

REVIEW ARTICLE



Vertical root fractures: A review

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Abstract

Vertical root fractures are mostly caused following endodontic therapy, and the chances are increased many fold if the final restoration includes placement of a post. The condition is difficult to diagnose and equally difficult to treat. Earlier treatment options included extraction of single rooted teeth, but with the advent of adhesive dentistry. There is a paradigm shift towards preservation of these teeth. This review addresses the etiology, diagnosis and management of vertical root fractures.

Keywords: Post endodontic failures, root fracture, vertical root fracture

Introduction

Vertical root fracture represents a partial or complete fracture line that extends through the long axis of the tooth.^[1] Vertical root fractures are most commonly seen in root filled teeth.^[2] The prevalence of vertical root fractures, in endodontically treated teeth, is 11-20%.^[3] Most of the causes for vertical root fracture are iatrogenic. Vertical root fractures can initiate from the coronal tooth structure or the apex of the tooth. For anterior and molar teeth, the fractures are generally in the bucco - lingual direction.^[4]

Predisposing Factors^[5]

- Excessive biomechanical preparation
- Overzealous widening for post-placement
- Exposure to occlusal forces beyond normal level
- Increased stress that exceeds the distributing capacity of the periodontal ligament (PDL) due to periodontitis or in cases of resorption
- Moisture loss in pulpless teeth
- Previous cracks in dentin due to pressure during obturation
- Loss of tooth structure due to caries or restoration.

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]

Teeth with vertical root fractures pose difficulties in diagnosis and treatment, and usually have a poor prognosis. Vertical root fractures are responsible for 32.1% of the reason for extraction of endodontically treated teeth, as found in a 5-year follow-up study.

Classification^[6]

- Based on the separation of a fractured root
 - Non-separated
 - Separated.
- Based on adjacent alveolar bone loss
 - Root fracture not involving bone resorption
 - Root fracture involving bone resorption.

Diagnosis

The diagnosis of vertical root fractures is difficult as there is no pathognomonic sign for the diagnosis. Final diagnosis is based on a panel of several signs and symptoms.^[7] Conventional methods for diagnosis of vertical root fracture include - illumination, radiographs, periodontal probing, staining, surgical exploration, the bite test, direct visual examination and observation under the dental operating microscope.^[8]

Clinical Presentation

The clinical presentation of vertical root fracture is variable. The clinical picture depends on the position of the fracture, tooth type, time elapsed after fracture, the periodontal condition, and architecture of bone adjacent to the fracture.^[4] The most common clinical findings are deep osseous defects and presence of a sinus tract closer to the gingival margin.^[7]

Patient usually presents with a history of variable discomfort or soreness, mild to moderate pain especially on biting. Vertical root fracture must be suspected if a root filled tooth presents with pain on biting and is also accompanied by a bad taste.^[4] It should also be suspected if a tooth with an apparently well condensed root filling is failing.

Swelling of soft tissue is present which is broad-based and mid - root in position. On palpation, swelling and tenderness are felt over the root itself and not the periapical area.^[4]

Development of deep, narrow isolated pocket in a tooth with no other periodontal attachment loss is pathognomonic of vertical fracture. Pocket is present adjacent to the fracture line and in cases where there is a complete fracture, there can be bilateral pockets.^[4]

Double or multiple sinus tracts are seen opening closer to the gingival margin. Where multiple sinus tracts are present, one or more of these tracts may be located some distance from the involved tooth and tracing sinus with gutta percha will help to isolate affected tooth.^[4]

Vertical root fractures can lead to dislodgement of posts or post crowns. Endodontic failure in teeth, which had previous healing may also point to the presence of a vertical root fracture.^[4]

During lateral condensation or cementation of a post, sometimes patients can feel a cracking or a popping sound, which is due to a fracture. There can also be bleeding during condensation of a root canal filling material and an apparent lack of resistance within the canal during condensation.^[4]

Diagnostic signs reflect the location and extend of the fractures:^[9]

- May involve full length of the root
- May involve a section-apical or coronal
- May extend into the crown and root
- May involve both sides of the root.

Radiographic Diagnosis

Conventional radiographs can have projection artefacts such as magnification distortion and super-imposition.^[7] Vertical root fractures can be overlooked if the X-ray beam does not pass along the fracture line and 2 or more radiographs with a 4-15° variation in horizontal angulation are recommended.^[7] Rud and Omnell have proved that a vertical root fracture line is evident radiographically only when the X-ray beam and the fracture line was within 4° of the fracture plane.^[9]

Cone beam computed tomography (CBCT) when used to obtain images of 0.3 and 0.2 voxels has proven to have similar accuracy as that of conventional radiograph taken in 3 different

angulations. The disadvantages of CBCT include the high radiation dose which increases as the voxel size decreases and streaking artefacts due to the presence of gutta percha points, or metallic posts can reduce the accuracy of the image.^[7]

Radiographic signs^[4,9]

- Separation of root fragments - once the fracture occurs; proliferation of granulation tissue often results in rapid movement of the fragment away from the remaining root.
- Fracture line along the root or root fillings - vertical radio-lucent line running across the root or root filling.
- Space beside a root filling - well condensed root filling that is in close contact with only one surface of the root
- Space beside a post
- Double images- radio- opaque images due to overlapping of fragments
- Radio-opaque signs this is caused by the extension of filling material or cement into the space between the fractured segments
- Patterns of bone loss- localized bone loss in otherwise well maintained attachment apparatus is suggestive of a fracture. This is due to the ingress of bacteria along the fracture line
- Widening of PDL space due to the generalized widening of the PDL space, the tooth appears to be more “in focus”
- Radio-lucent halos- at the apical region giving rise to a J-shaped radiolucency
- Step- like bone defects are seen in cases of oblique fractures or if the fracture line does not extend till the apex
- Isolated horizontal bone loss in posterior teeth
- Unexplained bifurcation bone loss this is seen mostly in mandibular molars along with halo-like radiolucencies^[3]
- V- shaped diffuse bone loss on roots of posterior teeth
- Resorption along fracture line
- Dislodgement of retrograde filling material.

Optical coherence tomography is a high resolution imaging technique which allows 1 µm scale imaging of biological tissues over small distances. It was introduced in 1991. It uses infra-red waves that reflect off the internal micro-structure. It gives a depth resolution of 10 µm.^[8]

Diagnodent that works on the principle of reflection of the laser from tissues also can be used in the detection of vertical root fractures. This is found to be particularly more effective in conjunction with dyes than using either of these methods alone.

Some cases can be diagnosed only by surgical exposure and exploration.

Management

Vertical root fracture is difficult to diagnose and more importantly, difficult to treat resulting in poor prognosis of the tooth.^[5]

When a diagnosis of vertical root fracture is made, a quick decision to extract the tooth or root is necessary since, inflammation in the supporting tissues can lead to periodontal

break down, followed by development of a deep osseous defect and resorption of the bone.^[4]

The treatment of vertical root fracture is important also for the reason that presence of bacteria in the root canal and damage to the cementum on the external root surface can result in external inflammatory root resorption.^[10]

In the case of fracture of a single root in multi-rooted teeth, resection of the root is advised so as to preserve the surrounding structures.^[4]

Replantation of root filled teeth with vertical root fracture reconstructed with resin bonding has emerged as a new promising method in recent years.^[5] The long-term prognosis of resin bonded and replanted teeth were determined by Hayashi *et al.* in 2004 in a 18 month follow-up study, which gave good results.^[11]

The prognosis of replantation therapy depends on: ^[4,10]

- Atraumatic extraction of the fragments
- Extra-oral time of <15 min as given by Pohl *et al.*
- Disinfection using short-term calcium hydroxide dressing
- Systemic tetracycline administration. This helps in disinfection as well as in a reduction of collagenase activity and motility of osteoclasts.

Improvement in the periodontal pockets and the recovery of alveolar bone is observed by intentional replantation with rotation and extrusion in order to avoid contact with the area where the PDL of the root surface was lost and the area where the alveolar bone was lost along the fracture line.^[12] By rotating the tooth before replantation, a barrier is created to epithelial down growth by the presence of healthy attachment on one side of the socket.^[12]

The materials used for reattachment of these fragments should have high bond strength and short polymerization time since the tooth continues to endure moisture and occlusal forces.^[5]

Materials used for reattachment of fragments include:

- Glass ionomer cement (GIC): Trope and Rosenberg used this material to bond a mesio-distally fractured maxillary second molar and reported successful functioning of the tooth. Stewart *et al* also reported some success with GIC.^[13]
- Cyanoacrylate: cyanoacrylate has been used in an attempt to bond the fragments of anterior teeth. While the treated teeth were comfortable at a 16 month follow-up, the long-term prognosis was considered poor due to deep pocketing and resorption. An *in vitro* study assessing the resistance to fracture of root segments bonded with GIC, composite resin, and cyanoacrylate concluded that the bond strengths of composite resin and cyanoacrylate were superior to GIC.^[14]
- 4-methacryloxy ethyl trimellitate anhydride (META)/methyl methacrylate (MMA) tri- n- butyl borane (TBB): 4-META/MMA TBB. The advantages associated with the use of 4-META/MMA TBB is low toxicity and biocompatibility for PDL cells. The cement interferes only slightly with cell attachment and proliferation. There is decreased level of inflammatory and replacement

resorption.^[12] Documentation of many successfully treated vertical root fracture with 4 META/MMA TBB have been done by various authors.^[5,12,15,16]

- Dual cure resin cements (e.g., Variolink II): These cements have high bond strength, good marginal integrity, acceptable biocompatibility and short polymerization time.^[5]

Mineral trioxide aggregate (MTA): MTA is a calcium-silicate based root repair material and has many applications in endodontics. Taschieri *et al.* in 2010 used MTA to repair incomplete vertical root fractures. A vertical groove was placed next to the fracture line and restored with MTA after ultrasonic cleaning. A resorbable membrane was placed next to the MTA to inhibit epithelial down growth. All 10 cases showed good results on 1 year follow up.^[17]

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