

IN THE NAME OF GOD

# Vertical root fracture

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# Definition

- A vertical root fracture is defined in the AAE Glossary of Endodontic Terms as a longitudinal fracture “in the root whereby the fractured segments are incompletely separated; it may occur buccal-lingually or mesial-distally; it may cause an isolated periodontal defect(s) or sinus tract; it may be radiographically evident”.

# Patient history

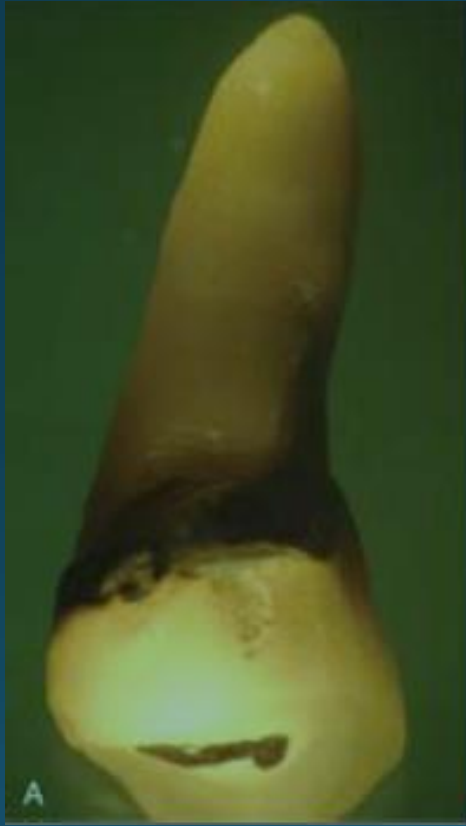
- Sensitivity and discomfort while chewing are also common complaints.
- Swelling may occasionally occur in the area.
- There is often a long history of failing to diagnose the cause of the spontaneous and dull pain and discomfort.
- Often retreatment or surgical retreatment may have been attempted to reveal the accurate diagnosis. Unfortunately, such ineffective treatment attempts may only worsen the dentist-patient relationship

# Clinical manifestations

Susceptible teeth and vertical root fracture location.

- VRFs are commonly associated with endodontically treated teeth with or without a post.
- Nevertheless, VRFs can also occur in teeth with no previous root canal treatment.
- **The most susceptible sites and tooth groups are :**
  - maxillary and mandibular premolars,
  - mesial roots of the mandibular molars,
  - mesio-buccal roots of the maxillary molars,
  - and mandibular incisors
- However, VRFs may occasionally occur in other teeth and roots as well.

- VRFs may progress in the bucco-lingual direction in these teeth and roots, which are typically narrow mesiodistally and wide buccolingually.
- But may affect the mesial or distal aspect of the root
- VRFs may be initiated at any root level.
- They may also be initiated at the apical part of the root and propagate coronally .
- Some VRFs originate at the coronal-cervical part of the root and extend apically
- and in other cases a VRF may be initiated as a midroot fracture



# Early manifestation.

- In the early stages of a VRF, there may be pain or discomfort on the affected side of the tooth. In particular, the tooth may feel uncomfortable and sensitive upon chewing, although this pain is often of a dull nature, as opposed to the sharp pain typical of a cracked cusp or tooth with a vital pulp.
- As the fracture and subsequent infection progresses, swelling often occurs, and a sinus tract may be present.

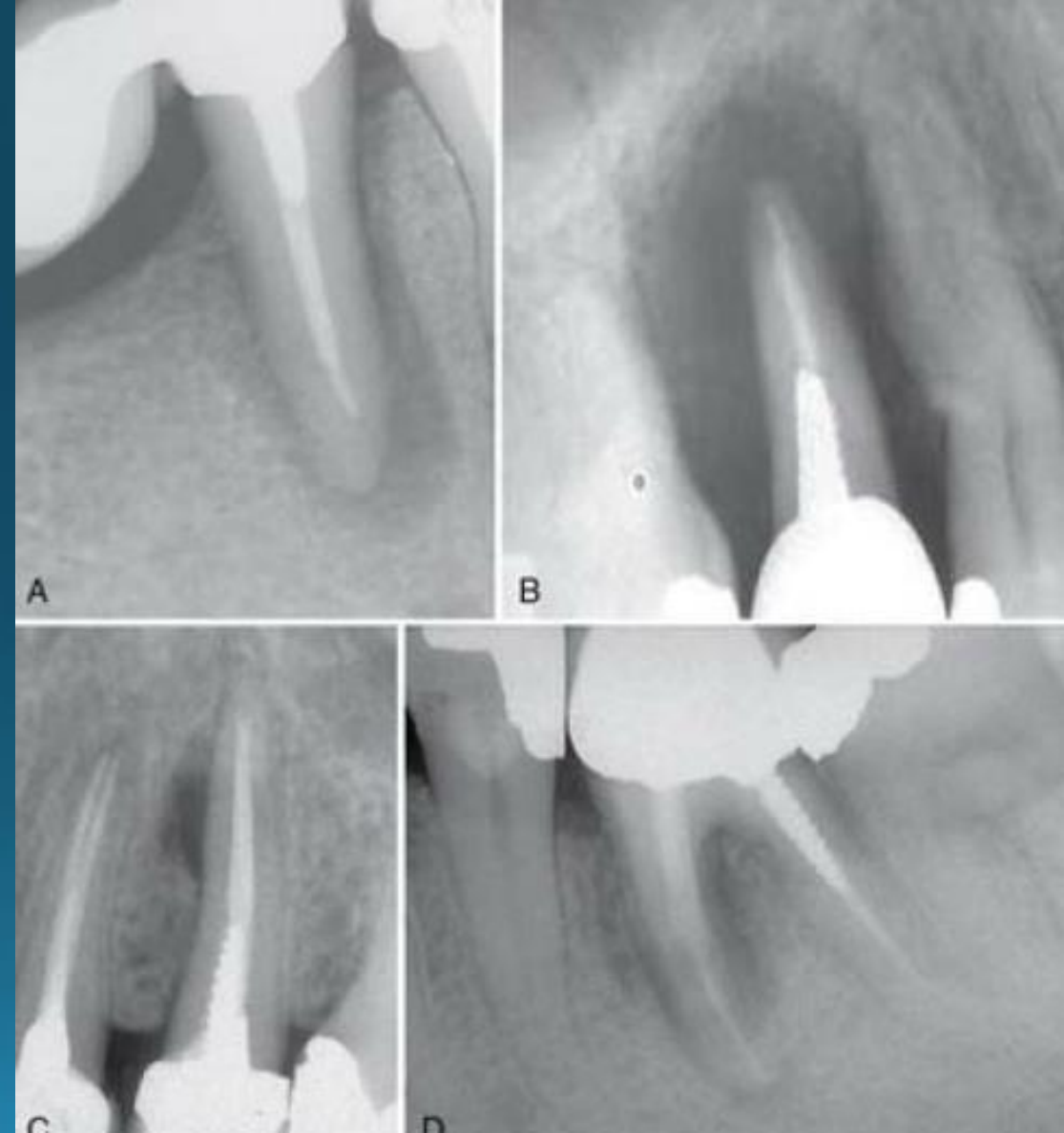
- Noteworthy is that the location of a sinus tract associated with a VRF is **more coronal** than a sinus tract that is typically associated with a case of a chronic apical abscess.
- These signs and symptoms are frequently similar to those encountered from nonhealing root canal treatment.
- In the early stages, radiographic findings are unlikely because (1) the root canal filling may obstruct the detection of the fracture and (2) the bone destruction (which still has limited mesiodistal dimensions) may be obstructed by the superimposed root structure

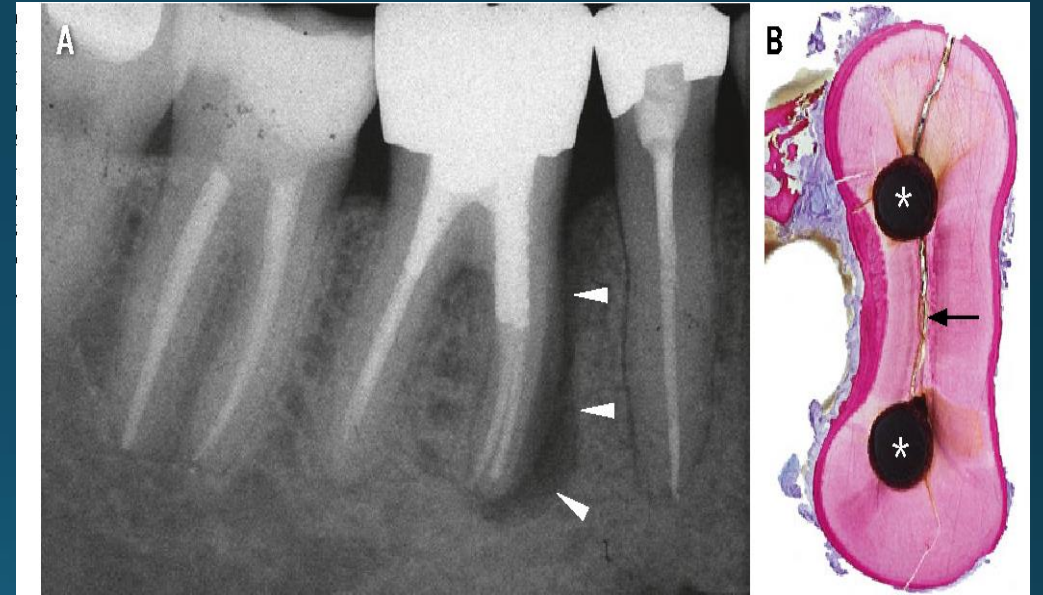




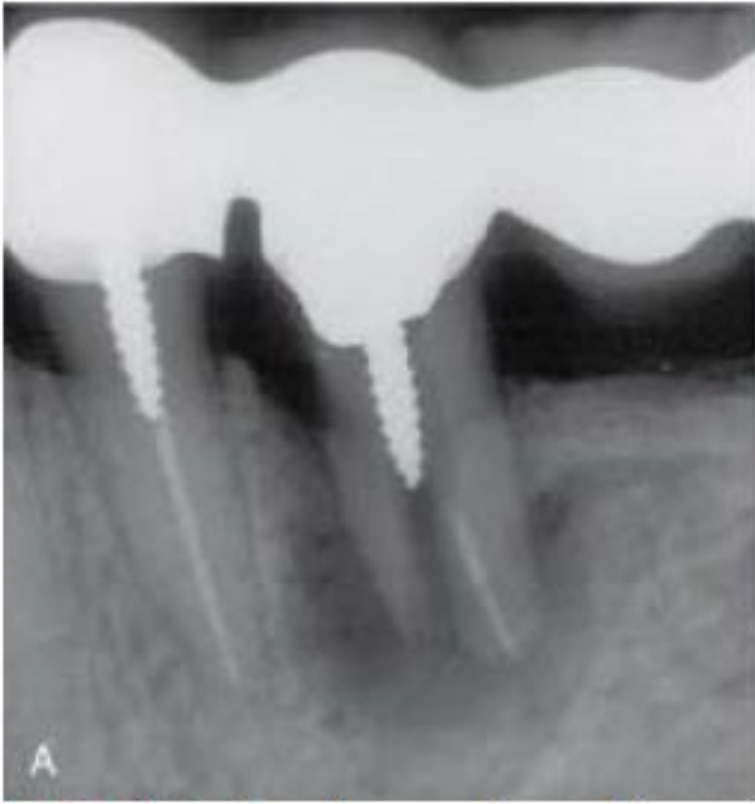
- Often in a case of a VRF, there is the presence of a deep, narrow, and isolated periodontal pocket.
- This presentation may be inconsistent with the surrounding periodontal status.
- This specific type of periodontal defect occurs secondary to the bony dehiscence caused by the VRF and is substantially different in its presentation from the pockets caused by advanced periodontitis.

- A longstanding VRF is easier to detect.
- One of the most typical radiographic signs is a J-shaped or halo radiolucency, which is a confluence of periapical and periradicular bone loss (i.e., bone loss apically combining with the bone loss on the side of the root, extending coronally)





- In addition, the pocket now approximating the fracture, which was initially tight and narrow, may become wider and easier to detect.
- In longstanding cases in which the bone destruction is extensive, the VRF may result in a split root whereby the segments of the root separate, resulting in radiographic evidence clearly revealing an objective split root



# Diagnosis

## Importance of early diagnosis

- Accurate and timely diagnosis is crucial in VRF cases, allowing the
- extraction of the tooth or root before extensive damage to the alveolar bone occurs.
- Early diagnosis is particularly important when implants are a potential part of the future restorative process; when an extraction is performed at an early stage, the uncomplicated placement of an implant is more likely.
- When the tooth is extracted after extensive damage has already occurred, bone regeneration procedures may be required, adding additional cost and time to the restoration process.

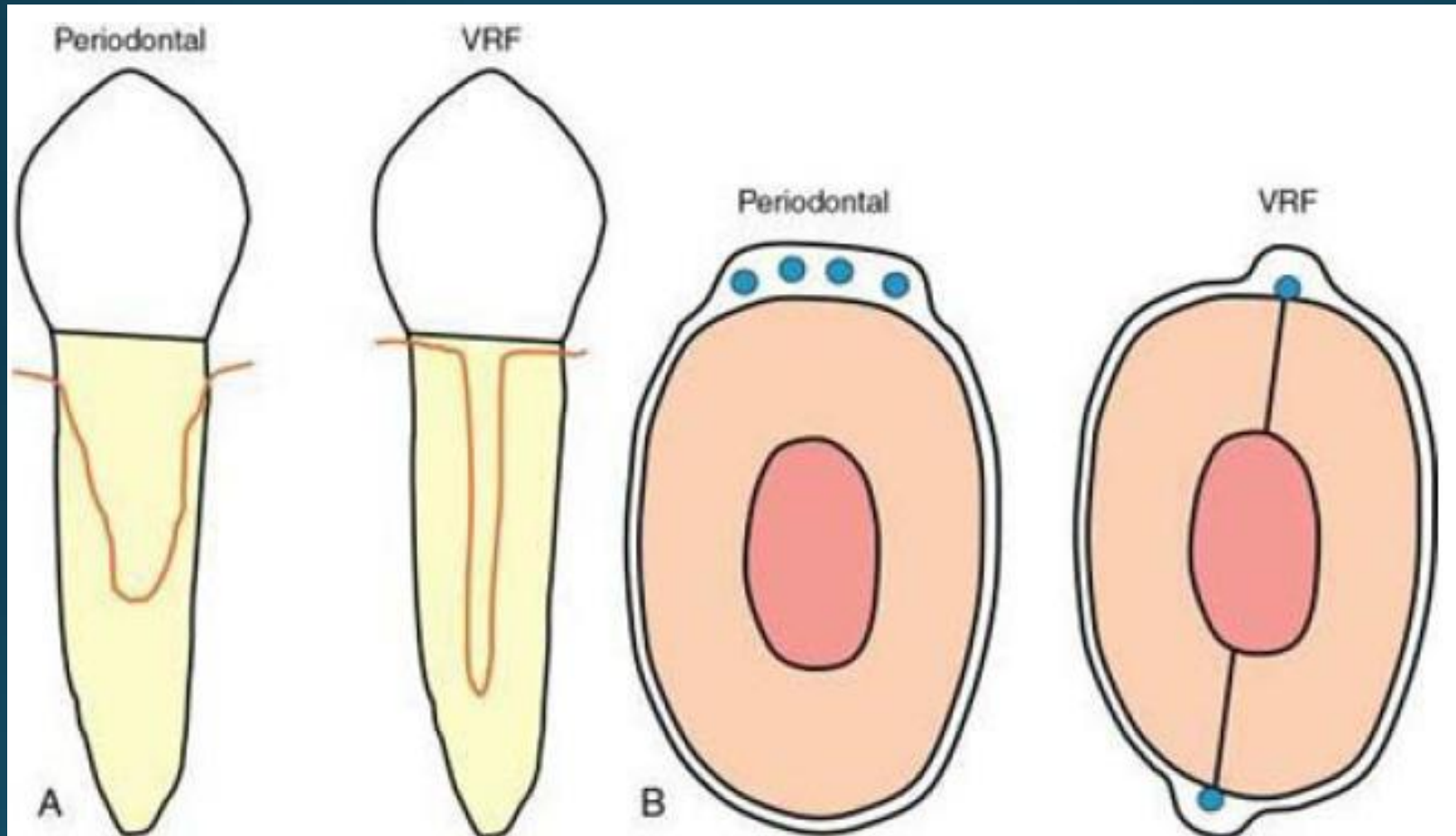


- The American Association of Endodontists stated in 2008 that a **sinus tract** and a **narrow, isolated periodontal probing defect** associated with a tooth that has undergone a root canal treatment, with or without post placement, can be considered pathognomonic for the presence of a VRF.
- However, the combination of the following two factors makes the early diagnosis difficult:
- (1) many of the clinical symptoms associated with VRFs mimic apical periodontitis or periodontal disease,
- (2) the narrow and tight pocket associated with early stages of VRF is difficult to detect using rigid probes, especially when the pocket is interproximal.
- Consequently, a delay in the accurate diagnosis or a misdiagnosis of a VRF may often occur



# Vertical root fracture pockets.

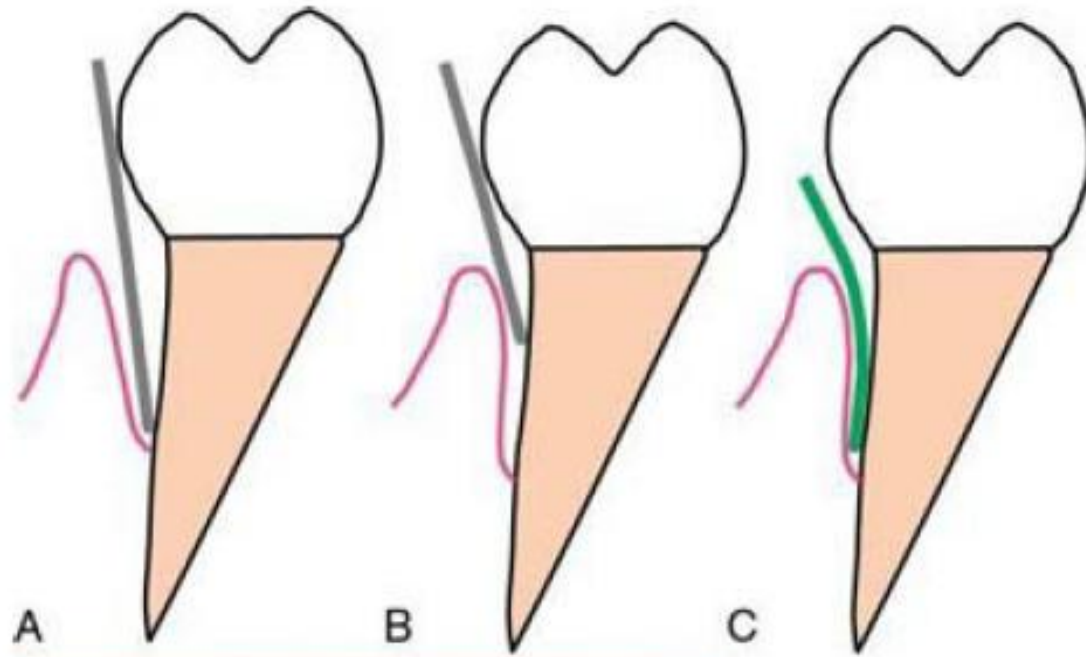
- The pockets that are typical of the early stages of VRFs differ substantially from the deep pockets associated with advanced periodontal disease.
- The deep pockets associated with periodontal disease develop as a result of the bacterial biofilm that initially accumulates at the cervical areas of the tooth and the destructive host response to these bacteria.
- deep periodontal pockets are typically wider coronally and easier to probe.
- This pocket (periodontal disease) often affects groups of teeth rather than an isolated location of a single tooth.



- The pockets associated with VRFs develop due to bacterial penetration into the fracture, triggering a destructive host response that occurs in the periodontal ligament along the entire length of the fracture.
- These bacteria may leak from an infected root canal or from the oral cavity.
- The pocket associated with a VRF is typically isolated and present only in a limited area adjacent to the affected tooth.
- This pocket is often located at the buccal or lingual convexity of the tooth.

- Because the pocket is narrow, probe insertion may result in the blanching of the surrounding tissue.
- This is specially the case when a more flexible plastic probe is used, as its coronal part is thicker than an equivalent
- metal probe
- This difference has been widely recognized, and terms such as osseous defect and probing defect or VRF pocket have been used to emphasize the point.
- Tamse et al. reported the presence of a typical VRF pocket in 67% of the VRF cases reported.





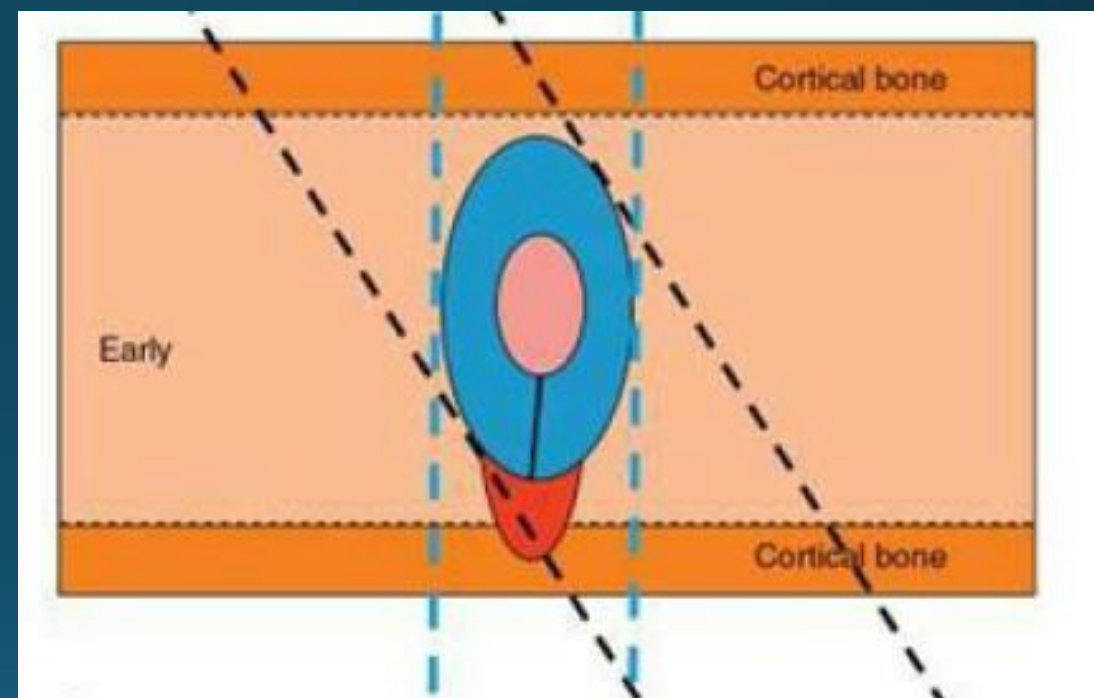
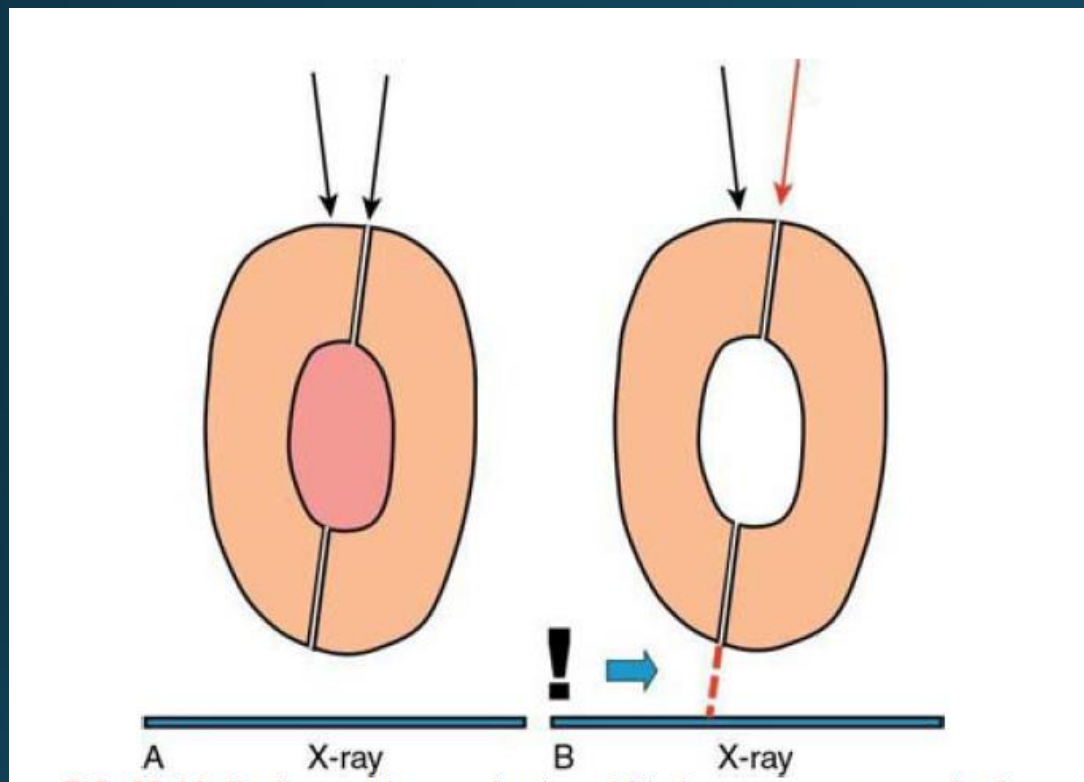
# Coronally located sinus tract.

- Sinus tracts that originate from a chronic apical abscess are typically detected at the site of least bone resistance, against the apical part of the root or in the area of the junction of the attached gingiva and the oral mucosa.
- Sinus tracts that are associated with a VRF pocket are often found in a more coronal position, as the source is not from a periapical lesion
- In four clinical retrospective case series, coronally located sinus tracts were found in 13% to 35% of these cases.
- As in the case of a VRF pocket, if the sinus tract is located at the furcation of a molar, this observation does not necessarily indicate a VRF, as periapical abscesses from re-infected root canal treatment can also drain in this coronal location

# Radiographic features.

- A definitive VRF diagnosis can sometimes be made based on the radiographic appearance of a thin radiolucent line extending longitudinally down the root.
- Such lines, however, are difficult to detect and are commonly not seen in routine periapical radiographs because either the root canal filling has “masked” the fracture line or the angulation of the x-ray beam is not optimal for discerning the fracture





- Rud and Omnell claimed that it was possible to observe fracture lines in 35.7% of cases, but many of these cases were not true VRF instances.
- Such an observation requires the x-ray beam to align with the plane of the fracture as well as the fracture line not being superimposed over the radiopaque root filling.
- Therefore, two or three periapical radiographs should be exposed from different horizontal angulations when a fracture is suspected.
- In most VRF cases, the clinician must make subjective interpretations or predictions based on the various patterns of periradicular bone destruction which, unfortunately, are also shared by other periodontal and endodontic-like lesions.

- In the early stages of a VRF, no radiolucent bone lesions may be observed which may be the reason why VRFs often remain undetected, delaying diagnosis and treatment.
- The significance of time was confirmed by Meister et al., who demonstrated that immediate radiographic detection is difficult due to the time required for bone resorption to occur or for the fractured segments to separate and be radiographically visible

- In a study of the patterns of bone resorption in 110 VRF cases, Lustig et al found that in 72% of patients with either chronic signs and symptoms (i.e., pertaining to a sinus tract, osseous defect, or mobility) or acute exacerbations, there was greater bone loss recorded compared to patients for whom a VRF diagnosis was made at an early stage.
- Despite the difficulty of diagnosing early stage VRFs in endodontically treated teeth, there are often several radiographic signs associated with later stages that are strong indicators of VRF.

- The J-shaped or halo radiographic appearance of bone loss, a combination of periapical and periradicular radiolucencies, was associated with a high probability of a VRF in a double-blind radiographic study involving 102 endodontically treated maxillary premolars .
- An angular resorption of the crestal bone along the root on one or both sides, without the involvement of the periapical area, mimicking a “periodontal radiolucency” was found in 14% of the cases.
- Tamse et al.<sup>84</sup> also reported the radiographic appearance of “halo” and “periodontal” radiolucencies in vertically fractured mesial roots of mandibular molars (37% and 29%, respectively).
- In that study, the use of these two variables, combined with bifurcation involvement (63%) and the presence of an amalgam dowel (67%), predicted fracture in 78% of the cases.

- The type of periradicular radiolucency associated with a VRF is not and should not be interpreted as a thickening of the PDL.
- Instead, it represents a substantial destruction of the cortical plate of the alveolar bone .
- In the case of a VRF in the bucco-lingual plane, often the bone resorption is limited at early stages, and any associated radiolucency may be obscured by the superimposition of the root .
- As the bone loss increases, the radiolucency becomes greater than the dimensions of the root, allowing it to be detected more clearly in the previously mentioned manner
- .

# Radiograph of empty canal

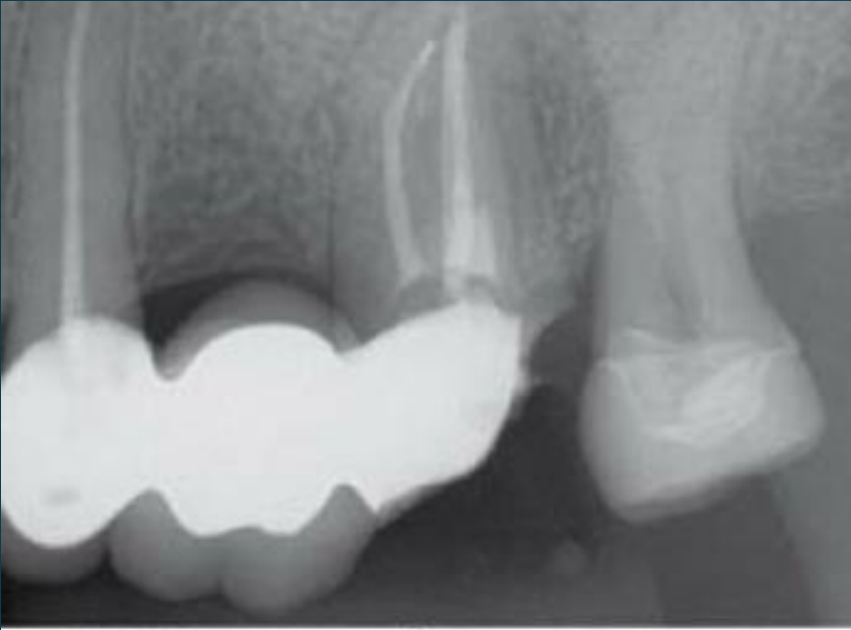
- As mentioned previously, the direct clinical detection of an early stage VRF from a periapical radiograph is unlikely, especially when there has been endodontic treatment. Because most VRFs are in the bucco-lingual plane, the radiopaque obturation often obstructs the view of the hairline radiolucency of the fracture .
- When a VRF is suspected, one may initiate root canal retreatment, removing the root obturation, and exposing radiographs at two or three different horizontal angulations.
- The detection of a hairline radiolucency may provide a more definitive diagnosis of a VRF .

# Cone-beam computed tomography in vertical root fracture diagnosis

- One of the unique features of CBCT is its ability to study the suspected tooth and associated bone in an axial plane (i.e., the horizontal sectioning of the root).
- Axial views may provide detailed information regarding the cross sectional appearance of the tooth and its surrounding bone.
- Considering the resolution of the current CBCT devices, the width of an unseparated fracture may be too small to be detectable.
- Therefore, given that the smallest voxel size currently available for a CBCT device is about 0.075 mm, CBCT imaging would not be able to visualize a root fracture unless the fracture width was greater than 0.15 mm.
- It should also be noted that the intracanal presence of gutta-percha or a metal post often causes artifacts that make it extremely difficult to discern a VRF







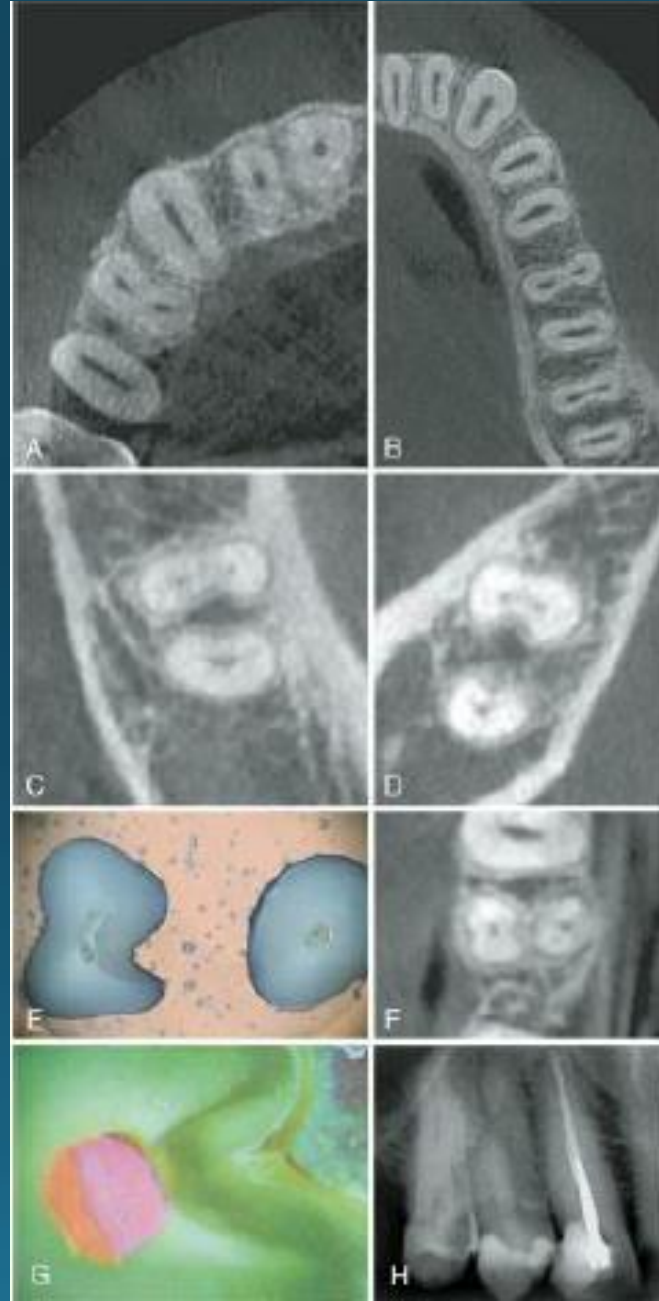
# Exploratory surgery.

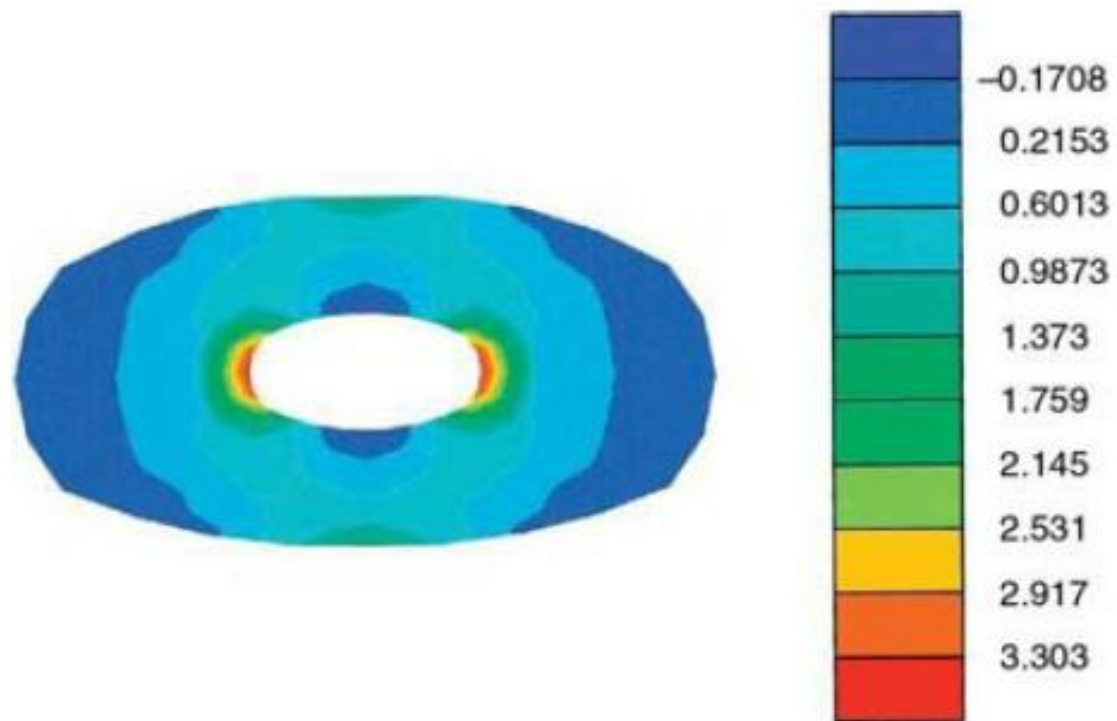
- When clinical and radiographic evaluations are equivocal in detecting a suspected VRF, exploratory surgery may be indicated.
- In the presence of a bony lesion, especially a bony dehiscence, the raising of a full-thickness flap and removal of the granulation tissue may help to facilitate the visualization of a VRF .
- The bone resorption pattern associated with a VRF is most often seen as a bony dehiscence, with the greater bone destruction being present on the buccal cortical plate located over the offending root.
- In a small percentage of the cases, a fenestration can be seen.
- Furthermore, it has been shown that the longer a VRF-related infection persists, the greater the resulting periradicular bone destruction



# Etiology

- Natural predisposing factors
- Shape of root cross section: One of the common anatomic features shared by teeth that typically develop VRFs is an oval cross section of the root, with a bucco-lingual diameter being larger than the mesiodistal diameter.
- These teeth include the maxillary and mandibular premolars, the mesial roots of the mandibular molars, and the mandibular incisors.







- Occlusal factors.
- Excessive occlusal loads or concentration of such loads may be another natural predisposing factor for VRFs.
- Load concentrations, such as those caused by occlusal prematurities in maxillary premolars, and excessive occlusal forces, specifically in the case of mandibular second molars, are good illustrations.
- In combination with other natural and iatrogenic predisposing factors, excessive occlusal loads may, over time, lead to VRFs



- Preexisting microcracks.
- Preexisting microcracks may be present in the radicular dentin, likely resulting from repeated forces of mastication or occlusal parafunction.
- Such fractures were also recently reported by Barreto et al.who found these microcracks present in 40% of intact maxillary incisors and canines.

# Iatrogenic predisposing factors

- Root canal treatment
  - VRFs mostly appear in endodontically treated teeth therefore, endodontic treatment may be considered an iatrogenic predisposing factor.
  - Teeth were once thought to be more susceptible to fracturing after endodontic treatment because of a decrease in hydration.
  - compromised by endodontic treatment, the radicular dentin, as a structure, may be compromised by the accumulative or combined effect of several natural or iatrogenic factors associated with the endodontic treatment and the restoration of endodontically treated teeth.

- Excessive root canal preparation.
- Excessive root canal preparation may be a predisposing factor for VRF development.
- In one study, cracks detected by transillumination were more frequent when the same teeth were subjected to a gradually increasing endodontic canal preparation.
- To reduce the risk of VRFs, less invasive methods may be considered, such as minimally invasive endodontic instrumentation

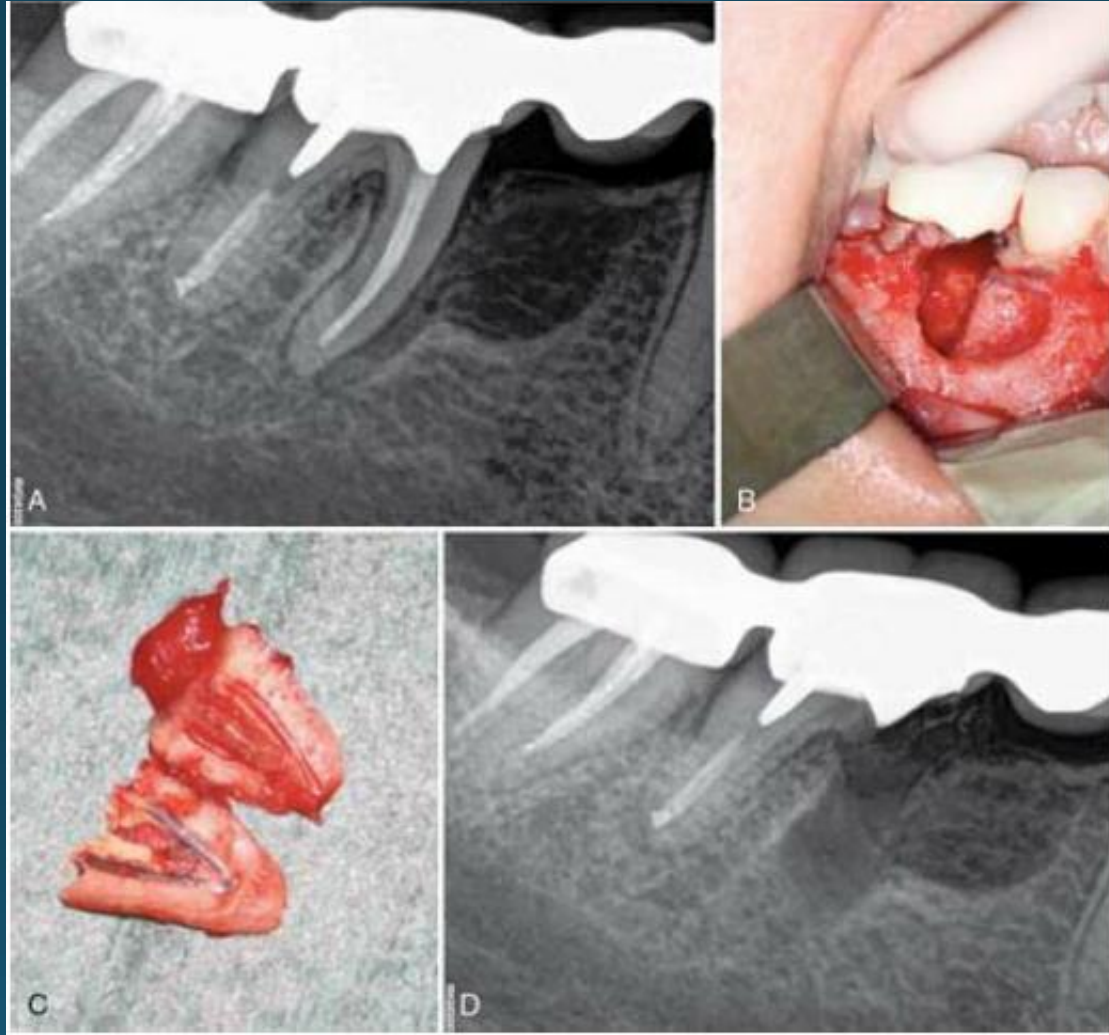
- **Microcracks caused by rotary instrumentation.**
- Shemesh et al. and others observed that root canal preparation using nickel-titanium rotary and reciprocating files often results in microcracks in the remaining radicular dentin .
- This finding, which was originally noted for single rooted teeth, has been further supported by Yoldas et al., who studied microcrack formation from rotary files in the mesial roots of mandibular molars.
- Each of the rotary file systems examined in this study caused frequent microcracks in the dentin, whereas both hand instrumentation with files and the self-adjusting file did not cause such cracks.



- Uneven thickness of remaining dentin
- Methods of obturation
- Type of spreader used
- Post design.

# Treatment planning

- When a VRF is determined to be present, extraction of the affected tooth or root is recommended as soon as possible.
- Any delay may increase the potential for additional periradicular bone loss and potentially compromise the placement of an endosseous implant.
- Attempts to “repair” a fracture by filling the crevice with a variety of restorative materials have been reported; however, none of these repairs is considered a reliable long-term solution.





- The End

