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Recent trends in vertical root fracture: A review

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Abstract--In the modern era where dentistry is more considerate in preserving the natural tooth in the oral cavity, Vertical Root Fractures (VRFs) are diagnosed as the third most common reason for extraction of tooth. VRFs are more common in endodontic ally treated tooth. As the symptoms of VRFs are not precise, the clinical diagnosis of VRFs at the early stage becomes questionable. Persistent presence of VRFs leads to the damage of the surrounding supporting structures making rehabilitation of extracted tooth site more challenging. In recent times emerging trends in treatment modalities of VRFs has been introduced. This review article highlights the recent trends in aetiology, diagnosis, pathogenesis and treatment of VRF teeth.

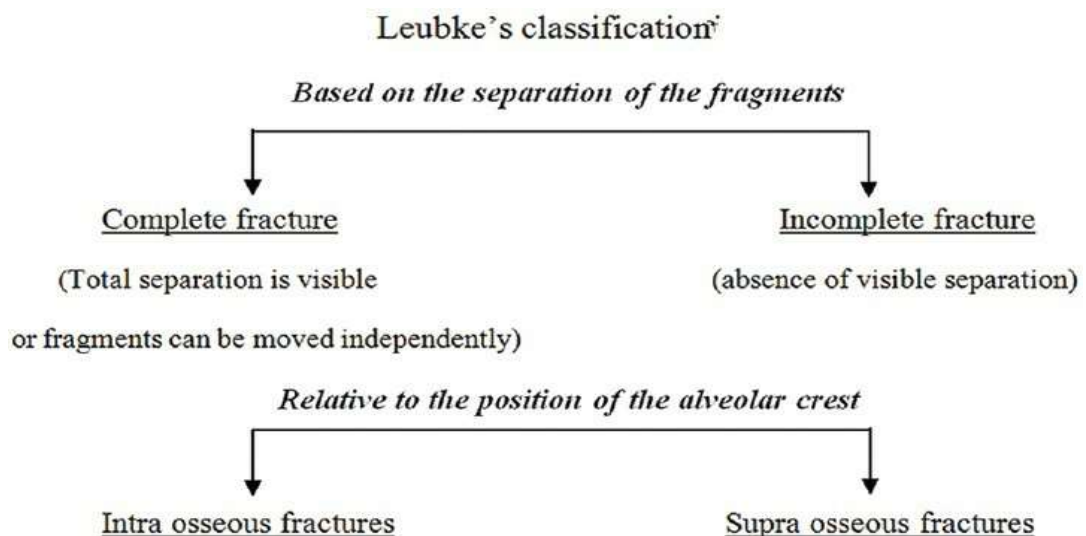
Keywords---cone beam computed tomography, root canal treatment, vertical root fractures.

Introduction

“Vertical root fractures (VRFs) are partial or complete fracture lines that extends along the long axis of tooth”.^[1] VRFs are the third most common cause for tooth extraction.^[2] Most of the times the cause being iatrogenic^[2] and most commonly occurring in endodontically treated teeth.^[3] In case of VRF in vital tooth, physical trauma to the tooth is considered the most common reason. It is most common in men rather than in women due to the strong masticatory forces, increased attrition, habitual chewing of hard foods etc. Fracture lines are generally directed in the buccolingual direction.^[4] VRF without infection is termed as “histological vertical root fracture”. When infection occurs it is known as “clinical vertical root fracture”. Diagnosing VRF at early stages is difficult as symptoms emerge only after peri-radicular infection. CBCT has become an acceptable method of diagnosis. Earlier the treatment plan for VRF was extraction but the current trend shows bonding of the fracture segments using biocompatible materials like MTA as a successful treatment option.

Classification

Complete fracture



It occurs when the entire fracture is seen and fractured parts can be moved without any dependence.

Incomplete fracture

It occurs when the entire fracture is not seen and fractured parts can be separated by instruments.

Supra-osseous fracture

It doesn't cause periodontal pocket formation and it terminates above the bone.

Intra-osseous Fracture

It causes the formation of periodontal pocket due to involvement of bone.

Predisposing Factors

- Endodontically treated tooth:
There are biomechanical changes in the root dentin due to the adaptation of dentin to functional stress during endodontic treatment and it causes buccolingual areas to get mineralized. Thus fracture will propagate in a buccolingual direction rather than towards mesiodistal areas as they are less mineralized with more collagen. ^[5]
- Decreased amount of sound tooth structure:
When there is excessive loss of tooth structure due to causes like dental caries then the tooth is highly susceptible for VRF. ^[5]
- Root canal anatomy:
Roots with narrow mesiodistal diameter and roots with curvature are more prone for VRF. Premolar's buccal roots and mandibular molar's mesial roots have developmental depressions that are more susceptible to fracture. ^[5,6]
- Residual dentin thickness:
In cases where excess dentin is removed, especially during post space preparation VRF is common. ^[5,6]
- Pre – existing cracks:
Small cracks, tooth infractions that are very small and clinical invisible are prone for the development of VRF. ^[7,8]

Etiological Factors

Etiology of vertical root fracture is multi-factorial:

- Post placement:
Overzealous widening of the root canal space for post placement leads to VRF. Tapered and threaded posts produce wedging effect near apex and increases the stress generation. Rigid zirconia posts cause VRF. Corrosion products of pins and posts also predispose to the development of VRF. ^[9, 10]
- Parafunctional habits:
Parafunctional habits like chewing ice and abrasive foods increases the possibility and risk for VRF. ^[9]
- Moisture loss:
Moisture loss in pulpless tooth after endodontic treatment produces brittleness and leads to VRF. Plastic deformation is more in pulpless tooth than that of normal teeth. Young's modulus that is stiffness is increased in pulpless tooth causing VRF. ^[10]
- Restorative treatment:
Extensively restored tooth are more prone to VRF. Large restorations, ill-fitting crowns, inlays, placement of pins can cause VRF due to wedging action. ^[9]
- Excessive canal shaping:
When the root canal is shaped excessively during endodontic treatment VRF is common. ^[11]

- Obturation techniques:
Excessive force during lateral condensation causes VRF.
- Use of spreader:
The wedging effect of the spreader during lateral condensation increases the chances of VRF.
- Instrumentation length:
Crack formation can be reduced by means of rotary files. When the rotary files are used at 1 mm short of apical foramen and when all instrumentation is terminated at the Cemento- dentinal junction (CDJ) that corresponds to the minor diameter, the incidence of VRF can be reduced. ^[10,11]

Clinical Manifestations

VRF has clinical manifestations that are not definite.

- VRF can cause a severe, deep, traumatic pain which is usually described by the patient as a shooting or throbbing usually during mastication.^[12]
- Most common clinical findings is the presence of multiple sinus tracts along the gingival margin.
- In cases where the obturation material is well condensed, but there is existence of a persistent peri-radicular lesion indicating failure of the endodontic treatment, then it is an illustration of VRF.
- Mid-root region has the presence of soft tissue swelling. When the swelling is palpated pain is felt over the root and not in the apical region.
- A typical feature of VRF is the appearance of deep narrow pocket but periodontal attachment loss is absent. Bilateral pockets may be present where there is complete fracture.
- VRF can be suspected when endodontic failure occurs in teeth which had healing points previously.^[13]
- VRF is seen when there is presence of bleeding or loss of resistance inside the canal during root canal filling.

Radiographic Features

Radiographic features of VRF may vary widely.

Radiolucent signs

- Presence of radiographic halo involving the entire root is a major finding of VRF.
- In root canal treated molars, bifurcation radiolucency is the primary radiographic feature of VRF.
- Radiolucency near the obturation material or spreader, void type radiolucent areas are common evidence of VRF.
- Separation of root fragments makes fracture line clearly visible.
- J shaped radiolucency is present due to radiolucent areas in the apical region.^[14]

Radio-opaque signs

- When the root filling material or root canal sealer extends into the space between the fractured segments, radio-opaque areas are visible.^[15]

Patterns of bone loss

- Around the whole length of the root widening of the periodontal ligament space is seen.
- Fractures which are obliquely oriented have a characteristic step like bone defect.
- Bilateral horizontal bone loss can be caused by mesio-distally oriented fracture.
- Diffuse V shaped radiolucency is a radiographic feature of a vertically fractured maxillary molar's buccal root or the mesial roots of mandibular molars.^[16,17]

➤ Radiographic features are highly indefinite and cannot be seen in the early stages. Only 33% of fractures may be directly observed by dental radiography.^[16]

Pathogenesis

The inflammatory process begins when VRF reaches the root's outer surface, where it connects with the periodontal ligament. Foreign material and bacteria start to enter the fracture site when it communicates with the oral cavity via the gingival sulcus. Inflammatory process starts and granulomatous tissue formation occurs. This leads to bone resorption and deep pocket depth formation.^[18]

Diagnosis

The diagnosis is achieved by combining the subjective complaints of the patient with objective- clinical and radiographic evaluations. The sequence of diagnosis is in this order: (1) Subjective evaluation, (2) Objective tests, (3) Radiographic examination (4) History of the tooth (5) Reflecting the flap when needed.^[9]

Direct visualization

Directly visualising the tooth using good illumination and magnification is important. When there is a dislodged crown, missing excess coronal structure fracture may be directly viewed. While separation of fractured segments, the fracture line is visible.^[9]

Staining

Fracture line can be identified by using disclosing agents. When using 70% isopropyl alcohol to clean the occlusal surface, the food colouring on the surface can be removed, but the food colouring in the fracture line doesn't disappear making the fracture line visible.^[18]

Bite test

Tooth sloth, fracture detector/ frac finder, cotton wood sticks, rubber wheels can be used as diagnostic devices to stimulate the pain as described by the patient. Patient feels at ease on biting but pain occurs when the patient releases the device and the bite opens.^[4]

Trans-illumination test

When the tooth is illuminated with a strong fibre optic light (no restoration should be present to block the light) at the gingival sulcus in the horizontal direction, the crack can be visualised. When a crack is present there will be light deflection at the crack. This reduces its transmission through the tooth and the other side of the crack will appear darker.^[4]

Probing test

A thin periodontal probe on probing reveals a periodontal defect that is narrow and isolated. When all other periodontal diseases are absent this narrow defect indicates VRF.^[4]

Cone Beam Computed Tomography (CBCT)

CBCT is superior to conventional radiography in the assessment of VRF perpendicular to the plane of axial sections. However high radiation dose, decreased availability and high expense limits its use in dentistry.^[14] Root canal filling materials create image artefacts that deteriorates the quality of the images and reduce their accuracy.^[15] So it is advised to remove the filling materials before imaging to improve the potential of CBCT. When periapical radiography does not show any evidence of suspected VRF then CBCT is the next reliable diagnostic method.^[16]

Surgical exploration

This method includes the lifting of a full thickness mucoperiosteal flap where the direct visualisation of root and bone is possible. This method is preferred when VRF is strongly suspected but other diagnostic methods don't favour the diagnosis.^[19]

Treatment

As soon as VRF is diagnosed it is important to administer immediate treatment as supporting tissue inflammation can lead to breakdown of the periodontal structures followed by deep osseous defect development and bone resorption.^[20]

Root amputation and extraction

In multi rooted tooth with VRF hemi section of the root will preserve the tooth. However, the prognosis for a single rooted tooth with VRF is poor, so extraction is treatment of choice. Farrar et al described a surgical technique which advocated

resecting the root and the remaining part to be filled with retro-filling material, like mineral trioxide aggregate.^[3] Matusow et al advocated a technique named as “root stripping.” He quoted a case of a mandibular second molar with fused mesial roots with VRF. The fused root was surgically “stripped,” leaving the distal root segment intact.^[3]

Re-plantation

In recent times a root that is vertically fractured is extracted, extra-oral endodontic treatment is completed, the fractured segments are approximated with resin bonding and it is replanted into the socket. In 2004 Hayashi et al published an 18 months follow-up study to determine the prognosis of resin bonding and replanted teeth. The factors which contributed to the prognosis are as follows:

- The fractured fragments needs to be extracted atraumatically.
- Pohl et al stated that extra oral time should be less than 15 minutes.
- Calcium hydroxide intra-canal dressing for disinfection.
- Systemic administration of tetracycline needs to be done. This disinfects, reduces the activity of collagenase and reduces osteoclasts mobility.^[21, 22]

The materials used for reattachment of fractured fragments must poses properties such as increased bond strength and decreased polymerization time as the tooth is always in contact with moisture and occlusal forces.

Material used for reattachment of fragments include:

- i. Glass ionomer cement
- ii. Cyanoacrylate
- iii. 4- methacryloxy ethyl trimelliate anhydride (META)
- iv. Dual cure resin cements
- v. Mineral trioxide aggregate ^[1]

The tooth during implantation is rotated 180 degrees. This provides a connection between the connective tissue of the socket wall which is periodontally involved with the healthy periodontal membrane remnants remaining on the root. ^[21] This cures the long narrow pockets formed in VRF. The tooth involved must be atraumatically extracted. The segments should be completely cleaned, irrigated and dried. Then they should be bonded with a bonding agent and must be held under pressure. Excessive adhesive on the surface should be removed. Re-implantation of the tooth in the socket is done and followed by splinting for two weeks.^[21] A proper follow up is mandatory for good prognosis of the tooth. After re-implantation bio-resorbable membrane can be applied that promotes periodontal healing by preventing the curetted root surface from coming into contact with any gingival connective tissue during healing and allowing periodontal ligament cells regeneration around tooth. This also prevents ankylosis.

Flap elevation and cementation

Without extraction of the tooth, flap can be elevated and fusion of the fractured tooth fragments can be done.

The flap procedure has many disadvantages:

- Formation of scar in the esthetic area of the gingiva
- Extra loss of healthy bone structure may occur due to the additional osteotomy that may be needed
- Recession of the gingiva

Due to the esthetic considerations this method is contraindicated in few cases.^[22] Other treatment options includes the fusion of the fractured tooth segments using CO² and Nd:YAG laser.^[4]

Conclusion

Though diagnosis of VRF remains a constant challenge with the increase of scientific technology it is made possible to identify it at an early stage. Early stage diagnosis of VRF proves to be the best factor for good prognosis of the treated tooth. Extraction of the tooth as a treatment option has drastically decreased with new bonding and re-implantation techniques.

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Conflict of interest:

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