp explorer or methylene blue staining may be used to detect a possible VRF. Changing the position of the light and employing different reflections is sometimes useful when trying to observe the fracture line. Many studies have concluded that direct visualization of the VRF via exploratory surgery is the gold standard.¹²⁻¹⁵ If the clinical and radiographic examination results are inconclusive, exploratory surgery is an option.

Management of vertical root fractures

In a multi-rooted tooth with VRF, resecting the root (root amputation or hemisection) can save the tooth.²¹ However, in single rooted teeth with VRF, the prognosis is unfavorable. Extraction may be required because of extensive bone loss and uncertain prognosis. However, many innovative attempts to treat and retain anterior teeth have been described in various case reports.

Extraction and replantation after bonding: Studies have reported successfully treating tooth with VRF by extracting the fractured tooth atraumatically, bonding the fragments, and then replanting the tooth either directly or with a 180 degree rotation.^{22,23} It was advocated that the deep and narrow periodontal pockets along the fracture line may remain if teeth with VRF are replanted without rotation²³ as intentional rotational replantation avoids contact with the area where periodontal ligament was lost and area where the bone was lost in the treatment of VRF.^{23,24} The rotation of the tooth was suggested to connect the remnants of the healthy periodontal membrane, remaining on the root, with the connective tissue in the periodontally involved socket wall.

Application of a bio-resorbable membrane to reinforce periodontal healing, by preventing any gingival connective tissue from making contact with the curetted root surfaces during healing and allowing for regeneration of periodontal ligament cells around the teeth has been suggested in few reports. This membrane also prevents the ankylosis after

replantation. Other treatment options like use of composite resins, mineral trioxide aggregate and glass ionomer cement for bonding the fracture line have also been tried.²⁵⁻²⁹

Conclusion

An evidence-based clinical approach should be followed for the successful treatment of a vertical root fracture. The clinician should have a thorough knowledge of etiological cause of fracture, classic signs and symptoms of fracture, availability and applicability of diagnostic methods, differential diagnosis, and factors determining the prognosis, so as to arrive at an appropriate diagnosis and design a suitable treatment protocol. This helps in distinguishing between restorable and non-restorable fractures. A functional and aesthetic outcome following treatment is achieved by a combined therapy, including restorative, endodontic, prosthodontic, periodontal and orthodontic therapies. A regular follow-up of teeth is required to evaluate the success of treatment and to do the necessary alterations in the suggested treatment protocol, if indicated. The pros and cons of a tedious and long conservative therapy should always be weighed against the option of extraction and replacement with other fixed prosthesis.

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