

Vertical Root Fractures – A Review

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Abstract:

Root fractures are fractures which involve dentin, cementum and pulp and comprise to about 0.5-7% of injuries affecting permanent dentition. They are broadly divided into horizontal and vertical root fractures. Vertical root fractures may be complete or incomplete fracture lines and are associated commonly with endodontically treated teeth, less commonly with vital teeth. These fractures present a challenging situation to the clinician owing to difficult diagnosis and management. The overall prevalence is about 3-5%. The etiology is multifactorial. Early recognition of such fractures is rare as signs and symptoms develop at a later stage which contribute to eventual loss of tooth. Conventional radiographs taken in different angulations together with advanced imaging modalities such as CBCT can best aid to visualize fracture. This review is a summary of the data collected from different sources. The purpose of my review is to summarize vertical root fractures and highlight different approaches in its management published by various authors.

Keywords: Vertical Root fractures, Endodontically treated teeth, Radiographic findings

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I. Introduction

Vertical root fractures (VRF) being one of the most frustrating complications to the clinician are also considered the most common cause of loss of tooth owing to their poor prognosis (Pitts and Natkin in 1983, Moule & Kahler 1999, Cohen et al. 2003). A VRF presents a challenge in its diagnosis and management. If unrecognized, may lead to inappropriate treatment.

According to American Academy of Endodontists, A “true” vertical root fracture is defined as a complete or an incomplete fracture initiated from the root at any level, usually directed buccolingually.¹ VRF can be longitudinal or oblique and does affect the root alone or both the root and the crown.⁶ Vertical fracture can occur at any level on the root portion and may involve one or both the proximal aspects. Root canal space may or may not be involved. The fracture originates as a dentinal crack and may progress to a fracture under masticatory forces. A VRF is different from a split tooth that begins with a crack of crown and propagates apically on to the root. Both complete and incomplete fractures can be seen in root dentin.

II. Prevalence and incidence

The overall prevalence of vertical root fractures is found to be in the range of 3-5%.^{2,3,8} These fractures usually occur in older patients in the age group of 45-60 years. In Endodontically treated teeth, the incidence of VRF was 1.4 times higher in males than in females and in patients presenting with VRFs in nonendodontically treated teeth, the incidence was found to be 3.6 times higher in males than females.⁷ Endodontically treated teeth are most susceptible to vertical root fractures of which premolars and molars are reported to have higher incidence and seldom affecting anterior teeth^{2,4} whereas other studies have shown molars having higher incidence of VRF.^{5,6,7,8} The incidence of fracture in distal roots of mandibular molars was much higher in endodontically treated (24%) than in non endodontically treated teeth (5%).⁷ Teeth with roots having narrow mesiodistal diameter are more frequently fractured.^{13,14,19} According to Chan et al⁷, of 315 patients with vertical root fractures, 40% occurred in non endodontically treated teeth. Although, in a series of 51 cases of root fractures in non endodontically treated teeth in Chinese patients, Yeh⁹ reported that 80% of the fractures were VRFs. Localized stresses in inner dentin and the irregularity of the root canal are closely associated with VRF.¹⁰

Also, in a histologic study conducted by Walton et al¹⁸, it was found that the fracture space had contained irritants such as bacteria, necrotic debris and degraded inflammatory cells adjacent to the fracture line on the root surface, inflammatory lesion was also demonstrated .

III. Etiology

The etiology of VRF is multifactorial. The reason for the occurrence of such fractures could be attributed to traumatic and iatrogenic causes in endodontically treated and non endodontically treated teeth.

In case of **non endodontically treated tooth**, the possible causes of a VRF may include

*Sudden trauma to the tooth.

*Presence of a developmental defects within the tooth such as root depressions, furcation grooves¹⁶

*Roots with narrow mesiodistal diameter, that is, in deep oval, flattened, or hour-glass-shaped roots and presence of curvatures^{14,15,19}

*Excessive biting force on a periodontally compromised tooth can predispose to tooth fracture as loss of bone support can result in reduced ability of the tooth to withstand functional stresses¹²

* Presence of large restorations

*The higher incidence of VRF in non endodontically treated teeth in males may be related to factors such as stronger masticatory force, increased attrition, habitual chewing of hard food⁷

*Presence of dentinal cracks which can propagate into fracture under masticatory load

In non carious ,non-endodontically treated teeth, fractures might also be related to special diet patterns or chewing habits¹⁷ , excessive, repetitive and heavy masticatory stress⁹

*moderate to severe attrition in non endodontically treated teeth and

*habits such as bruxism and teeth clenching

A VRF is most commonly associated with endodontic therapy .Average time between root filling and appearance of a vertical root fracture is between 39 months and 52.5 months; with a range of 3 days to 14 years.⁴ This may be due to loss of moisture in dentin as compared with teeth having vital pulps but is considered a predisposing factor for root fracture rather than an etiological one

In **endodontically treated teeth** Reasons for fracture include:

*Excessive rem oval of root dentin during shaping of canals can predispose to incidence of VRF.

*According to Meister et al 1980, excessive force during lateral condensation technique of obturation or in seating Silver cones are the major causes of vertical root fractures.

*Forcing or tapping intracoronary restorations or dowels into place and overpreparation of post space are suggested to be secondary causes.⁸

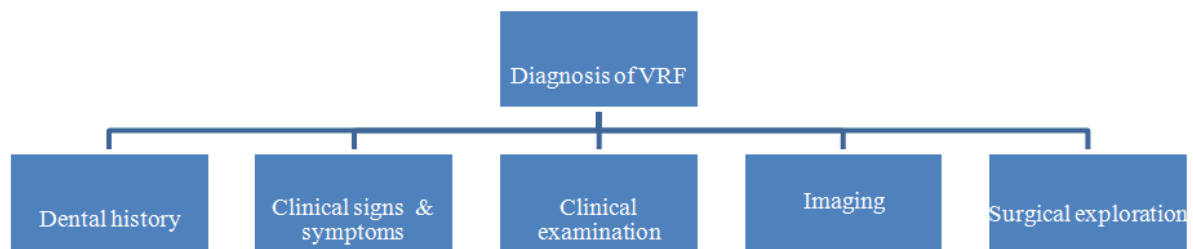
*Tapered and threaded posts generally produce the highest root fracture incidence (7%), followed by tapered and parallel posts.²⁰ According to George and Stewart²⁵, vertical fractures were frequently related to screw type of posts than smooth tapered posts.

*Choosing an inappropriate abutment for a fixed prosthesis may also contribute to the development of a VRF.¹¹

IV. Diagnosis

The diagnosis of VRF is often challenging. Delayed diagnosis frequently leads to extraction or atleast root amputation. Early root fractures are difficult to detect. The detection becomes quite easier when there is separation of root fragments.²⁵ Traditionally the vertical fractures are diagnosed by a combination of clinical and radiographic findings. There is no single clinical feature that can indicate the presence of root fracture⁶ and there is also delay in the exhibition of signs and symptoms. If presented, such signs and symptoms will be more similar to the ones seen in failed root canal treatment cases. As a result of which vertical fracture presents to the clinician, a difficult situation. However, all the vertically fractured teeth present with specific clinical and radiographic signs that can alarm a clinician for the possibility of root fracture being present. Although, all these signs and symptoms may not be presented in a single case of vertical root fracture.

The diagnostic approaches to a suspected VRF are given below in flow chart

**Dental history:**

History of endodontic treatment, large failing restoration, history of chewing habits which are many a times associated with VRFs.

Clinical signs and symptoms:

The clinical presentation of vertical root fracture is variable. Clinically, vertical root fracture may mimic of a periodontal disease or of a failed root canal treatment. Therefore, it is vital to differentiate a VRF from other similar clinical conditions. Careful evaluation of clinical signs and symptoms can help in diagnosing a VRF. Majority of cases of VRFs present with mild pain.⁸ Patient usually complains of dull discomfort and soreness which may be due to local chronic infection, mild to moderate pain on biting and on consumption of cold drinks, which may be due to involvement of pulp. Sometimes there will be presence of soft tissue swelling which on palpation will be tender over the involved root. This swelling is usually broad based and midroot in position.²¹ The sinus tract is commonly found in association with VRF (13-42%) located more towards the gingival margin. But, the presence of sinus tract may not be detected in early stages of fracture. Presence of two or more sinus tracts is almost pathognomonic for such fractures.^{2,6} Vertical root fractures may exhibit selective sensitivity when the tooth is percussed.³⁹ Increase in probing depth with isolated, deep, narrow pocket is found commonly adjacent to the fracture line with no other periodontal attachment loss.⁶ Another clinical sign of a VRF may be the presence of a periodontal abscess and slight to moderate mobility of the tooth involved.⁸ Occasionally, a sharp cracking sound can be heard during the condensation of gutta percha (GP) or cementation of posts.^{8,17} Bleeding and lack of resistance during condensation of GP within the canal^{17,21} can also be a sign of vertical fracture.

Clinical examination

Certain methods of clinical examination will aid in identifying the tooth suspected with VRF such as

Visual examination :Thoroughly examining the tooth for the presence of visible cracks or separated fractured fragments, large/extensive restorations/carious lesions, severe attrition. One should suspect a root fracture when there is dislodgement of an otherwise well fitting post.²¹

Pulp testing : When patient complains of sharp pain in a sound tooth, pulp testing will be helpful to assess pulpal involvement of fracture.

Illumination test: Fibre optic transillumination may be used to visualize a crack. On illumination the crack deflects light and reduces the transmission making cracked lines appear darker.

Bite test : Pain described by the patient can be simulated by performing bite test using objects such as orangewood stick, rubber wheel or burlow wheel, tooth sloth. Pain on release of bite indicates a cracked tooth

Periodontal probing: Probing the tooth in all aspects reveals presence of an isolated, deep, narrow periodontal pocket situated adjacent to the fracture line. Deep probing in two different positions on opposite sides of involved tooth is almost pathognomonic for presence of fracture.²¹

Sinus tract tracing: Helps to identify the origin of defect.

Staining : Once the old restoration is removed under dental operating microscope, staining with disclosing dyes such as gentian violet can help visualize the crack more conveniently

Radiographic imaging :

The radiographic signs at times can be specific. These signs vary depending on x-ray beam angulation, time elapsed from the fracture and degree of separation of fractured fragments. In many cases, the fracture line will not be evident radiographically unless it has advanced to a stage where separation of root fragments has occurred.²¹ Radiographic identification of a root fracture may be possible only if the X-ray beam is projected parallel to and within 4 degree of the fracture plane.⁴² Periapical radiographs may detect a fracture line in only 35.7% cases. To visualize horizontal fractures, usually in case of fractures of cervical third of root, the central

beam should pass through the tooth. In oblique fractures such as in apical third of root, an occlusal radiograph or radiographs with varying horizontal angles are more likely to detect the fractures.⁵¹

CBCT in detecting Vertical root fractures - When conventional radiographs fail to detect VRFs, CBCT can be recommended. Images taken by CBCT have proven to detect fractures better than conventional radiographs.²² CBCT has shown to accurately detect vertical root fractures with thickness of 0 to 2 mm.⁴⁶ It has been shown that the CBCT voxel size can influence the visibility of a fracture line in the image. All the voxel dimensions can detect a vertical fracture on a CBCT but, it has been reported that as the voxel size increases the percentage of detecting VRF decreases. Sensitivity, specificity and accuracy were found to be high for detecting a VRF on CBCT scans.⁵⁰ Fracture having a width more than 120 μ m is reported to have been better visualized on a CBCT radiograph.⁴³ According to Pradeep Kumar et al, of a group of patients with and without VRF, 78% of patients with VRF and 80% of patients without VRF were identified after evaluation with CBCT.⁴⁴ In a study conducted by Khedmat et al, it has been found that CBCT is the most sensitive in detecting vertical root fractures when compared to Multidetector CT and digital radiography.⁴⁷

Radiographic changes seen in vertically fractured teeth are²¹

Separation of root fragments (Figure 1): The fracture becomes clearly visible on a radiograph once the root fragments have been separated by the growth of granulation tissue between the fractured fragments.

Presence of fracture line along the root fillings (Figure 2): Sometimes the fracture will be visible directly on the radiograph as a radiolucent line along the root filling. But to visualize this the x-ray beam must pass directly down the fracture line and no change in horizontal angulation is advisable

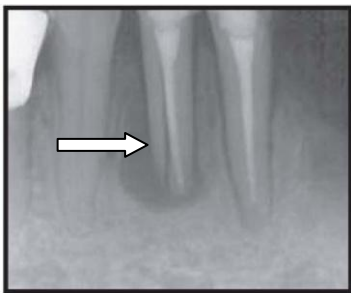


Figure 1: Separation of root fragments.(Picture credit – Kukreja et al⁴¹)



Figure 2: Presence of fracture line along the root filling(Picture credit – A J Moule, Kahler B²¹)

Space beside a root filling or a post (Figure 3) : Due to minor separation of root fragments, a vertical space beside the root filling in an otherwise well obturated canal can be seen. Root fracture must be suspected if the root filling is well condensed but in close proximity to only one root canal wall. In the presence of post within the canal, a space can be seen between the post and the edge of the canal

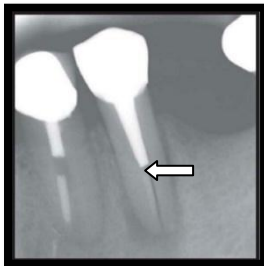


Figure 3: Space beside a root filling or post (Picture credit – Kukreja et al⁴¹)

Double images: Seen as a result of overlapping of fractured fragments when wide separation occurs in a direction other than parallel to the direction of x-ray beam.

Bone loss :Localized infection caused by entry of bacteria will result in periodontal bone loss adjacent to the fracture line. The amount of bone loss occurring will depend on the nature, extent and duration of fracture.¹⁸ On the Radiographs, specific patterns of bone loss will be visible.²¹

Widening of periodontal ligament(pdl) space (Figure 4) around the whole length of the root is a classical sign of vertical root fracture

Radiolucent halos (Figure 5) around the whole root surface described by Pitts and Natkins.²³

Step like bone defects (Figure 6) develop when the fracture runs obliquely across the root.²³ Such defects may mimic simple endodontic lesions from other causes like vertical grooves or post perforations



Figure 4 : Widening of pdl space around the root (Picture credit – A J Moule, Kahler B²¹)



Figure 5: Radiolucent Halo around the root (Picture credit – Kukreja et al⁴¹)

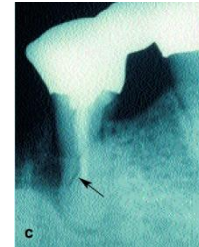


Figure 6 : Step like bone defects (Picture credit – A J Moule, Kahler B²¹)

Radiopaque signs- If a fracture line is present during or prior to obturation of the root canal, a radiopaque line is seen because of extrusion of the root filling material. This sign can be visible on the radiograph if the fracture line is in buccolingual direction. The radiopaque line will be seen as a thin film extending on to the root surface through the root filling if the fracture line is mesiodistal.²¹

Isolated horizontal bone loss in posterior teeth(Figure 7) When in the entire dentition only an isolated tooth shows bilateral horizontal bone loss, the presence of mesio-distal root fracture must be suspected especially in the presence of successful endodontic therapy.

Unexplained bifurcation bone loss (Figure 8) without any apparent periodontal or periapical disease

V shaped diffused bone loss (Figure 9) Wide at the crestal bone and narrow at the apex can be seen on roots of posterior teeth specifically when confined to single root/tooth

Resorption along the fracture line is a presenting sign of a VRF

Dislodgement of retrograde filling material (Figure 10) due to inadequate retention^{23,24}

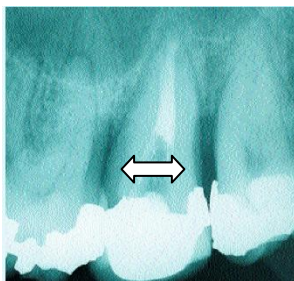


Figure 7 : Isolated horizontal bone loss (Picture credit – A J Moule, Kahler B²¹)

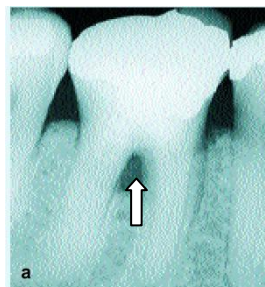


Figure 8: Bifurcation bone loss (Picture credit – A J Moule, Kahler B²¹)



Figure 9: V shaped bone loss (Picture credit – A J Moule, Kahler B²¹)

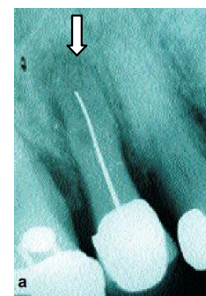


Figure 10: Dislodgement of retrograde filling material (Picture credit – A J Moule, Kahler B²¹)

Surgical Exploration of fracture site :

Direct visualization by surgically raising the flap over the fracture site suspected clinically and radiographically can help to arrive at a definite diagnosis and is considered as a gold standard in the diagnosis of vertical root fractures^{1,45}

V. Prevention

The best prevention is to prevent the etiological or the predisposing factors that can lead to fracture. Some of the preventive measures are

- Avoid excessive canal and post space preparation
- Avoid excess cutting of sound tooth structure during cavity preparation
- Night guards can be used in patients with bruxism to minimize the risk of fracture.

VI. Management

A vertical root fracture is difficult to diagnose, so is its management. The treatment options of a vertically fractured tooth depend on the location, the time duration from the occurrence of fracture to its identification. Once the presence of fracture is confirmed, the decision has to be made regarding the treatment. Usually a VRF is unrecognized until it has reached a stage where the prognosis of the tooth becomes hopeless. In such scenarios, extraction of tooth is the only treatment option which is undesirable. Extraction is indicated in single rooted teeth whereas multirooted teeth can be effectively treated by resecting one of the roots or by performing hemisection.^{23,26} Studies have reported 94% survival rate at 5 years²⁷ and 68% success rate at the end of 10 years²⁸ of a root resected tooth. In general, for single rooted teeth the prognosis is poor and extraction is often the treatment of choice.

However, other treatment modalities have also been suggested in the literature. As an alternative to extraction, root with VRF has been treated successfully using adhesive resin cement to bond the fracture lines extraorally and then intentional replantation of the reconstructed tooth.²⁹ The application of a bio resorbable membrane for periodontal healing and prevention of ankylosis after the replantation has also been suggested.^{30,31}

International Association of Dental Traumatology (IADT) has given guidelines for managing a root fracture- *Repositioning the displaced coronal segment of the tooth as soon as possible and confirming position radiographically. *Splinting to stabilize the tooth with a flexible splint for 4 weeks and upto 4 months for fracture near cervical area of tooth. *Root canal treatment of the coronal segment in case pulpal necrosis develops.⁵¹

Another treatment modality which gave satisfactory result was treating an incomplete vertical root fracture with ultrasonics and mineral trioxide aggregate. The fracture line was prepared using zirconium nitride retro-tips (ProUltra Surgical Tips; Dentsply, Maillefer Instruments, Ballaigues, Switzerland) driven by an ultrasonic device and the groove along the fracture line was dried with paper points and sealed with MTA.³²

Orthodontic elastics were used by Takastu et al. to join the buccal and palatal segments of a vertically fractured maxillary second molar which were then sealed with a photocured resin liner followed by endodontic treatment and restoration with a cast crown.⁴⁰

A new approach for the management of VRF caused due to trauma was presented by Baranwal et al as an alternative to extraction. This case report described successful management of a complete vertical root fracture with the help of Biodentine, a bonding agent, a fiber post, and dual-cure resin cement and an all ceramic crowns.³³ The separated fragments in clinical crown region were joined using universal dentin bonding agent and flowable composite. After completion of root canal, fiber post was placed and post endodontic restoration was done by an all ceramic crown.

Other treatment options attempted to treat a VRF include

Glass-ionomer cement with guided tissue regeneration therapy³⁴

The use of cyanoacrylates³⁵

Adhesive resin cement (4-META/MMATBB)³⁶ to reunite the fracture fragments.

Kallel I et al reported a case of VRF where the fracture site was surgically explored and the fracture line was filled using adhesive resin. The treated tooth remained asymptomatic after a follow up of 36 months.⁴⁸

Repositioning and Fixation with wire^{37,38} and mineral trioxide aggregate. However, long term follow ups of these treatment strategies should be carried on to confirm the success rates.

Recently, a novel approach was reported using 3D- printed template to precisely locate the fracture site and treat it microsurgically.⁴⁹

VII. Prognosis

The prognosis of a tooth with a vertical root fracture will mainly depend on the location, extent and duration of fracture. A VRF identified at its early stages and not progressed to involve the pulp has favourable prognosis. Whereas teeth with fracture causing splitting of tooth into separate fragments has poor prognosis leading to extraction. A VRF in a single rooted tooth has guarded prognosis and in cases of multirouted teeth where root resection has been attempted has favourable prognosis.

VIII. Conclusion

Vertical root fractures are one of the most challenging complications seen in clinical practice, commonly associated with endodontically treated teeth and less common in vital teeth. Early identification of these fractures is difficult, however, it is imperative for the clinician to diagnose/ identify a VRF in its early stage so that tooth retention can be anticipated.

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Conflicts of interest : No

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