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Quality Resource Guide

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Diagnosing and Managing the Cracked Tooth Part 2: Vertical Root Fractures

Educational Objectives

Following this unit of instruction, the practitioner should be able to:

1. Differentiate vertical root fractures from other dental fractures.
2. Recognize the usual symptoms of vertical root fractures.
3. Describe methods for diagnosing vertical root fractures.
4. Recognize the risk factors associated with vertical root fractures.
5. Describe treatment options for vertical root fractures.
6. Evaluate the prognoses for vertical root fractures.

Introduction

Dental fractures have been categorized into: (1) crown-originating fractures (COF); (2) vertical root fractures (VRF), and; (3) trauma-related fractures.[1] The first category was described in Part 1 of this two-part Quality Resource Guide (QRG) series (*Diagnosing and Managing the Cracked Tooth Part 1: Crown-Originating Fractures* 1st Ed 2017). The focus of this QRG is vertical root fractures (VRF).

Differentiating between teeth with COF and VRF is an essential clinical task when making a clinical diagnosis. The type and the origin of the fracture dictate different treatment options and prognosis. These two types of fractures differ in etiology, origin, locations in the tooth, and directions of fracture propagation (Table 1). Because of the differences, diagnosis and treatment options are different for each category, as is the prognosis.

A VRF is often not diagnosed early since symptoms frequently are lacking or mild in nature. This complicates the management of teeth with VRF. In addition, the clinical presentation can be confused with other dental conditions and lead to misdiagnosis. The goal of this QRG is to describe clinical and radiographic aspects of VRF and discuss management of these dental problems.

Description of VRF

Vertical root fractures occur most commonly in restored endodontically treated teeth (Figure 1).[2] They typically originate at the root apex and progress toward the crown. Additionally, vertical root fractures can occur in the mid-root region at the terminus of posts.[3] Although these fractures often are asymptomatic initially, they allow ingress of bacteria into the fracture lines leading to bone resorption and periodontal pocket developments.

Figure 1

A vertical root fracture (VRF) in the mesial abutment tooth of a 3-unit fixed bridge - apical origin of the fracture is evident.

FIRST EDITION

Author Acknowledgements

Leif K. Bakland, DDS
Emeritus Professor

Tory Silvestrin, DDS
Assistant Professor

Loma Linda University, School of Dentistry
Loma Linda, California

Drs. Bakland and Silvestrin have no relevant relationships to disclose.

The following commentary highlights fundamental and commonly accepted practices on the subject matter. The information is intended as a general overview and is for educational purposes only. This information does not constitute legal advice, which can only be provided by an attorney.

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Table 1

Differences Between COF And VRF

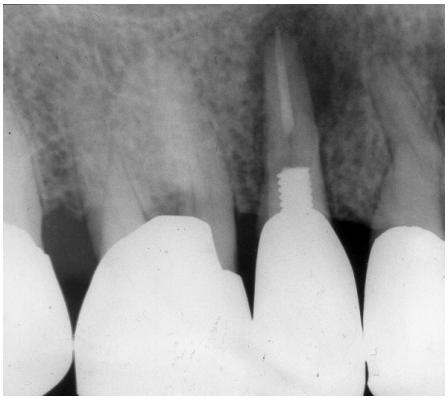
	Crown-Originating Fractures (COF)	Vertical Root Fractures (VRF)
Origin	Fractures originate in the tooth crown - Usually run in a mesio-distal direction	Fractures usually originate at root apex - Often run in bucco-lingual direction
Symptoms	Variety of symptoms from absent to severe - Lancinating pain	Usually mild and often described as soreness
Radiographic Appearance	Not observable unless x-ray beam runs parallel to fracture line	Not observable unless x-ray beam runs parallel fracture line, but PDL and alveolar bone may show changes
Prognosis	If diagnosed early and managed properly, teeth with COF can survive for many years	Prognosis is generally poor except in teeth where root amputation may be completed

Excessive condensation forces during obturation of root canals and extensive post space preparations (Figure 2) may weaken a tooth and predispose it to a VRF.[4,5] The etiology of VRF appears to be unrelated to thermal cycling that causes flexure of dentin, but weakening of the dentinal walls from the root canal preparation has been suggested as a contributing factor for VRF.[2,6,7] The beginning of the fracture is in the dentin near the pulp and extends to the external root surface.[8] In contrast to crown-originating fractures (COFs) which usually develop in a mesio-distal direction, VRF typically occur in a bucco-lingual direction.[5] There is a low reported prevalence of teeth with VRF (2-5%), but when found, the management of such teeth is usually extraction or possibly root amputation in multirooted teeth.[9,10,11] Tamse et al.[12] found 10-20% of extracted teeth had VRF.

The clinical presentation of VRF may occur some period of time after the initiation of the fracture. The undetected fracture allows ingrowth of bacteria resulting in bony and soft tissue pathosis that often manifest as a periodontal pocket (Figure 3).

Vertical root fractures usually start in the apical region of a root, where endodontic files may have created micro fractures during canal preparation (Figure 4);[13,14] however, they may also start in the coronal and middle portions of the root.[3] It is not known how extensive a fracture needs to be to create symptoms. Teeth most susceptible to VRF are those with narrow mesio-distal diameters relative to wider bucco-lingual diameters. This root configuration is found in teeth with oval, ribbon shaped and kidney shaped roots (mandibular anterior teeth, maxillary and mandibular premolars, mesial roots of mandibular molars and buccal roots of maxillary molars).[9]

Figure 2

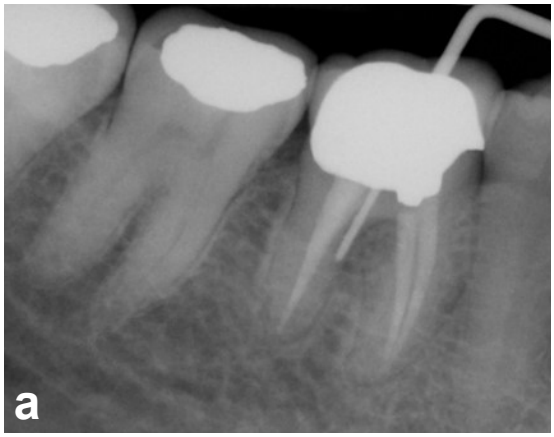


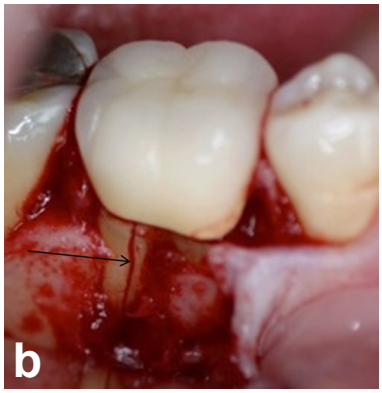
The excessively large post preparation in tooth #4, along with the type of post used, contributed to the fracturing of the root - the radiographic lesion draping around the root is characteristic of a VRF.

Figure 4

Vertical root fractures typically originate in the apical area and progress coronally.

Figure 3





(a) An apparent periodontal pocket in the furcation area was caused by a VRF (arrow) - clinically shown in **(b)** - fracture appears to originate in the cervical region of the root.

Symptoms

A vertical root fracture allows fluid and bacterial ingress, leading to inflammation and surrounding bone loss. A tooth with a VRF often creates varying degrees of biting discomfort, swelling, tenderness to percussion and palpation, and purulent drainage through the sulcus or a gingival sinus tract.[4] Other symptoms that are associated with VRFs include deep periodontal probing defects, periodontal-type abscess formation, periapical radiolucencies, and tooth mobility. Symptoms of a VRF are variable from patient to patient, and tooth to tooth. Often the signs and symptoms are difficult to interpret and may overlap with many other dental conditions. VRF signs and symptoms are often similar to those of periodontal disease and/or failed endodontic treatment. It should be noted that the degree of pain experienced by patients with VRF is often remarkably mild, resulting in a delay in seeking treatment that can lead to extensive bone loss (Figure 5).

Diagnosis

Detection of VRF usually begins with the patient reporting symptoms such as: pain (which is generally described as "soreness"); soft tissue swelling; or presence of a sinus tract. A VRF may also be detected incidentally by observation of radiographic changes of the lamina dura and periodontal ligament space around the root and its apex. A combination of a sinus tract located near the free gingival margin, combined with a deep and narrow periodontal pocket, is an indicator of a possible VRF. Clinical examination can be aided by the use of stains and transillumination. Staining the canal space with a dye such as methylene blue allows the dye to preferentially flow into the fracture line where it may be visualized, especially with magnification. Transillumination directed into an endodontic access cavity and down the root canal may allow visualization of a root fracture.[4,15]

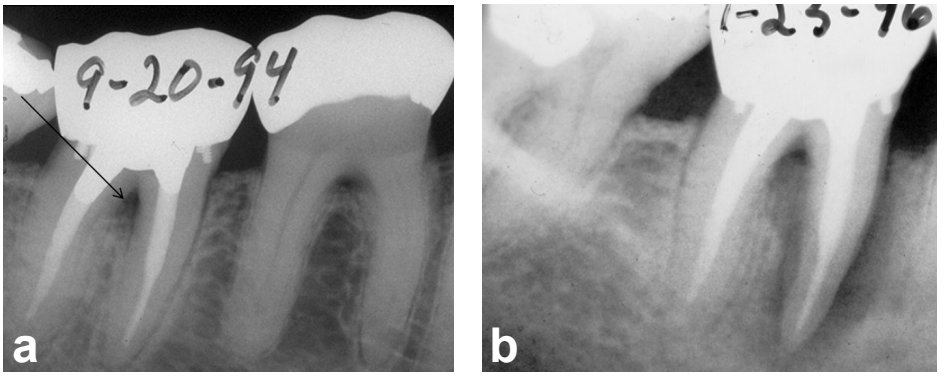
Time needed for development of a VRF is uncertain.[16] It may be years after endodontic treatment, restoration of the tooth, or post placement before evidence of a fracture is clinically detected. Although there are certain findings that are indicative of VRF (dual bucco-lingual sinus tracts, "J" shaped radiolucencies periapically and along the root surface (Figure 6), and narrow deep periodontal pockets, no one finding is singularly definitive of VRF. The periodontal pockets that form are typically not as narrow as those associated with a COF and can usually be probed without using an anesthetic (Figure 7).[17]

Visual evidence of the fracture is the only way to establish a definitive diagnosis of VRF. This may be accomplished by re-opening the original access cavity for internal examination, or externally by raising a tissue flap (see Figure 3b). A review on the diagnosis of VRF concluded that there is no effective non-invasive clinical technique or radiographic markers for a definitive diagnosis of VRF.[18]

The difficulty in diagnosing VRF is due to several factors. For most dental problems, dentists rely on radiographic imaging; a VRF will go undetected radiographically, unless the x-ray beam runs parallel to the fracture line. Despite not being able to routinely visualize a VRF radiographically, the alveolar bone appearance around a tooth may provide clues of a VRF. A loss of crestal bone continuity and/or a loss of a cortical plate may indicate an apically progressing VRF that originated in the crown.[19]

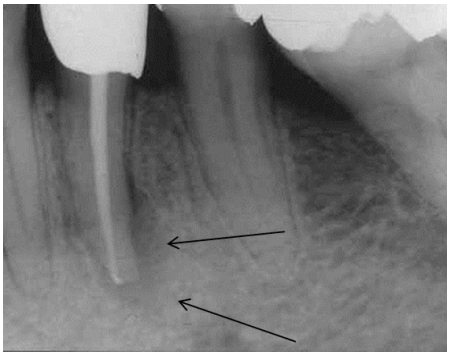
Cone beam computed tomography (CBCT) has been used to locate and diagnose a VRF.[20] Some studies, however, question the sensitivity and specificity of CBCT used for this purpose.[21,22,23] Radiopacities within a field can create scatter and artifacts, lowering the diagnostic ability of CBCT to locate and definitively diagnose a fracture. Since a VRF most commonly occurs in endodontically treated teeth and may be associated with a metal post in the root, CBCT scans are

Figure 5



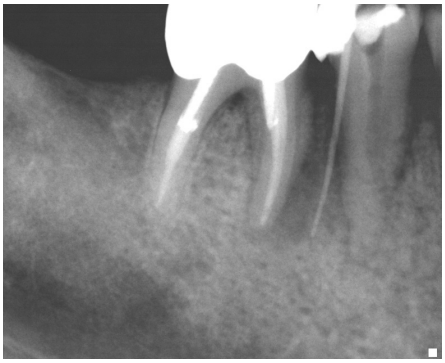
(a) Five years following root canal treatment of tooth #31, a lesion (arrow) was noted in the furcation - the patient had minimal symptoms and preferred to postpone any corrective treatment - **(b)** two years later a large bony lesion surrounded the mesial root, yet the patient had noticed only minor soreness in the region.

Figure 6



VRF produces an apical lesion that radiographically appears to drape around the root in a "J" shaped configuration (arrows).

Figure 7



Tooth #30 has a VRF in the mesial root that has resulted in a periodontal pocket that can easily be probed to the apical area without discomfort to the patient (a gutta-percha point is used for radiographic purposes).

not as useful for their assessment as one might anticipate. Endodontically treated teeth also have radiopaque cores, and many have radiopaque crowns, all of which add further scatter to the image.

Misdiagnosis of teeth with VRF can complicate or delay eventual definitive treatment. Because of overlapping signs and symptoms of a VRF with other dental conditions, a careful and methodical approach to diagnosis must be used to reduce errors. Early identification of a VRF has many benefits, including preservation of alveolar bone, which is important for any subsequent prosthetic replacement of the fractured tooth.[19]

Treatment Options

Treatment for a tooth with a VRF is usually extraction, or possibly root(s) amputation in some selected multirooted cases. Outcomes following root amputation, especially in mandibular molars, have been shown to be uncertain.[24,25] However, Langer[26] following his original report,[24] and noted that, in contrast to mandibular molars, resection of a single root in a maxillary molar resulted in a rather good long term prognosis. Many clinicians have confirmed that observation. Retaining a maxillary molar for as long as possible - absent risk of continuing bone loss – appears to be a prudent treatment recommendation.[27]

Prior to the introduction of dental implants, the primary aim of VRF management was to repair the fracture, or replace the tooth with a fixed or removable prosthesis.[28] Current treatment options that may be considered include the following:

- **Bonding the vertical fracture extraorally followed by replantation of the tooth[29]**
  The prognosis of teeth treated by bonding of the VRF segments has been shown to initially have a high success rate (88.5% at 12 months) but it progressively drops over time (59% at 60 months).[30] A recent prospective case series of re-bonded teeth with VRFs, placing Mineral Trioxide Aggregate (MTA) into the fractures, noted clinical and radiographic success at 12 months.[31]
- **Root amputation**
  Root amputation or hemisection in mandibular teeth with VRF have not been favorably reported in the literature,[24,25] but clinical experience has demonstrated some positive outcomes in maxillary multirooted molars (Figure 8).
- **Autotransplantation of teeth[32]**
  Donor teeth for this procedure would ideally be nonfunctioning teeth located elsewhere in the mouth. Donor teeth must have adequate periodontal ligament support and root forms that either fit to the recipient site or the socket can be modified to receive the donor teeth (Figure 9).
- **Extraction and replacement with fixed/removable prosthesis or implant**
  Extraction of a tooth with a VRF often leaves a defect in the alveolar ridge that must be augmented for the replacement prosthesis or implant to function satisfactorily (Figure 10).

Prognosis

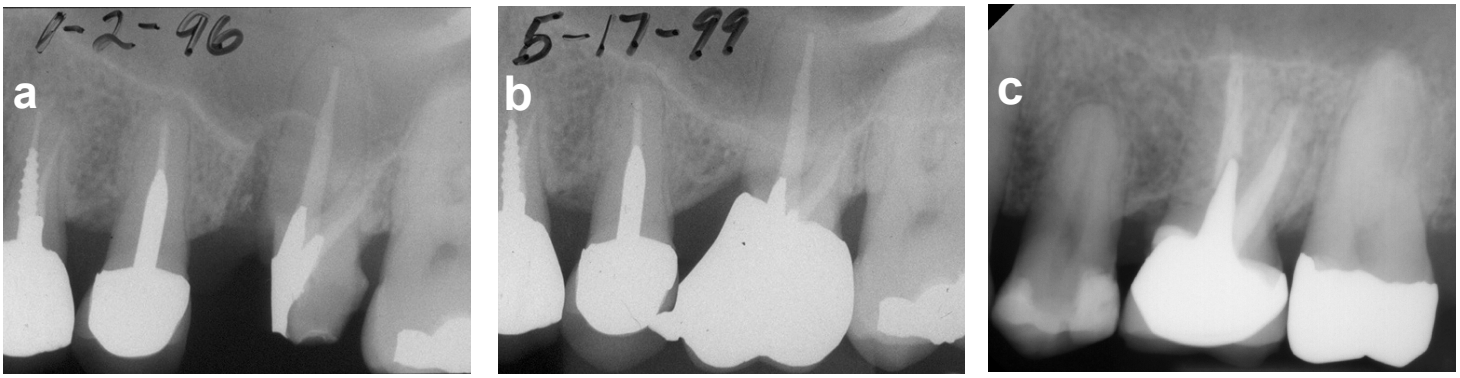
Due to constant ingress of bacteria into the fracture lines, a tooth with a VRF will gradually lose support due to bone resorption. Left untreated, the condition will continue to deteriorate and can result in serious damage to the alveolar bone. Success rates for fixed prostheses or implant supported crowns surpasses that of root resections,[27,33] but preserving a maxillary molar by resecting the fractured root may delay tooth removal.[26]

Patient Information

Due to the difficulty in diagnosing a potential VRF, it is beneficial both for the patient and the dentist to have a thorough discussion when a VRF is suspected. The discussion should include methods to be used when attempting to identify the fracture, a realistic prognosis if a VRF is present, replacement options if the tooth is non-salvageable and the importance of immediate treatment to avoid further loss of supporting tissues that can complicate tooth replacement.

The possibility of a resulting VRF should be included in informed consent discussions with patients prior to any root canal treatment. Also, the possibility that a VRF may be discovered when endodontic surgery is performed should be part of the pre-surgery discussion with the patient. Many patients appreciate a careful and clear description of how a VRF may occur and why teeth with a VRF should not be left untreated.

Figure 8

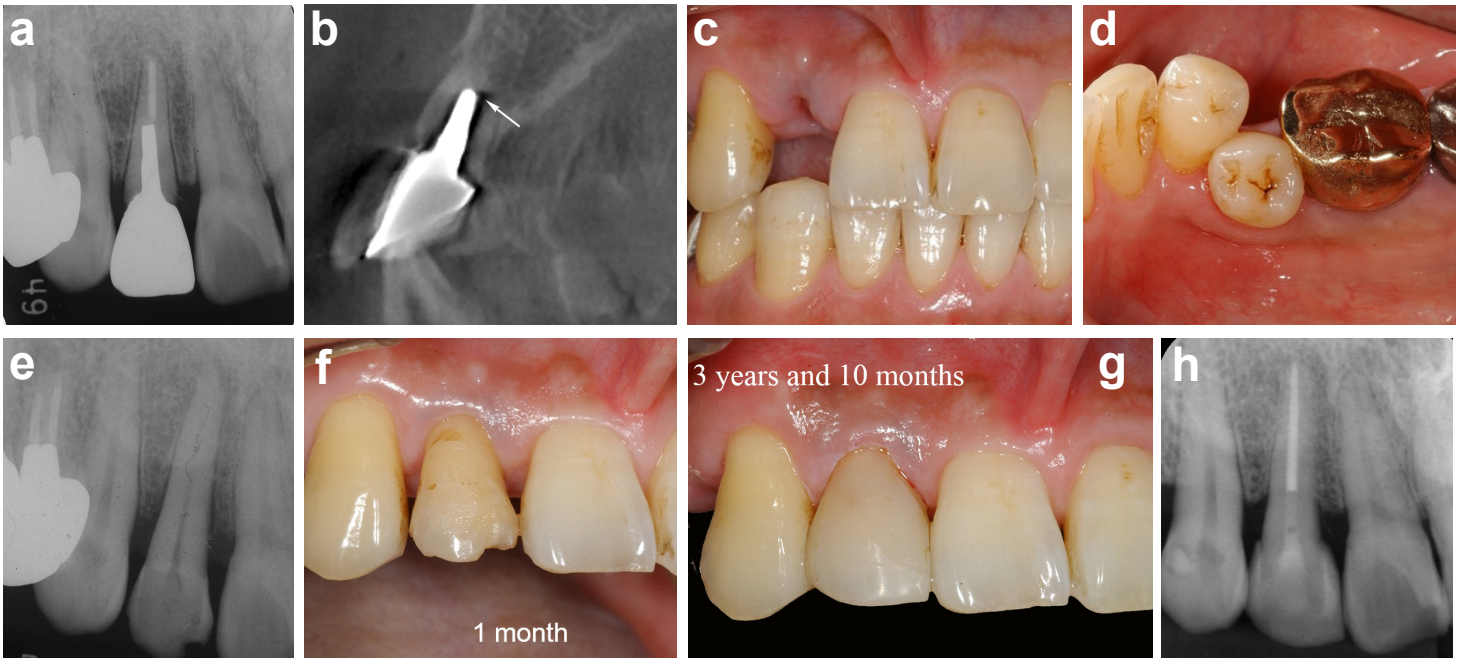


(a) Tooth #14 had a VRF in the MB root - the root was resected - **(b)** three years post-op shows good healing (while further radiographs are not available based on patient's choice, clinically the tooth is still functioning with no reported symptoms at the date of this report). **(c)** Radiograph of another patient's tooth (#14) which had the MB root amputated 14 years earlier because of VRF.

Conclusion

Vertical root fractures are often noted initially when secondary radiographic changes occur. They can lead to significant bone loss if not treated in a timely manner. Although occasionally amputating the root with the fracture can retain a multirooted tooth with a VRF, often teeth with a VRF must be extracted. Today, a number of options are available for management of teeth with a VRF. All the options have better outcomes if early recognition and diagnosis of the VRF is made.

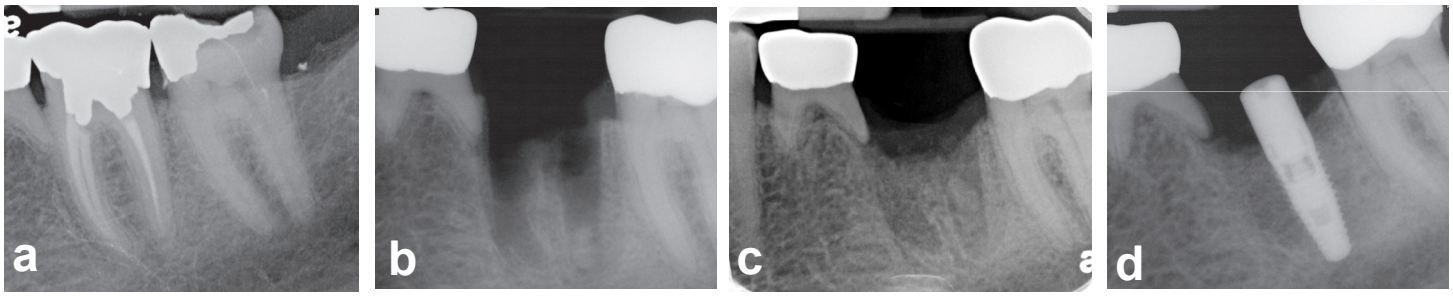
Figure 9



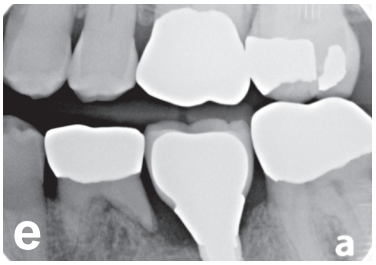
Autotransplantation - **(a)** Radiograph of tooth #7 in a 50-year old male who complained of a sore and loose tooth. Root canal treatment, post and core and a crown had been completed many years earlier. **(b)** CBCT image shows the fractured root (arrow). **(c)** Clinical photo after extraction of #7. **(d)** Photo showing tooth #12 in a crowded alignment; the patient agreed to have it transplanted to the #7 site. **(e)** Radiograph taken immediately after transplantation. Root canal treatment was completed 4 weeks later. **(f)** Photo taken 1-month post- surgery showing soft tissue healing. **(g,h)** Photo and radiograph taken 3 years and 10 months after transplantation.

Case Courtesy: Dr. Mitsuhiro Tsukiboshi, Aichi, Japan

Figure 10



Replacement of a tooth with a VRF with a dental implant supported prosthesis. **(a)** Radiograph of tooth #19 in a 77 year-old male who complained of pain to chewing. The root canal treatment had been completed ten years prior. Loss of bone along the distal aspect of the distal root was observed. **(b)** The tooth was extracted and a VRF was confirmed clinically. The radiograph shows a bony socket that will support the implant. **(c)** An allograft was placed in the extraction socket and a resorbable membrane placed to allow maintenance and healing of the alveolar housing for the implant. **(d)** After maturation of the bone graft for 3 months, an implant was surgically placed and a healing abutment was attached. **(e)** Following osseointegration of the implant and restoration with a crown, a bitewing radiograph shows maintenance of the crestal bone around #19 similar to the level at time of grafting.



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(1.5 CE Credit Contact Hour) Please circle the correct answer. 70% equals passing grade.

1. Vertical root fractures frequently occur in which direction?
a. Facial-lingual
b. Mesio-distal
c. Multidirectional
d. Horizontal

2. The origin of crown-originating fractures is usually:
a. from enamel toward the pulp.
b. from the pulp toward the enamel.
c. from the apex of the root.
d. from the cervical area.

3. Which of the following symptoms is common in vertical root fractures?
a. Pain similar to trigeminal neuralgia
b. Ear-ache type pain
c. Soreness to chewing
d. Sensitivity to cold food

4. Which of the following diagnostic procedures has only a minor role in identifying teeth with vertical root fractures?
a. Cone-beam computed tomography
b. Percussion
c. Periodontal probing
d. Transillumination

5. Periodontal pockets associated with a tooth having a vertical root fracture has these characteristics, EXCEPT:
a. They often extend to the tooth apex.
b. They can usually be painlessly explored.
c. They are very narrow.
d. They resemble pockets associated with periodontal disease.

6. Which of the following treatment procedures is not recommended for a tooth with a vertical root fracture?
a. Amputation of a vertical root fractured root in multi-rooted teeth.
b. Replacement of root canal filling.
c. Replacement with dental implant.
d. Bonding fractured segments.

7. Which of the following treatment procedures is not likely to contribute to a vertical root fracture?
a.. Adjusting an occlusal contact.
b. Extensive dentin removal from root canals during canal preparation.
c. Large post space preparation.
d. Vigorous use of endodontic files, especially in apical areas of the root canal.

8. Which of the following examination procedures provides the most accurate diagnosis of a vertical root fracture?
a. Conventional radiographic images
b. CBCT images
c. Direct visual observation
d. Percussion tests

9. Which of the following types of roots are least likely to develop a vertical root fracture?
a. Premolar roots
b. Palatal roots of maxillary molars
c. Mesial roots of mandibular molars
d. Buccal roots of maxillary molars

10. The prevalence of reported teeth with vertical root fractures is:
a. low.
b. moderate.
c. severe.
d. unknown.

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Quality Resource Guide - Diagnosing and Managing the Cracked Tooth - Part 2

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5. The use of evidence-based dentistry on the topic when applicable.	☐	☐	☐	☐	☐	☐ N/A
6. How relevant was the course material to your practice?	☐	☐	☐	☐	☐	
7. The extent to which the course enhanced your current knowledge or skill?	☐	☐	☐	☐	☐	
8. The level to which your personal objectives were satisfied.	☐	☐	☐	☐	☐	
9. Please rate the administrative arrangements for this course.	☐	☐	☐	☐	☐	

10. How likely are you to recommend MetLife's CE program to a friend or colleague? *(please circle one number below:)*

10 9 8 7 6 5 4 3 2 1 0

extremely likely neutral not likely at all

What is the primary reason for your 0-10 recommendation rating above?

_____

11. Please identify future topics that you would like to see:

_____

Thank you for your time and feedback.

To Complete Program Traditionally, Please Mail Your Post Test and Evaluation Forms To:

MetLife Dental Quality Initiatives Program
501 US Highway 22
Bridgewater, NJ 08807