Review article:

Review of Vertical Root Fractures in Dentistry

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Abstract :

Clinical detection of Vertical Root Fracture associated with endodontically treated teeth and less commonly in vital teeth is one of the most difficult clinical problems to diagnose and treat. Early diagnosis of Vertical Root Fracture prevents the damage to the supporting tissues and bone. This review focuses on the etiology and early diagnosis of Vertical Root Fracture. It adds to the preventive measures and better prognosis of the treatment which can be incorporated during routine clinical procedures.

Keywords: root fracture, vital, teeth

Introduction

Vertical Root Fracture is defined as a longitudinal fracture confined to the root that usually begins on the internal canal wall and extends outward to the root surface[1].From a horizontal aspect,the fractures initiate in the root canal wall and extend to the root surface,involving either one side(incomplete fracture) or both sides(complete fracture)[2,3].Vertical Root Fracture can be initiated from the coronal tooth structure or at the apex[4].Vertical Root Fracture largely occur in teeth during or after endodontic therapy,in patients older than 45years of age[5] and more in males, although occurrence in non-restored teeth has also been described[6,7,8]. In molar and anterior teeth, the fracture is most commonly bucco-lingual in orientation in individual roots[9].Vertical Root Fracture is a serious clinical concern, resulting almost inevitably in extraction of the tooth or resection of the affected root[5].Diagnosis is challenging as signs and symptoms are often delayed, however all vertically fractured teeth exhibit specific clinical and radiographic signs which should alert the clinician to the possibility of a root fracture being present.

Etiology: Contributing anatomic factors and habits[10]

Anatomic tooth form[11]: canal shape, root shape and dentin thickness affect tensile stress distribution, Traumatic occlusion: causes FATIGUE ROOT FRACTURE. These fractures in posterior teeth could be due to the “nut cracker effect”. Deep bite, cross bite, occlusal discrepancies such as open bite, irregular teeth alignment and edge to edge occlusion causes untoward forces during mastication on teeth which make them more susceptible to Vertical Root Fracture, Lack of calcification coalescence in the enamel along proximal walls and marginal ridges during tooth development, Hypomineralization of tooth structure, Deep developmental grooves that fail to have uniting enamel covering, Para functional habits such as bruxism.

Contributing restorative and endodontic factors

Gold inlays, Large amalgam restoration undermining tooth structure, Excessive removal of tooth structure[11] in endodontically treated teeth[13], Long term calcium hydroxide as a root canal dressing may increase the risk of root fracture.It

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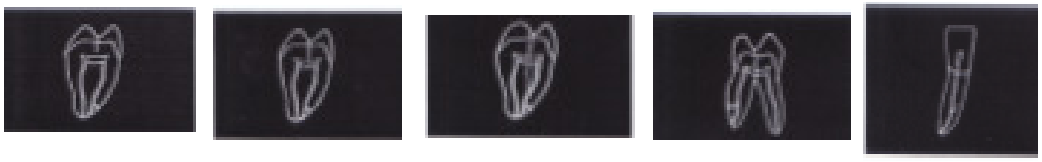
causes changes in organic matrix ,which is due to disruption of link between the hydroxyapatite crystals and collagenous network in dentin[14].There is weakening of dentin by 23-43.9% following root canal placement of calcium hydroxide[15], Reinforcing pins and Intraradicular posts and dowels, Insertion (hydrostatic) pressures during post placement, Failure to restore endodontically treated teeth in a timely manner, Improper occlusal adjustments, A cantilever bridge, Excessive canal preparation, Excessive compaction forces[16]: Excessive hand pressure during lateral or vertical compaction of gutta-percha, Wedging of filling materials and instruments spreaders, pluggers[16], Excessive use of **s**traight rotary instruments[17] such as gates Glidden burs or peso reamers in thin roots, Excessive use of sonic or ultrasonic instruments.

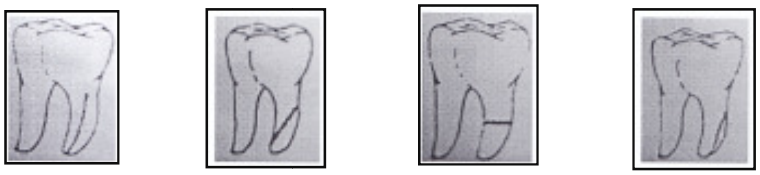
Additional predisposing factors: Periodontal diseases' with significant bone loss, pathologic migration or drifting of a tooth, corrosion of intra radicular posts[4, 17] and Tooth attrition.

Classification of cracked tooth syndrome by Williams[20] (fig 1)



Class I: Incomplete Vertical Fracture**-** Incomplete vertical fracture through enamel into dentin, but not into pulp. Class II**:** Pulpal involvement- Incomplete crown fracture involving the pulp. Class III: Attachment involvement- Incomplete vertical fracture involving the attachment apparatus. Class IV: Complete separation of tooth Fragments- Fracture divides the tooth. Class V: Retrograde root fracture- Apically induced fracture.

Classification of fatigue root fracture by Chin- Jyh Yeh[8] (fig 2)



Vertical fractures: the fracture line is parallel to the long axis of the root, and located only in the root. Oblique fractures: the fracture line follows an angle in relation to the long axis of the root. Horizontal fractures: the fracture line is perpendicular to the long axis of the root. Laminar fractures: a piece of root fragment, not involving the root canal.

Classification of Vertical crown-root fractures by Raymond G Luebke[21] (fig 3)

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Based on the nature, extent and the condition of the bone adjacent to the defect

Class I Fracture: Incomplete, Supraosseous, No periodontal defect, Class II Fracture: Incomplete, Intraosseous, Minor periodontal defect, Class III Fracture: Complete or Incomplete, Intraosseous, Major periodontal defect

Prevalence of Vertical Root Fracture

Reports from case series[22] and follow up of patients treated with prosthetic reconstructions and retrospective radiological studies[24] suggest a prevalence of 2% and 5% with the greatest incidence occurring in teeth during or after endodontic therapy and in patients older than 45 years of age and more in males. Maxilla is more affected than mandible especially premolars and molars. Roots that are wide facio lingually but thinner mesio-distally tend to fracture more often. Example mandibular premolars, maxillary second premolars and mesiobuccal roots of maxillary molars, mesial and distal roots of mandibular molars.Roots of maxillary central incisors,lingual roots of maxillary molars and maxillary canines tend to be rounder and more resistant to VRF.[25].The incidence of VRF in non-endodontically treated teeth (mostly in eastern countries mainly china) is two times higher in males than in females.It is due to factors such as strong masticatory forces,wrong dietary habits, presence of severe attrition and increased bone density[8].

Pathogenesis of Vertical Root Fracture

Depending on the nature of the stress factors: VRF usually originates from the apical end of the root and propagate coronally or can originate from the cervical portion of the root with extension in an apical direction. Incomplete and complete VRF [9, 17]in horizontal aspect: VRF expands laterally from the root canal wall to the root surface and it may result in an incomplete fracture involving only one side of the root. When VRF occurs, whether incomplete or complete, it extends to the periodontal ligament, where upon soft tissue grows into the fracture space and increases the separation of the root segments.On communication with the oral cavity through the gingival sulcus,foreign material, focal debris and bacteria obtain access to the fracture area.Entry of these elements to the fracture space causes an inflammatory process resulting in periodontal ligament breakdown,alveolar bone loss and granulation tissue formation[9].The osseous defect usually propagates faster apically and inter proximally.The breakdown is especially rapid in teeth and roots in which the buccal plate is thin that is in the maxillary premolars and mesial roots of the mandibular molars,the most susceptible teeth and roots to fracture. If VRF is confined to the apical root portion without communication with the oral cavity, the inflammatory process in the surrounding supporting tissues will depend on the release of any existing irritants in the root canal, including bacteria and sealer material.

Bone resorption patterns: The typical pattern of bone resorption facing the maxillary and mandibular premolars and mesial roots of mandibular molars was described by Lustig et al[26] as ‘dehiscence’ and was found in the buccal plate in 90% of the cases examined.Initially, when a thin buccal plate is resorbed, a narrow bone cleft develops and resorbs in an apico-coronal direction that is it propagates with the fracture to form an oval or oblong type of bone resorption. At a later stage the bone effect becomes wider as it extends laterally to the interproximal areas.At the lingual aspects, the spongeous bone and the thicker cortex create a ‘shield phenomenon’ by which the bone resorptive process following backward and lateral propagation forms a shallow rounded U-shaped

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bone defect with the height of the plate reserved.Usually, in a periapical radiograph no radiolucent area is seen when dehiscence type of bone resorption has occurred. It may only be diagnosed in radiographs when the osseous defect has extended laterally to the inter proximal areas.

A 'fenestration' type of bone resorption may occur when the fracture exists somewhere along the root, usually at the buccal aspect without involving coronal or apical parts. Although fenestration is not a typical sign of VRF, it was found in almost 10% of cases[26; 27.]An abscess similar to a dento-alveolar abscess of endodontic origin can be the only clinical sign in these fenestration cases. It is speculated that inflammatory process progresses apically, followed by rapid bone resorption in this specific area. Although Walton et al could not determine the precise etiologic factor of osseous defect; they suggest that bacterial infection from the oral cavity probably entered the area when the fracture communicated with the periodontal sulcus.Granulation tissue in these cases replaces the resorbed bone along the fracture line and fills the entire defect. Bacterial infection from the root canal and excess sealer are other irritants that could add to the inflammatory process. When the fracture starts to separate, fragments communicate with periodontium and percolation of tissue fluids occur.

Diagnosis of Vertical Root Fracture

Diagnosis of Vertical Root Fracture is challenging as there is often no single clinical feature which indicates that root fracture is present and signs and symptoms are often delayed[17.] To ascertain a diagnosis of Vertical Root Fracture the clinician should undertake the following steps

1. Identify susceptible teeth and roots for fracture.
2. Take a complete history of the susceptible tooth
3. Clinically examine for pain on mastication and prolonged discomfort
4. Observe for a crack or incomplete fracture line in the crown.
5. Use a periodontal probe to detect an osseous defect, especially at the buccal aspect of the suspected root.
6. Take at least two angulations with periapical radiographs to detect either a fracture line or typical periradicular radiolucency.
7. Elevate an exploratory flap that usually helps to visualize the pattern of bone loss and fracture.

Clinical signs and symptoms

8. Pain is usually mild to moderate.Mild pain is the only symptom in majority of cases[18].
9. Spontaneous dull pain on mastication or tooth mobility can be present.
10. Single sinus tract is most frequently seen.Intra oral swelling with multiple sinus tracts is also common.
11. Isolated pockets with characteristics of sinus tracts on probing extend from gingival sulcus part way or all the way to the apex. Deep narrow isolated periodontal pocket is a common feature of vertically fractured tooth.
12. Periodontal type abscesses are seen
13. A root filled tooth associated with pain on biting and bad taste
14. Sharp cracking or popping sound during obturation, a sharp stab of pain, bleeding in the canal or enlarged canal allowing large number of accessory cones-any one of these or a combination during obturation

Radiographic features

15. Diffuse widening of periodontal ligament[18].

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16. Dislodgement of retro-filling material[27].
17. Vertical bone loss[28]
18. Separation of root fragments[29].
19. Dislodgement of apical portions of root[30].
20. Presence of radiolucent halo (combination of periapical and perilateral radiolucency).
21. Periodontal type lesions.
22. In endodontically treated molar,bifurcation radiolucency in conjunction with other areas is the first evidence of Vertical Root Fracture.
23. Bony dehiscence and fenestration[31, 32]
24. Radiolucent areas adjacent to obturating material or spreader void type lucent areas.
25. Double images of the external root surface in radiograph seen as step-like image on the external outline of a tooth.
26. If Vertical Root Fracture is prior to root filling or occurs during root filling and separation of fracture occur, extention of root filling material through apex can result in a tangle of accessory points at the apex (apical spaghetti)
27. Resorption along the fracture line[33].
28. Dislodgement of retrograde filling material[34, 12].
29. Bifurcation bone loss in molars for no apparent reason and without any obvious sign of apical pathosis
30. V-shaped diffuse bone loss on roots of posterior teeth: V-shaped radiolucency confined to a single root or single tooth in mouth, widest at the crestal bone, narrowing towards the apex.[12]

Diagnostic tests

Medical history, dentalhistory, subjective examination, visual examination, dental operating microscope, tactile examination, vitality test, bite test, periodontal probing, radiographs, removal of restoration, staining with dye such as methylene blue, transillumination, computed tomography, cone beam computerized tomography imaging has started to gain broad acceptance,optical coherence tomography, flat panel volume detector computer tomography,tuned aperture computer tomography(TACT), lasers(DIAGNODENT),surgical assessment(triangular miniflap).

Treatment

31. Bonding using glass ionomer cement and composite resin.
32. Bonding using wires.
33. Bonding using adhesive resin cement.
34. Bonding using adhesive resin cement and rotational replantation.
35. Fusing the fragments using Co_2 and Nd: YAG laser.
36. Hemisection and root amputation.
37. Extraction.
38. Surgical management.

Prevention: The cardinal safety rules are[1]:

39. Avoid excessive removal of intraradicular dentin[35].
40. Minimize internal wedging forces.
41. Treatment and restorative procedures that require minimal dentin preparation should be selected.
42. Condensation of obturation materials should be carefully controlled.
43. More flexible and less tapered finger pluggers or spreaders are preferred.
44. Posts weaken the roots and should not be used unless they are necessary to retain a foundation.
45. The post design least likely to cause stress and fracture in dentin is the flexible or cylindrical (parallel sided) preformed post.

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46. Any post used should be as small as possible, have a passive fit, and not grip or lock the root internally with threads.
47. Cementation should be done carefully and slowly; an escape vent for the cement is probably helpful.
48. Adequate ferrule that effectively resist functional forces and enhances fracture strength of post core restored endodontically treated tooth should be prepared[36].

Conclusion

VRF can be detected early by listening to the patient's chief complaints, carefully examining radiographs and performing a thorough clinical examination. VRF associated with root canal treated teeth is one of the most difficult problems to diagnose and treat. Early detection has two fold advantages –It prevents unnecessary frustration and inappropriate endodontic treatment and prevents extensive damage to the supporting tissues. Before any complex experimental treatment procedures are considered, the desirability for retention of the tooth root should be carefully weighed against extraction and replacement with a denture, bridge or implant.

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