Diagnosis and clinical management of teeth with vertical root fractures: a literature review

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Abstract

The diagnosis of vertical root fracture (VRF) is at times complicated for lack of specific signs, symptoms and/or radiographic features. It constitutes an important threat to the tooth's prognosis during and after root canal therapy and may result in root or tooth extraction. Early detection and management of VRF remain a vexing issue that has caused needless stress for both the dentist and the patient.

This paper presents an overview of the prevalence and multifactorial aetiology of VRF, the clinical and radiographic features of this disorder, the importance of correct diagnosis and treatment options available for both anterior and posterior teeth. An exhaustive review of literature was done using Medline to bring out various etiologic factors, clinical presentations, radiographic features and treatment alternatives available for VRF. There are, however, many specific clinical and radiological signs which when present, can alert clinicians to the existence of a fracture. Even though VRF are commoner in endodontically treated teeth, its occurrence in non-restored teeth has been described. Clinical signs and symptoms vary according to the position of the fracture, tooth type, duration after fracture, periodontal condition of the tooth and architecture of the bone adjacent to the fracture. The radiographic appearance of teeth with VRF is variable depending on the angulation of X-ray beam in relation to the plane of the fracture, the time after fracture and the degree of separation of the root fragments.

It is important to recognize the sometimes subtle findings in VRF so that patient can be properly informed about the prognosis and the potential for successful treatment in affected tooth\teeth.

Introduction

A Vertical Root Fracture (VRF) is a most frustrating complication of root canal therapy in an endodontically treated tooth[1]. It has been described as longitudinally oriented fractures of the root, extending from the root canal to the periosteum[2]. Though it usually occurs in endodontically treated tooth, occurrence in non-restored teeth has been described[3]. These fractures can be complete or incomplete but most are complete[4,5]. When complete, they extend a variable length along the root generally in a buccolingual direction and may extend into the crown [6,7,8]or can originate from the cervical portion of the root with extension in an apical direction [9,10].

In molar teeth, the fracture is most commonly buccolingual in individual roots while mesio-distal fractures are less common. In anterior teeth however, the fracture is most commonly in a buccolingualdirection[11]. In a horizontal aspect VRF expands laterally from the root canal wall to the root surface where it may result in an incomplete fracture involving only one side of the root. A complete fracture expands in opposite directions of the root canal and involves two root canal surfaces[12].

Etiology

VRFs in an endodontically treated tooth have a multifactorial etiology that can be divided into predisposing and iatrogenic factors.

Many factors that predispose to VRF cannot be altered or controlled by the practitioner. These include masticatory accidents[7], natural tight cusp-fossa relationships, steep intercuspation or bruxism[6], loss of healthy tooth substance as a result of caries or trauma which increases the risk for cracks in the body of dentine that can later propagate to fracture[13,14], the unique anatomy of susceptible roots[15] i.e. the narrow mesio-distal dimension compared with the buccolingual, makes these roots and teeth susceptible to fracture especially at a later stage when additional tooth structure is removed during root canal and post preparations[16] Others are moisture loss in pulpless teeth[17], previous cracks in the dentine [18], and loss of alveolar bone support[19].

Root canal treatment procedures and the use of intraradicular posts are the two main iatrogenic factors associated with VRF. Enlargement of coronal third of the root canal space is considered important to support root canal length measurement, debris removal, and canal obturation. Excessive use of rotary instruments during preparation of canal space by cutting dentine to straight lines weakens the root structure [20].In addition, excessive

removal of tooth structure contribute to overall weakening of the tooth. The use of excessive pressure for compaction during lateral condensation of guttapercha can result in VRF[21]

VRF can also be caused by restorative procedures carried out after root canal therapy such as over preparation of the canal for a post, resulting in excessive width and length of a post space in relation to the tooth's anatomy and morphology, or excessive pressure during placement of the post [22-24].

Clinical detection of fractures can be exceedingly difficult in the initial stages of development beneath extensive restorations or in teeth after prosthetic treatment. Clinical signs and symptoms are often elusive in nature and may be difficult to detect or reproduce during patient examination. The patient symptoms may mimic many other possible diagnoses such as sinus problem, vague headaches or earache.

The affected root or tooth has an unfavourable prognosis and extraction is usually the only treatment option. This review focuses on the clinical and radiographic diagnosis of vertical root fracture in non restored/diseased teeth and the treatment options available.

Pathogenesis

When VRF occurs, it usually extends to the periodontal ligament so that soft tissue grows into the fracture space and increases the separation of the root segments. Communication with the oral cavity is through the gingival sulcus and through this opening foreign materials, food debris and bacteria obtain access to the fracture area. An inflammatory process is induced in the adjacent periodontal tissue as a result of entrance of these foreign bodies into the fracture space. This then result in periodontal ligament breakdown, alveolar bone loss and granulation tissue formation[25]. The osseous defect usually propagates apically and interproximally in a very quick manner. The breakdown is especially rapid in teeth and roots in which the buccal plate is thin, i.e. in the maxillary premolars and mesial roots of the mandibular molars, the most susceptible teeth, and roots to fracture[26,27].

Clinical Presentation (Signs and Symptoms)

The clinical presentation of VRF is extremely variable. Clinical signs and symptoms vary according to the position of the fracture, tooth type, duration after fracture, periodontal condition of the tooth and architecture of the bone adjacent to the fracture.

Teeth involved usually present with a long history of variable discomfort or soreness which is associated with local chronic infection. Pain may be mild or moderate and rarely severe. There may also be associated pain on biting which is also accompanied by a bad taste.

In an endodontically treated tooth, when the tooth does not settle after root filling is completed, this may be an indication of VRF.

Sometimes, a sharp cracking sound can be heard by patient during condensation of gutta percha or cementation of a post[28].

Presence of bleeding during condensation of a root filled material and apparent lack of resistance within the canal during condensation, leading to an almost unlimited ability to condense gutta percha into the canal are signs of a VRF[22].

Swelling may be noted and this is usually broad based, mid-root in position. Palpation will often show swelling and tenderness over the root itself but little swelling in the periapical region. Sinus tract when present is usually located close to the gingival margin. Presence of two sinus tracts at both buccal and lingual aspects is almost pathognomonic of a VRF[1]. Tamse et al[26] observed that in 35% of the cases reviewed with a sinus tract, 24% had a deep osseous defect, mostly at the buccal tooth aspect.

Development of deep, narrow, isolated periodontal pocket is a common feature of VRF. Pocketing is usually situated adjacent to the fracture site. When the fracture extends right through the root, probing pattern may be bilateral. In a tooth with a periodontal disease, the pocket is fairly consistent in depth around a large part of the tooth. Probing area then will be limited to the side that faced the fracture in the root which initially was narrow and difficult to locate and probe. As the bone defect extended apically and laterally, probing becomes easier. Pocket probing depths in VRF are in isolated areas whereas in a patient with periodontal disease, more sites can be probed and more than one tooth is usually involved. Deep probing in one position around the circumference of the tooth in the presence of normal attachment usually indicates that the tooth is fractured. Deep probing in two positions on opposite sides of the infection is pathognomic for the presence of a fracture[29,30].

A common presenting feature of VRF is the dislodgement of a post or post crown. A root fracture should be suspected if an apparently well sitting post becomes loose or dislodged. It is not uncommon therefore for teeth with VRF to have been treated repeatedly by surgery because of the problem with diagnosis before the presence of a fracture is suspected. When surgery fails, for no obvious reasons, a vertical fracture should be considered a possibility before the periapical area is re-entered surgically[31].

Radiographic Signs/Features

The radiographic appearance of teeth with vertical root fracture is variable depending on the angulation of X-ray beam in relation to the plane of the fracture, the time after fracture and the degree of separation of the root fragments usually accompanied by large bone loss surrounding the tooth or root.

The amount of bone loss is dependent on the extent of destruction, the plane of fracture and the architecture of the bone adjacent to the fracture. Appearance of bone destruction seen when the fracture plane is buccolingual will be different from that seen when the plane of the fracture is mesiodistal[29]. Bone destruction associated with anterior teeth will be easier to see than that associated with lower molars because of the thick buccal plate of bone. Pitts and Natkin[2]described a halo like radioluscency which runs around the whole length of the root surface when the plane of the fracture is at right angles to the X-ray beam. The halo radioluscency is a classic sign of a vertical root fracture. When the fracture runs obliquely across the root or where the fracture does not extend into the apical portion, a characteristic step-like bone defect develops[2].The appearance of a step-like bone defect on a particular tooth is subject to the angulation of the x-ray beam. Step-like bone defects can mimic simple

endodontic lesions resulting from other causes, like post perforations and vertical grooves. Step-like bone defects are only a sign that a fracture may be present.
When an isolated tooth shows bilateral horizontal bone loss, the presence of a mesio-distal root fracture should be expected more so in the presence of successful endodontic therapy and when periodontal condition is stable.
Presence of unexplained bifurcation bone loss without any obvious sign of apical pathoses. A diffuse V-shaped radioluscency which is widest at the crestal bone, narrowing towards the apex when confined to a single root or a single tooth in the mouth in posterior teeth is almost pathognomic. Dislodgement of a retrogade root filling is a likely cause of a vertical root fracture and this can be expelled through soft tissues[32].Wide enlargement of the periondontal ligament around the length of the root is an indication that the tooth is vertically fractured.

Diagnosis
The clinical and radiographic features suggestive of VRF in susceptible teeth have been discussed earlier. To ascertaina a diagnosis of VRF , the clinician should undergo the following steps:

i. Identify susceptible teeth and roots for features.
ii. Take a complete history of susceptible tooth.
iii. Clinically examine for pain on mastication and prolong discomfort.
iv. Use periodontal probe to detect an osseous defect, especially at the buccal aspect of the suspected root.
v. Take at least two periapical radiographs in different angulations to detect either a fracture line or typical periradicular radioluscency.
vi. Elevate an exploratory flap that usually helps to visualize the pattern of bone loss and fractures .

Other tests that can be conducted in arriving at a diagnosis are ;

i. Bite test: rubber wheels, cotton wool sticks, tooth sloth, fracture detector can be used to replicate masticatory motion so as to reproduce pain described by patient.
ii. Transillumination test: as by a strong fibre optic light shone through the tooth may help the clinician visualize a crack.
iii. Stainning test: use of disclosing dye such as blue or green vegetable dye helps the clinician visualize a suspected crack.

Recently, alternative diagnostic imaging systems with Computed Tomography were suggested[33,34] though could visualize vertical root fracture, they use harmful ionised radiation and sensitivity of detecting VRF is low. Bahcall & Bars[35]suggested a fibreoptic endoscope to image the canal internally but images of a VRF were never obtained because the imaging probe used 0.7mm which implies that canal would have to be enlarged up to size 70-80 which is seldom performed in adult teeth. More so, a dry canal is required for an endoscope to be used which might be difficult in teeth with VRF.

Optical Coherence Tomography (OCT) is a high resolution technique that allows micrometer scale imaging of biologic tissues over small distances[36]. It was introduced in 1991 [37] and uses infrared light waves that reflect off the internal microstructure within the biologic tissues. OCT has been shown to be a valuable tool in assessing intracanal anatomy, cleanliness of the canal after preparation and even perforations. Shemesh & others [37]in their study to evaluate the ability of an OCT system to diagnose VRF under different conditions deduced/concluded that the OCT is a powerful tool for evaluating VRF and has the potential to both identify VRF and detect its specific location along the root

Treatment Alternatives
Once the presence of a VRF is confirmed, decision needs to be made regarding the future treatment of the tooth. Treatment of VRF is difficult and is dependent on the tooth type as well as on the extent, duration and location of the fracture. Majority of vertical fractures involve the gingival sulcus and result in destruction of the periodontium to the apical extent of fracture, due to ingress of bacteria and other irritants resulting, in alveolar bone loss.
Multirooted teeth can often be successfully treated by resecting the fractured root, either by root amputation or hemisection[38]. Studies of root resected teeth have reported 5 year retention rates of 94%[39] and ten year retention rates of 68%[40]. However, the desire to retain part of a vertically fractured tooth should be carefully considered as against extraction and replacement with a denture, bridge or implant.
Prognosis for single rooted teeth is poor and extraction is often the treatment of choice to prevent further bone loss. However, many case reports are described in literature with innovative attempts to treat and retain anterior teeth with varying success. Cyanoacrylate has been used in an attempt to bond the fragments of anterior teeth[41]. The treated teeth were comfortable at a 16 months follow up, long term prognosis was considered poor due to deep pocketing and resorption.. Some have reported using glass ionomer cements because glass ionomer cements bond around the fracture line, preventing propagation of the fracture[42]. Also condensing glass ionomer cements and amalgam intothe coronal half to two-thirds of the root canal in teeth with incomplete vertical root fractures has been reported to be successful at eight month follow –ups but long term follow-ups have not been recorded[43]. Gore-Tex membrane in association with glass ionomer cement to bond fragments of tooth together can only be regarded as experimental.
Regeneration of bone has been shown to occur after surgical removal of the fractured segment from an anterior tooth, but long term follow-up was shown to be unfavourable due to deeppocketing and mobility [44]. Claims have also been made for the successful conservative treatment of VRF which originate apically but which does not involve the gingival sulcus. Root extrusion or intentional replantation in an extruded and/or rotated position are possible [45,46,47]. It has also been suggested that if the fracture involves only the facial wall and does

not involve the gingival sulcus, the fracture may be eliminated with the preparation of a long amalgam restoration(48). In a study by Takatsu et al(49) , orthodontic elastics were used to join the buccal and palatal segments of a vertically fractured maxillary second molar which were then sealed with a photocured resin and a cast crown was then placed on it. The tooth remained in function for more than three and half years with a reduction in pocket depth. The use of CO_2 and Nd-YAG laser to fuse fractured roots was tested in an in vitro study, but proved ineffective(50)

Conclusion

VRFs present a challenge to the clinician in that the diagnosis is often difficult, and is based on some subjective parameters. However, presence of pain, sharp cracking sound, two sinus tracts at both buccal and lingual aspects, deep narrow periodontal pocket should make clinician suspect a vertical root fracture. Two periapical X-rays taken at different angles with transillumination test are necessary to confirm the diagnosis of a VRF which can be treated either surgically or by extraction depending on the tooth type involved, the severity, duration and location of the condition.

Most of the case reports reviewed in anterior teeth were only carried out on small number of teeth and long term prognosis are usually uncertain. Treatment procedures which successfully remove fractured segments in posterior teeth either by hemisection or root amputation can result in a long term successful result while those in anterior teeth can best be regarded as experimental. It is important to recognize the sometimes subtle findings to properly inform the patients so that they have a better understanding of their prognosis and the potential for successful treatment.

References

1. TamseAviad . Vertical root fractures inendodontically treated teeth: diagnostic signs and clinical management. Endodon Topics 2006; 13: 84-94.
2. Pitts DL, Watkin E. Diagnosis and treatment of VRF. J Endod 1983; 9:338-346.
3. Chan C-P, Tang S-C, Lin C-P et al. VRF in nonendodontically treated teeth. A clinical report of b4 cases in Chinese pts. J Endod 1998; 24:678-681.
4. Hiatt Wit. Incomplete crown-root fracture in pulpal -periodontal disease. J Periodontol 1973; 44:369-379.
5. Makkes C, Folmer T. An unusual vertical root fracture of the root. J Endod 1979; 5:315-316.
6. Walton, RE, Michelrch RJ, Smith, GN. The histopathogenesis of VRF. J Endod 1984; 10:48-56
7. Meister F Hommel TJ, Gerstein H. Diagnosis possible causes of vertical fractures. Oral surg Oral Med Oral Pathol 1980; 49:243-253.
8. Murgel CAF, Walton RE. Vertical rot fracture and dentine formation in curved roots: the influence of spreader design. Endod Dent Traumatol 1990; 6:273-278
9. Endodontics: Colleagues for excellence. Cracking the crack tooth code. American Association of Endodontists,1997: Chicago
10. Rundquist BD, Verslius. How does canal taper affect root stress? Int Endod J 2006; 39:226-237
11. Holcomb JQ, Pitts DL, Wilcholls J. Further investigation of spreader loads required to cause vertical root fracture during lateral condensation. J Endod 1987; 13:277-284.
12. Walton RE, Michelrch RJ, Smith GN. The histopathogenesis of vertical root fractures. J Endod 1984; 10:48-56.
13. Sornkul E, Stannard JG. Strength of roots before and after endodontic treatment and restorations. J Endod 1992;440-443
14. Trabet KC, Caputo AA, Abou-Rass M. Tooth fracture. A comparison of endodontic and restorative treatments. J Endod 1978; 4:341-345.
15. Gutman JL. The dentin-root complex: Anatomic and biologic considerations in restoring endodontically treated teeth. Prosth Dent 1992; 67:458-467.
16. Pilo R, Tamse A. residual dentin thickness in mandibular premolars prepared with Gates glidden andparapost drills. J Prosth Dent 2000;83:617-623.
17. Sedgley CM, Lommel TJ, Gerstein H. Diagnosis and possible causes of vertical root fracture. Oral Surg Oral Med Oral Pathol 1980; 49:243-253.
18. Onnink PA, Davis RD, Wayman BE. An in-vitro comparison of incomplete root fractures associated with obturation techniques. J Endod 1994; 20:32-37.
19. Reinhardt RA, Krejer RF, Pao YC, Stannard JG: Dentine stress in posts reconstructed with diminishing bone support. J Dent Res 1983; 62:1002-1008.
20. Bender TB, Freedland JB. Adult roots fracture. J Am DentAss 1983;107:413-419
21. Tamse A. Iatrogenic vertical root fracture in endodontically treated teeth. Endod Dent Traumatol 1988 ; 4:190-196.
22. Christensen GJ. Posts concepts are changing. J Am Dent Assoc 2004;135:1308-1310
23. Schwartz RS, Robins JN. Post placement and restoration of endodontically treated: a literature review.JEndod 2004; 30:289-301.
24. Kishen A. Mechanisms and risk factors for fracture predilection in endodontically treated. Endod Topics 2006; 13:57-83.
25. Bergenholtz, Hosselgren G Endodontics/Periodontics. In: Lindhe J (ed) Clinical Periodontology and Implant Dentistry. 4thedn. Blackwell Munksgaard, Copenhagin 2003, 318-351.
26. Tamse A, Fuss Z, Lustry J, Kaplavo J. An evaluation of endodontically treated vertically fracturde teeth. J Endod 1999; 25:506-508.
27. Cohen S, Blanco L, Berman I. Vertical root fractures-Clinical and radiographic diagnosis. J Am Dent Ass 2003; 134:434-441.
28. Lommel TJ, Meister F, Gerstein et el. Alveolar bone loss associated with vertical root fractures. Report of six cases. Oral Surg Oral Med Oral Pathol 1978; 45:909-919.
29. Alex JM, Bill K. Diagnosis and management of teeth with VRF. Austral Dent J 1999; 44:75-87.

30. Tamse A. Vertical root fractures in endodontically treated teeth: Diagnostic signs and clinical management. Endod Topics 2006;13:84-94.
31. Zimet PO, Endo C. Preservation of the roots: Management and PreventionProtocols for cracked tooth syndrome. Ann R AustralasColl Dent Surg 2000;15:319-324.
32. Alexander SA, Spontaneous expulsion of a retrograde filling. Oral Surg Oral Med Oral Pathol 1983; 56:321-323.
33. Nair MK, Nair UDP, Grundah HG, Webber RL, Wallace JA. Detection of artificially induced vertical radicular fractures using tuned aperture computed tomography. Eur J Sc 2001; 109:375-379.
34. Hanning C, Dullin C, Hulsmann M, Herdrich G. Three dimensional, non distructive visualization of VFR using flat panel volume of detector GT: an vivo and in vitro case report. Int Enod J 2005; 38: 904-913.
35. Bahcall J, Barss J. Orascopicvisualisation for conventional and surgical endodontics. Int Endod J 2003; 36:441-447.
36. Brezinski ME. Optical coherence Tomography-Principles and Applicationns. Burlington,MA: Academy Press Elsevier, 2006.
37. Shemesh Hagay ,Gijs Van Soest, Minkaiwu, Paul RW. Diagnosis of vertical root fractures with Optical coherence Tomography. J Endod 2008; 34:739-742.
38. Korte PF, Carr JG, Cohen J. Vertical root fracture and its relationship to the periodontium. J Mich Dent Assoc 1980; 62:382-389
39. Langer B, Stein S, Wagenberg B. An evaluation of root resections. A ten year study. J Periodontol 1981;52:719-722
40. Buhler H. Evaluation of root- resected teeth. Results after 10 years. J Periodontal 1988; 59: 805-810.
41. Oliet S. Treating vertical root fractures. J Endod 1984; 10:391-396.
42. Stewart GG. The detection and treatment of vertical root fractures. J Endod 1988; 14: 47-53.
43. Gutmann JL, Rakusin H. Endodontic and restorative management of incompletely fractured molar teeth. Int Endod J 1994;27:343-348.
44. Sinai IH, Kratz HR. Management of a vertical root fracture. J Endod 1978; 4:316-317.
45. Heithersay GS. Combined endodontic-orthodontic treatment of transverse root fractures in the region of the alveolar crest. Oral Surg Oral Med Oral Pathol 1973; 36:404-415.
46. Kawai K, Maska N. Vertical root fracture treated by bonding fragments and rotational replantation. Dent Traumatol 2002;18:42-45
47. Kudou Y, Kubota M. Replantation with intentional rotation of complete vertically fractured root using adhesive resin. Dent Traumatol 2003;18:115-117
48. Milobski Sa. Repair of vertical root fracture. J Dist Columbia Dent Soc 1970; 45:8-10.
49. Takatsu t, Sano H, Burrow MF. The treatment and prognosis of a vertically fractured maxillary molar with widely separated segments: a case report. Quintessence Int 1995; 26:479-484.
50. Arakawa S. Treatment of root fractures by CO2 and Nd- YAG laser. J Endod 1996; 22:662-667.