

**REVIEW ARTICLE****Longitudinal tooth fracture**Aditi Shukla<sup>1</sup>, U.P.Singh<sup>2</sup>**Abstract**

Coffee is one of the most consumed beverages in the world and is commonly consumed in India on an everyday basis as it is considered to be psychoactive, mood elevator and provides relief from cold and headache. Components of coffee that have been found to have such effects include caffeine, caffeic acid, and chlorogenic acid. Caffeine, a component of coffee, exerts antioxidant and anti-inflammatory effects. Caffeine suppresses human lymphocyte function as indicated by reduced T-cell proliferation and impaired production of Th1 (interleukin [IL]-2 and interferon [IFN]- gamma), Th2 (IL-4, IL-5) and Th3 (IL-10) cytokines.

**A longitudinal tooth fracture is a fracture that occurs along the vertical lines of a tooth from the crown towards the root or vice versa.**

The term longitudinal fracture typically represents vertical extensions of fractures over distance and time.<sup>1</sup> While crown fractures occur most frequently in the permanent dentition, root fractures account for 0.5-7% of trauma that occur in the permanent dentition.<sup>2</sup> The diagnosis can be difficult; the symptoms can be either vague or specific, yet they are often insufficient for a definitive diagnosis.<sup>3</sup>

For a successful outcome, it is imperative to arrive at an appropriate diagnosis and design a Clinical management of the crack or fracture depends on its extent. Prevention of a potential crack or fracture is a fundamental principle, and early detection is imperative.

treatment plan accordingly as soon as possible.<sup>4</sup> Hence, the aim of the present article is to present an overview of various types of longitudinal

**CLASSIFICATION FOR LONGITUDINAL FRACTURE**

The location, direction and extent of a crack have a profound effect on the choice of treatment. So according to the **American Association of Endodontists 2008**<sup>1</sup>, the five types of longitudinal tooth fractures are described as follows:

- (i) craze line(Fig 1)
- (ii) fractured cusp(Fig 2)
- (iii) cracked tooth(Fig 3)
- (iv) split tooth(Fig 4)
- (v) vertical root fracture(Fig 5)



Fig 1 - Craze line



Fig 2 - Fractured cusp



Fig 3 - Cracked



Fig 4- Split tooth



Fig 5 - Vertical root fracture

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According to Ingle<sup>5</sup>, they may also be classified as-

1. Tooth infraction
2. Vertical root fracture (VRF).

**Tooth infraction** can be defined as an incomplete tooth fracture extending partially through a tooth. It can be identified as three fairly distinct types:

- (1) those confined to enamel (“craze lines”)
- (2) those related to cuspal fracture that typically do not involve the pulp,
- (3) those more centrally located that do involve the pulp.

**Vertical root fractures** are longitudinal fractures that originate in the roots of teeth, in contrast to tooth infractions that originate in the crowns.

### ETIOLOGY

Restored teeth are more commonly associated with tooth infractions than non restored teeth as compared to vertical root fracture which is generally seen in root filled teeth

1. Excessively **large and incorrectly designed** restorations.<sup>6</sup>
2. Use of **pins** for restoration ,like self-threading and friction-lock pins.<sup>7</sup>
3. **Age changes** leading to reduced collagen deposition and increased mineral deposition.<sup>8</sup>
4. **Oral habits** such as bruxism, causing a series of loading and unloading forces on the tooth.<sup>9</sup>
5. **Thermal cycling** changes in tooth due to extreme cold or hot temperatures.<sup>10</sup>
6. Application of **sudden large amount of force** beyond the limit of tooth may cause sharp pain.<sup>11</sup>
7. **Plunging cusps** from the maxillary tooth imparting continuous forces on the central fossa of the mandibular tooth.<sup>12</sup>
8. **Decreased residual tooth structure** following endodontic treatment.<sup>13</sup>
9. **Pre existing micro cracks** and fractures in minimally or unrestored vital teeth.<sup>14</sup>
10. **Dehydration** after endodontic treatment leading to overall decrease in strength.<sup>15</sup>
11. The presence of **isthmi, hourglass- shaped root canal cross- sections, increased root canal curvature** have increased risk for fracture.<sup>16</sup>
12. Use of **root canal irrigants** that has exhaustive effects on organic and inorganic portions of tooth.<sup>17</sup>
13. Long term **use of medicaments** such as calcium hydroxide causes changes in the organic matrix of the tooth structure.<sup>18</sup>
14. **Excessive forces** during obturation.<sup>19-21</sup>
15. Use of an **intra- radicular post** following completion of root canal treatment.<sup>22</sup>

### DIAGNOSIS

The most common symptoms associated with symptomatic tooth infractions are pain on chewing, followed by pain on exposure to cold food and in some cases sweets.

### Clinical examinations :-

**Transillumination** - Tooth to be examined should be without restoration, in case of a fracture line in the dentin, the light beam will bend and not pass through the fracture line and the opposite tooth structure will be dark.

**Wedging forces** - Wedging force is used to test for movement of the segments.

**Biting test** - It is performed with the help of burlew wheels, rubber wheels, Tooth Sloothand Fracfinder. Pain is felt after the release of pressure, indication fracture.

**Vitality test** - Symptomatic tooth infraction is generally sensitive to cold tests and EPT with exaggerated response to both of them.

**Percussion sensitivity** - This is not as frequent as biting sensitivity and appears to require periapical tissue involvement.

**Explorer tip** - Thin sharp explorer may be used to probe around the cervical circumference of tooth, a click may be encountered by the explorer suggestive of fracture.

**Periodontal probing** - A deep, isolated narrow periodontal probing depth may be a sign of a long- standing VRF. A narrow and/or flexible periodontal probe is used which is gently ‘walked ’around the entire circumference of the tooth, to ensure that any isolated periodontal pockets are not missed.

**Staining** - The use of stain such as methylene blue is generally done for diagnosing the fracture line.

**Sinus tract** - The presence of a sinus tract associated with VRFs has been reported to occur in many cases.

**Surgical exploration** - In case of VRF , if it is not visible by the above methods, surgical procedures may be used to visualize its presence. It is seen that, buccally directed fracture has a more **oblong type of bone loss** while lingually directed fracture has a bone loss in **U - shaped pattern**.<sup>23</sup>

### Radiographic examinations :-

In cases of tooth infraction, the fracture line runs mesiodistally hence it is not seen on the radiograph while in case of VRF, it is generally in the buccolingual direction, hence it can be seen on periodical radiographs if x rays are taken on multiple angulations. The radiographic features suggestive of longitudinal fracture are -

**J shaped / Halo radiolucency** - Vertical bone defects include the ‘classic ’J- shaped radiographic lesion of a long-standing VRF or a ‘halo ’radiolucency often involving the furcation region.

**Lateral radiolucency** - Root filled teeth restored with cast posts may present with a radiolucency on the lateral root surface, at the base of the post; indicative of a VRF.

Periapical radiographs have several limitations like anatomical noise and geometric distortion. Hence to overcome it , other method of radiographic diagnosis is used

**Ultrasound** - Ultrasound helps in identifying physical discontinuances (cracks) in hard tissues such as enamel and dentin.

**CBCT** - This method applies the use of thin sections of tooth for the exact evaluation of the fracture line and its extent.

**Infrared Thermography** - It helps to detect microcracks by the friction heat generated from ultrasonic vibration.<sup>24</sup>

### CRAZE LINES

These are fracture lines only extending in the enamel. They extend over marginal ridges, buccal and lingual surfaces in posterior teeth, and as long vertical defects in anteriors. As they only affect the enamel, they cause no pain and are of no concern beyond the aesthetic. Occlusal forces, and thermocycling are the most common etiology, while being asymptomatic in nature. They are generally diagnosed by transillumination. Generally no treatment is required, while in cases of esthetic consideration, composite veneers may be placed.<sup>1,25</sup> (Fig 6)



Fig 6 - Craze line

### FRACTURED CUSP

The term fractured cusp is defined as a complete or incomplete fracture initiated from the crown of the tooth and extending subgingivally, usually directed both mesiodistally and buccolingually. Etiological factors mainly include, high masticatory forces, bruxism, thermocycling, fatigue root fracture, large restorations and traumatic injuries. They are symptomatic in nature with pain on chewing which is sharp in nature and immediately stops after once the stimuli is removed, the pain may also radiate to nondental locations. It is seen that lingual cusps are fractured more frequently than buccal cusps in mandibular molars and that buccal cusps fractured more often in maxillary premolars. The diagnosis is based on the typical characteristic of cracked cusps which is sharp pain upon chewing and as the tooth is vital, and its response to a cold stimulus may be normal. In later stages, the fracture line may extend separating the cusp from the remaining tooth, while in cases if the fracture line extends subgingivally, gingival fibers or the periodontal ligament will often retain the fractured cusp. If the remaining tooth structure is supra gingival, dentin and enamel bonding with adhesive resins, along with cuspal protection. In cases of sub gingival extension, the tooth is treated by removing the affected cusp and restoring with a direct or a cuspal-reinforced restoration.<sup>1,25</sup>(Fig 7)



Fig.7 Transillumination of crack

### CRACKED TOOTH

A cracked tooth has an incomplete crack originating coronally and extending cervically. They occur commonly in mandibular molars. The crack is usually centrally located and can cross one or both marginal ridges and may extend into the proximal surfaces. The **etiology** includes- Plunging cusps, use of pins in restoration, repetitive occlusal forces. They generally show- Sharp shooting pain on chewing, sensitivity to cold stimuli and usually seen mesiodistally. For **diagnosis** bite test is the most reliable method. They can also be identified by staining and transillumination, a deep narrow pocket may be seen. Wedging force is used to differentiate a cracked tooth from a fractured cusp or split tooth. No movement of the segment implies a cracked tooth. **Treatment** - A tooth with a minimal crack requires root canal treatment only if the diagnosis indicates a need for it. If presence of the fracture line only in the area of the cavity floor that would include the initiation of an ideal endodontic access opening is helpful in determining the apical extent of the crack and whether the pulp is involved. While if the fracture line lies on the proximal external surface portion of the tooth below the level of the cement-enamel junction it should be removed with a fine tapered bur to prevent excess tooth removal. **Prognosis** - It is questionable, as the long-term prognosis for a cracked tooth is better when no crack is visible or the crack does not extend to the chamber floor and the tooth is rendered pain free by banding or the placement of a temporary crown.<sup>1,25,26</sup>(Fig 8).



Fig 8 - Fractured cusp

## SPLIT TOOTH

The termsplit tooth is defined as a complete fracture initiated from the crown and extending subgingivally, usually directed mesiodistally through both of the marginal ridges and the proximal surfaces. It is the end result of a cracked tooth. **Etiology** -More commonly seen in posterior teeth than anterior teeth due to closeness to the temporomandibular joint. Pain on biting and slight mobility of the broken segment are the most common. **sign and symptoms** seen. **Diagnosis** include - On application of wedging forces, there is complete movement of the broken segment. Removal of restoration is done to check for the extent and prognosis of the split tooth. **Treatment** - If the fracture is severe, the tooth must be extracted but if the fracture is not too apical, then the smaller segment can be removed and the rest of the tooth saved by endodontic treatment followed by prosthodontic rehabilitation.<sup>1,25</sup>(Fig 9).

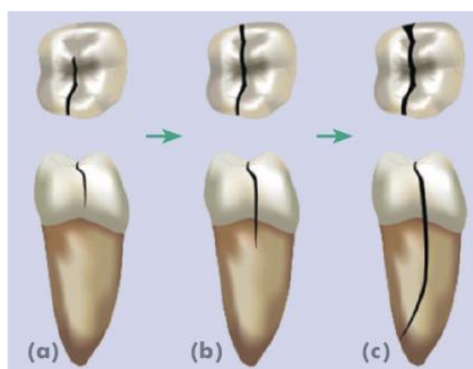


Fig 9 - Pathogenesis of fracture (a) crack initiation, (b) fracture propagation, (c) separation

## VERTICAL ROOT FRACTURE

According to **American Association of Endodontists**,<sup>1</sup> VRF is defined as

“A longitudinally oriented fracture of the root that originates from the apex and propagates to the coronal part”.<sup>27</sup> VRF represent between 2 and 5% of crown/root fractures, with the greatest incidence occurring in endodontically treated teeth. Vertical root fractures are classified into two types based on separation of the fragments

1. Where total separation is visible or fragments can be moved independently. This is defined as **complete fracture**.
2. An **incomplete fracture** is said to occur in the absence of visible separation.<sup>28</sup>

## PATHOGENESIS OF VERTICAL ROOT FRACTURES

VRF begin as cracks, at either the coronal or apical aspect of the root, and progress in apico- coronal or bucco- lingual

planes. There are three main stages for the development of VRFs

1. **Crack initiation** - This is characterized by the development of micro- defects in dentine, which may first develop coronally or apically.
2. **Fracture propagation** - Several biomechanical factors have been proposed to influence the progression of a micro-crack into a fracture, like strain and stress within the residual dentin.
3. **Separation** - In advanced cases of VRF, complete separation of the root occurs due to a continuous ingress of microbes and the formation of a biofilm..

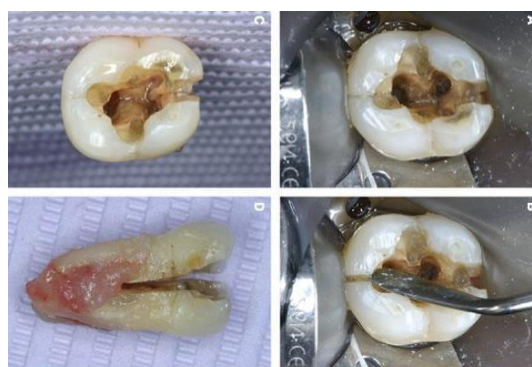


Fig 10 -Split tooth

## Etiology -

- Decreased residual sound tooth structure following endodontic treatment
- Existing cracks in minimally or unrestored vital teeth can ultimately result in pulp infection and necrosis.
- Endodontic treatment can result in depletion of the organic components of root dentine and reduction in free water content with a consequent effect on the viscoelastic properties making the tooth fragile and prone to fracture.
- The presence of isthmi, hourglass- shaped root canal cross- sections, increased root canal curvature and/or a narrow mesio- distal cross- sections have been shown, to be risk factors for VRF due to the natural planes of weakness created within the root hence, mesio- buccal roots of maxillary molar teeth and mesial roots of mandibular molar teeth have a higher incidence of VRF.
- More common in posterior teeth as they are last standing molar, and are subjected to higher functional and non-functional occlusal loading.
- Loss of sound dentine, more specifically the PCD, incurred during ‘traditional’ access cavity and root canal preparation may predispose the residual tooth structure to fracture and impact survival.
- Direct conservative access cavity preparation should be preferred over caries- driven access or restoration driven in order to minimize overall tooth volume loss. Small piece of roof around the entire pulp chamber should be preserved according to **Soffit**.

- The use of root canal irrigants such as sodium hypochlorite, EDTA solution has deleterious biomechanical effects on dentine, reducing the microhardness, elastic modulus and fracture resistance, when high concentrations are used for prolonged periods.
- The prolonged use of calcium hydroxide has been found to adversely affect the biomechanics of dentine by reducing its microhardness, rendering it more brittle and prone to fracture.
- Excessive forces may be imparted on the root during obturation, particularly with the use of large spreaders during lateral condensation technique. Hence a smaller size spreader should be used to limit the amount of force applied.
- Corrosion products of pins and posts also contribute to root fractures.

#### Signs and symptoms -

- Early stage VRFs are a challenge to detect as the patient may present with symptoms or signs of apical periodontitis (AP) such as tenderness to percussion, swelling, tooth mobility, evidence of marginal ridge fractures and/ or pain on biting.
- Sharp cracking sound at the time of condensation of gutta percha or cementation of a post .
- Bleeding during condensation of a root filling material and an apparent lack of resistance within the canal during condensation leading to an almost unlimited ability to condense gutta- percha in to the canal.

**Diagnosis** - To detect a VRF, it is essential to use magnification and illumination.

- The fracture line may be visible along the pulpal floor, extending down beyond the canal entrances and/or involving the isthmi.
- A deep, isolated narrow periodontal probing depth may be a sign of a long- standing VRF, and pathognomonic if detected on both sides of a root which may be located more coronally.
- If it is still not readily visible, exploratory surgical procedures may be necessary to visualize it.
- It include the 'classic 'J'- shaped radiographic lesion or a 'halo 'radiolucency may be seen.
- Root filled teeth restored with cast posts may present with a radiolucency on the lateral root surface.
- Periapical radiographs have several well- established limitations in the detection of radiographic signs of endodontic disease, for example, anatomical noise and geometric distortion.

**Differential diagnosis** - VRF should be distinguished from other entities that are associated with local periodontal symptoms: endo-perio lesion , external or cervical

resorption, iatrogenic perforation, longitudinal fracture, palatal groove or lateral canals.<sup>29</sup>

#### Treatment -

- In the majority of VRF cases, extraction of the tooth is the most predictable treatment of choice.
- In case of incomplete root fracture, novel technique may be applied for the restoration of the fractured segment and retaining the tooth. The use of adhesive resins and/or cements, glass- ionomer and bioactive restorative materials such as Biodentine is done in these cases.
- It can either be done by removing the tooth and then reimplanting post restoration or by raising the surgical flap and restoring the tooth.
- In case of complete tooth fracture, treatments such as root amputation of the fractured root, or hemisection, may be appropriate as an alternative treatment option to extraction, permitting retention of the tooth.
- **CO<sub>2</sub> and Nd:YAG lasers** have been used for the treatment of vertical root fractures but lasers do not have capability to fuse the fractured roots. This is because it is not possible to predict the thermal changes in the target tissue.<sup>1,24,25</sup>



Fig 11 - Vertical root fracture with classical radiolucency

#### PREVENTION

A range of measures can be taken during endodontic treatment to reduce the likelihood of a longitudinal fracture-

- 1) Presence of any parafunctional habits (e.g., bruxism). If it is present, patient education, as well as the fabrication of an occlusal splint and/or re-establishment of canine guidance.
- 2) Deflective contacts and excursive interferences may lead to excessive lateral forces on the implicated teeth, hence it is desirable to consider the replacement of missing posterior units, to increase the number of occlusal contacts and distribute occlusal and non-occlusal loading.

- 3) Preservation of pericervical dentine during endodontic treatment.
- 4) Cuspal coverage should be done as early as possible .24

## CONCLUSION

Root fractures are uncommon lesions accounting for 0.5–7% of traumas that occur in the permanent dentition. They involve the tooth's supportive tissue, dental pulp and mineralized structures. By carefully continuing the patient's history and symptoms as well as radiographic and clinical findings, it will often be possible to verify the presence of a fracture and adopt a treatment plan. Continuous follow up of the patients' oral hygiene and radiographic controls for the detection of early signs of any pathology are required in all of the trauma cases. The diagnosis and management of fractured roots will affect the total treatment of a patient and hence the quality of life.

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