Third Edition

Quality Resource Guide

Diagnosing & Managing the Cracked Tooth Part 1: Crown-Originating Fractures

Author Acknowledgements

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Educational Objectives

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

1. Describe the three categories of dental fractures.
2. Explain the usual symptoms of crown-originating fractures.
3. Discuss the role of radiography in diagnosis of crown-originating fractures.
4. Describe the clinical tests used for identifying teeth with crown-originating fractures.
5. Describe treatment options for crown-originating fractures.
6. Discuss the prognosis for a crown-originating fractures.

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Introduction

The term 'cracked tooth' has been used to describe many types of fractures and cracks in teeth. Other terms have also been used (**Table 1**) for this dental problem, indicating that dentistry has not previously been able to develop a generally accepted categorization scheme. Efforts have been made over the years.[1] Recently a proposal to use the term 'Dental Fractures' as the umbrella term for all fractures of teeth was published.[2] Under this term dental fractures are categorized into: (1) crown-originating fractures (COF); (2) vertical root fractures (VRF), and (3) trauma-related fractures (**Table 2**). The latter fracture category is distinctly related to acute dental trauma and frequently includes horizontal root fractures. This Quality Resource Guide (QRG) will focus on the first type of fracture, the COF. A follow-up QRG will discuss VRF.

Table 1 - Terms Used for Dental Fractures

- Cracked tooth
- Cracked tooth syndrome
- Green stick fracture
- Cuspal fracture odontalgia
- Vertical root fractures
- Tooth infractions
- Craze lines
- Split tooth
- Fractured cusp
- Hair-line fractures
- Incomplete tooth fractures
- Crown-root fractures
- Longitudinal tooth fractures

Description of COF

Crown-originating fractures (COF) occur spontaneously, originate in the tooth crown, and progress in an apical direction in the roots. In contrast to vertical root fractures, they are not related to previous root canal treatment. The fractures are progressive in nature and propagate from a coronal origin into the root, and may continue apically down the root or toward the root surface, the latter resulting in cuspal fractures (**Figure 1**). The end result, if no treatment is rendered, will either be a split tooth or a cuspal fracture. In the latter situation, the pulp may or may not be directly exposed. If a cuspal fracture does not create a periodontal problem, the crown may usually be restored satisfactorily.

Teeth most commonly affected with a COF are maxillary premolars and molars.[3] Teeth with COF typically have vital pulps and pain originating in the pulps result in unusual pain patterns making diagnosis difficult.[4] COFs most often occur in a mesio-distal direction (**Figure 2**), though they can occur in a facial-lingual direction (**Figure 3**) and, in some cases, in a combination of both directions. The presence or absence of coronal restorations does not seem to be a determinant factor; COF is observed in teeth with carious, restored or intact crowns. One might intuitively expect teeth with restorations to be more prone to a COF than those without. The available evidence, however, is not conclusive, though one might assume that the type of restoration in a tooth plays a role.[5]

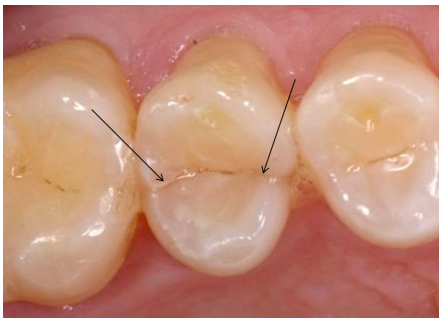
Table 2 - Dental Fractures

Categories	Characteristics
Crown-originating fracture (COF)	Spontaneous fracture originating in the crown and progressing into the root in an apical direction.
Vertical root fracture (VRF)	A root-originating fracture that may begin anywhere in the root; it occurs primarily in endodontically treated teeth.
Trauma-related fracture	Tooth fracture of acute nature that may involve the crown or the root or both and are often horizontal fractures.

Figure 1

COF originates in the crown and progresses toward the apex.

Figure 2



COF running in a mesio-distal direction.

Figure 3

COF running in a facial-lingual direction between cusps.

The origin of COF is usually in one (**Figure 4**), or both, of the marginal ridges (**Figure 5**) if the fracture is in a mesio-distal direction. The origin of a COF is typically between the cusps if it is in a facial-lingual direction (**Figure 3**). COF progression is from enamel into dentin; from there the fractures may enter the pulp (**Figure 6**), or may skirt the pulp, avoiding direct pulpal contact.[5]

A minor type of COF is an enamel craze line (**Figure 7**). These are limited to enamel and rarely extend into dentin. Treatment is usually not needed except for esthetic reasons when discoloration of the craze line becomes noticeable.[1]

Symptoms

Pain on chewing is the most common finding in symptomatic teeth with COF.[1,4-6] The range of discomfort varies from almost none to the most severe of orofacial pains, including pain similar to that described by patients with trigeminal neuralgia (tic douloureux). The diversity of symptoms contributes to the difficult task of making a diagnosis. Examples of symptoms may include: a description that a tooth "feels weak" (See case history in **Figure 14**); sharp pain when chewing certain foods; or sudden electric shock-like stabbing pains. Symptoms may also resemble those experienced by patients with an earache, TMJ dysfunction, sinusitis, or various neurological problems. It is now recognized that COF may be associated with chronic orofacial pain,[4] emphasizing the need to include a COF as an option when searching for the etiology of unusual dental pains. Teeth with a COF can also create non-localized vague pains or pain referred to other oral regions. The longer the symptoms are present and the more diffuse they become, the more difficult diagnosis becomes.[4] Even lack of symptoms can be frustrating since bacteria in such cases may infect pulps, leading to pulp necrosis.[7]

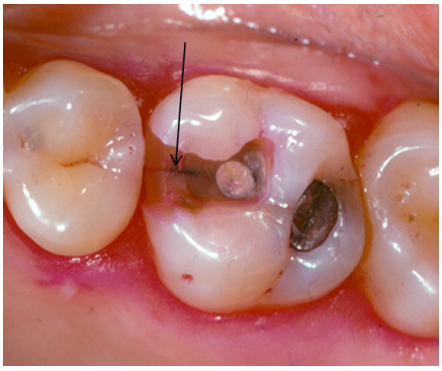
It would be reasonable to expect that teeth with COF, and being painful on mastication, would also be hypersensitive to percussion. However, this does not always appear to be the case.[8] It has been suggested that sensitivity to percussion occurs when the pulp becomes involved, and the pulp may not initially be involved in all COF.[9] There may not be a painful response to percussion with COF in which the pulp is not directly involved. Until a COF has progressed all the way from the pulp to the PDL, localization by percussion of the tooth is difficult.[10]

Pain response to sweets in teeth with COF has been reported.[11] This is probably related to the presence of microorganisms located in the tooth fracture (**Figure 8**) causing pulpal inflammation.[12] Pain can also be felt in the PDL as parts of a fractured tooth move, regardless of pulpal involvement.[11] Since pain responses in teeth with

Figure 6

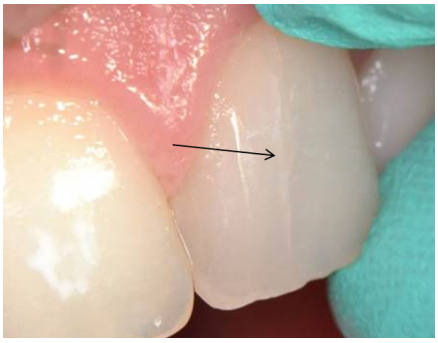
This cuspal fracture barely bypasses the pulp - in some cases the COF directly enters the pulp and in other instances fractures are located some distance from the pulp.

Figure 4



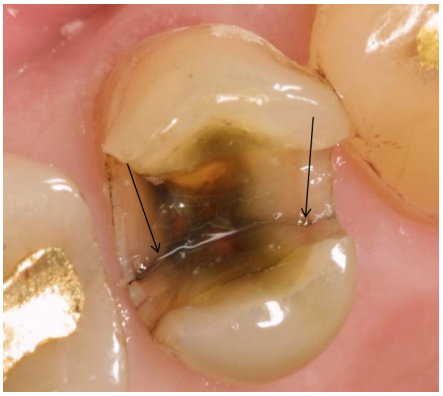
COF can begin in one of the marginal ridges; in this case, the mesio-marginal ridge - the fracture is highlighted using a red dye.

Figure 7



Arrow points to a typical example of an enamel craze line - such fractures are confined to enamel and seldom present any problems other than possible discoloration.

Figure 5



Mesial and distal marginal ridges are involved in this COF.

Figure 8

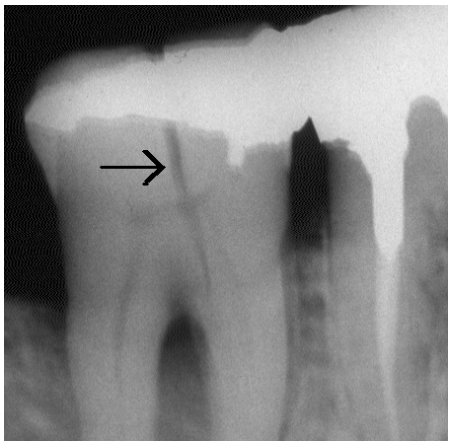
Fracture line runs from the crown periphery (left side) to the pulp (right) and is filled with bacteria -*histologic section courtesy Dr. Henry O. Trowbridge.*

COF can mimic many other conditions, such as teeth with caries, it is prudent to maintain a high degree of suspicion when a general dental examination yields symptoms and examination findings that are contradictory.

Diagnosis

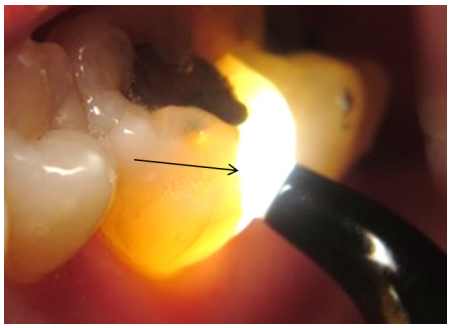
A tentative diagnosis of COF can sometimes be made based on symptoms. Absent caries, a tooth that is painful to chewing (particularly fibrous food) may be considered to possibly have a COF. But since symptoms can be very diverse and clinical findings difficult to obtain, the clinician must systematically collect available information before finalizing a diagnosis.

Figure 9



Facial-lingual COF (arrow) is visible radiographically because the x-ray beams run parallel to the fracture line.

Figure 10



Transillumination highlights a fracture (arrow) that involves the enamel and dentin.

A study of 95 patients presenting with longitudinal fractures in teeth were evaluated with periapical radiographs and CBCT. CBCT showed 4.4 times greater odds to detect bony defects suggestive of fractures versus periapical radiographs. Teeth with vertical root fractures (VRF) were more associated with absent bony cortical plates, showed J-shaped radiolucencies and deeper probings (>6 mm), and were associated with indirect restorations. Cracked teeth (COF) were associated with direct restorations, shallower probings (<6 mm), and the cortical plates were intact. The CBCTs showed angular bony defects.[13]

Radiographic Information is often of relatively minor value in identifying a COF. Since the vast majority of fractures run in a mesial-distal direction, a typical radiographic image will not show a break in tooth continuity. However, in a small number of facial-lingual positioned fractures, the radiographic image can show the fracture since the x-ray beam runs parallel to the fracture (**Figure 9**).

Cone beam computed tomography (CBCT) has made radiographic examination of dental conditions more easily visualized than ever before. Teeth with vertical root fractures (VRF) can be recognized on CBCT images,[14] But this technology is less applicable for the diagnosis of teeth with a COF.

Clinical Findings can provide many clues. Direct observation of an intact tooth with no restorations may allow identification of fracture lines. If a possible fracture is noted on one or both of the marginal ridges, confirmation of a COF can be obtained by transillumination.[15] Fracture lines in dentin will block transilluminated light and the tooth structure opposite the fracture line will be dark (**Figure 10**).[15] An enamel craze line may be highlighted with transillumination, but it will not prevent the light from continuing through the crown (**Figure 7**). Fracture lines may also be highlighted with the use of red dye (**Figure 4**) or methylene blue. If restorations are present, they may need to be removed for direct observation of potential COF. Since localization of the affected tooth can be difficult, it may sometimes be necessary to remove restorations from several teeth before identifying the correct one. Brynjulfsen *et al.*[4] recommended methodically removing restorations, one tooth at a time, to locate teeth with COF in patients with long standing, undiagnosed orofacial pain.

An important step in the clinical examinations is conducting a biting test.[16] Various techniques have been recommended, such as biting on Burlew Wheels, rubber wheels, cotton tip applicators, moist cotton rolls, and commercial biting applicators. To differentiate between biting pain from restorations and microleakage/pain from COF, a biting applicator can be placed separately on either the restoration or the cusps. The result may suggest a leaky restoration or a COF. Another clue to the possibility of COF is the response to biting. A significant pain response to biting, experienced on release of biting pressure, is referred to as either “rebound pain” or “relief pain”.[16] Kahler *et al.*[11] explained that the pain associated with release of pressure results from fluid movement as the crack rapidly closes. This can be used diagnostically by having the patient bite on a moist cotton roll. If “rebound” pain occurs on release, there is a higher likelihood that one of the two opposing teeth has a COF (**Figure 11**).

Figure 11

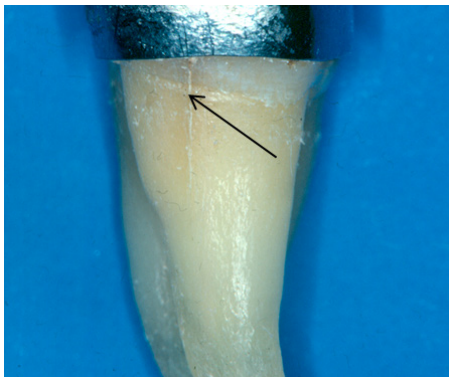
Clinical test for COF using a moist cotton roll placed between a maxillary and mandibular tooth - a “positive” test is “rebound” pain coming from one of the teeth.

Cold Stimulus Application and Electric Pulp Testing (EPT) provide information about the status of the pulp. There is evidence that teeth with COF respond at lower threshold levels to cold and EPT stimulation compared to non-fractured teeth.[6] Since any tooth with pulpal inflammation is likely to have a lowered pain threshold, it is not a particularly discriminative tool. However, it can add to the total information about the tooth.[17]

An Explorer (thin and sharp) was used by Cameron[18] to probe around the cervical circumference of teeth suspected of having fractures, particularly in interproximal areas not readily visible if the tooth has a large or full coverage coronal restoration. Both the "click" of the explorer tip encountering the fracture, and perhaps the patient's response, as in touching a sensitive spot on the root surface, can provide a diagnostic clue (**Figure 12**). Another clue can be found by using a sharp explorer at margins of large restorations. A sharp pain may be elicited if a crack is present.[6]

Percussion eliciting sensitivity in teeth with COF is not as common as biting sensitivity.[8] An explanation for this may be that the fractures in teeth with COF typically originate internally and propagate peripherally,[11] so a tooth with a fracture is not likely to be identified by percussion until the fracture extends to involve the periodontal ligament (PDL).[10]

Figure 12



COF (arrow) has progressed down the root below a crown margin - using a sharp explorer to trace the cervical area can generate a 'click' that would help to locate the fracture.

Periodontal Probing is recognized as an indispensable part of dental examinations in general. It is also useful for examining teeth with potential fractures. Probing depths of more than 5 mm indicates the tooth has a reduced prognosis (**Figure 13**).[19] Since pockets adjacent to the fracture lines in teeth with COF are extremely narrow, in contrast to those adjacent to endodontically treated teeth with VRF, it is usually necessary to anesthetize the tissues surrounding the tooth prior to probing.

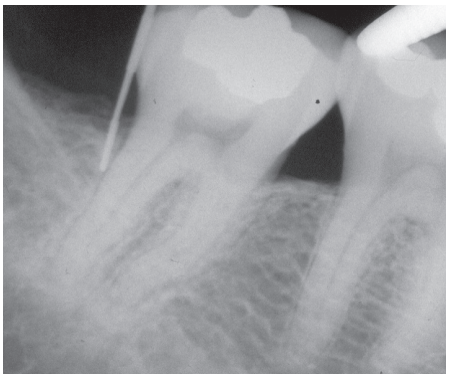
Treatment Options

Clinicians treating teeth with COF recognize that dentin, and probably also enamel, cannot be permanently re-bonded once a fracture line develops. The treatment goal therefore is to immobilize the segments that move on loading. Such attempts to delay the continuing separation of the tooth segments may also help to keep bacteria from colonizing the fracture spaces. **Figure 14 a-j** illustrates an effort to both reduce bacterial entry into the fracture as well as immobilizing the fractured segments. How long the tooth will remain functional and asymptomatic is not predictable.[12,19] Root canal therapy, while reducing or eliminating symptoms, will not change the fact that a tooth with a fracture is weakened and likely will not last as long as a non-fractured tooth.[20]

The need for evidence-based treatment guidelines for COF has been identified.[5] While these are not yet available, there is some agreement that many teeth with COF may be treated, but it is not clear if they all require root canal therapy.[20,21] The lack of clear understanding is probably related to the difficulty in determining if a COF communicates directly with the pulp, in which case endodontic treatment would more likely be a part of treatment, or the fracture is cuspal and may not communicate with the pulp.

Using the commonly accepted criteria for pulpal diagnosis, Krell and Rivera[22] reported the outcomes of symptomatic, fractured teeth that were initially diagnosed with reversible pulpitis and treated with full coverage restorations.

Figure 13



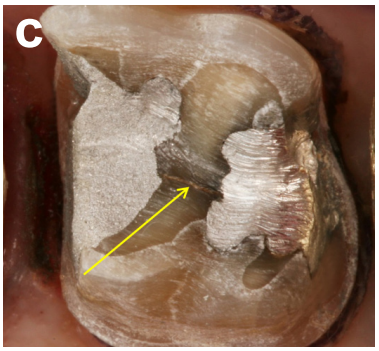
Use of a periodontal probe to explore the apical extent of a COF.

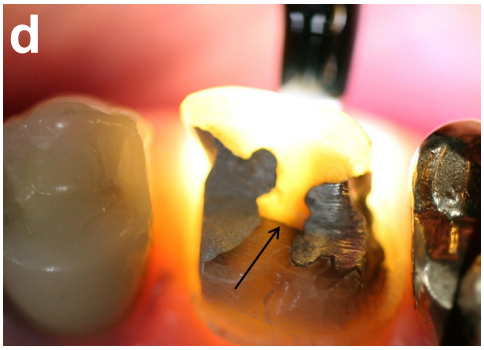
The outcomes in their case series suggest that, if a COF is identified early and the tooth is diagnosed with reversible pulpitis and a crown is placed, root canal treatment will be necessary only about 20% of the time.

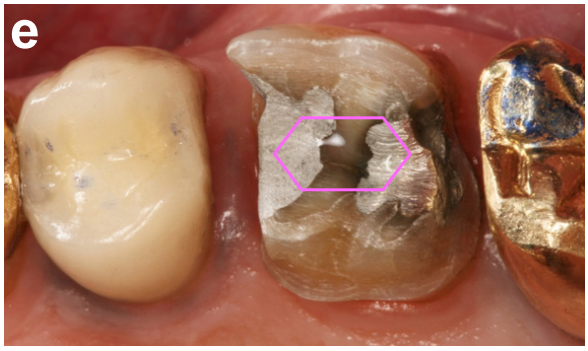
An approach that can help the clinician to decide if endodontic therapy for a tooth with COF is necessary is to use the following protocol:[4,16] 1) If a tentative diagnosis of reversible pulpitis has been determined (based on no lingering pain to cold and no spontaneous, severe pain), the tooth is stabilized with an orthodontic band for about two weeks; 2) If symptoms subside within that period, the patient may be offered the option of only placing a restoration that binds the tooth together, such as a full crown*, with the awareness that the tooth may later need root canal therapy.[21] The reason for waiting after placement of the orthodontic band is because it takes some time before cold sensitivity subsides. Davis and Overton[23] found that it took two weeks for cold sensitivity to subside after restoring teeth with bonded amalgam restorations. Another study, looking at cracked teeth treated with orthodontic band placement, found 92.6% of teeth with preoperative reversible pulpitis reverted to a normal pulp. Approximately two months was required to determine a definitive pulpal diagnosis, but teeth showing more preoperative pain required a longer period of time to determine a definitive pulpal diagnosis.[24]

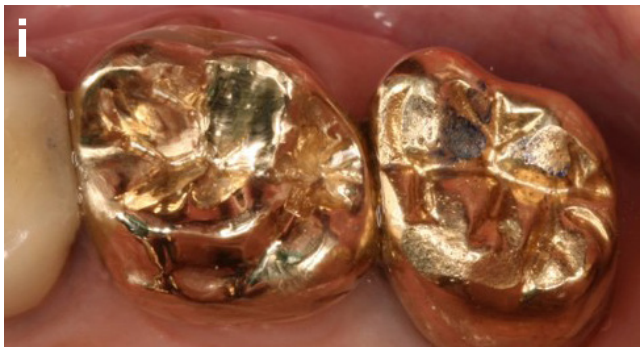
* *Treatments described to bind fractured teeth together include the use of adhesives,[23] amalgam restorations with retention on both sides of the fracture,[22] full coverage crowns[4,18,23] and bonded composite overlays.[24]*

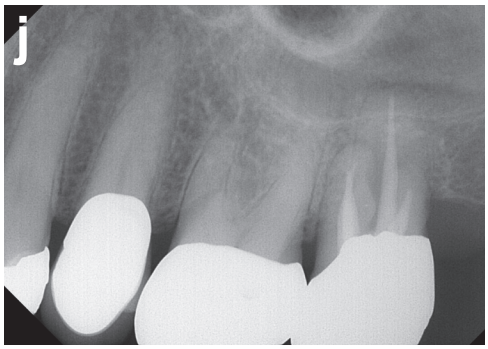
Figures 14 a-j











Figures14 a-j:
A patient (male, age 76, good health) reported that the tooth felt "weak" when chewing, experienced no pain to chewing and had no complaints of temperature sensitivity – (a) the initial radiograph shows tooth #14 to have MO and DO metal restorations, and no evidence of apical lesions – (b) clinical assessment finds an area of possible decay and a COF (arrow) – (c) fracture (arrow) becomes more evident after crown preparation – (d) fracture is further highlighted by transillumination – (e) area of the fracture (within the box) was soaked with chlorhexidine, anticipating that some of the solution would penetrate the fracture and kill bacteria - (f) area was etched in preparation for application of (g) dentin bonding agent and (h) polymerizing – provisional crown was placed and (i) subsequently the new crown was cemented – (j) tooth has remained asymptomatic and 5-year post-op film shows no indication of endodontic involvement - *case courtesy of: Dr. Charles Goodacre, Loma Linda University School of Dentistry.*

When a fractured tooth has *irreversible pulpitis* or *pulp necrosis*, endodontic therapy is necessary if the tooth is to be retained. Endodontic therapy will eliminate pulpal pain and sensitivity to temperature changes and sweets, but one should not expect a tooth with a COF to be free of chewing pain. Pain to mastication is associated with inflammation in the PDL. Such inflammation is generated by bacteria in a fracture.[11,12] The problem (not being able to predict if pain on chewing will cease after completion of the root canal treatment and restoration) can be addressed by initially placing an orthodontic band as discussed above, followed by endodontic therapy if chewing pain subsides. If the patient is not comfortable with the tooth following application of the band, extraction becomes the alternative treatment option.

A recently published article, Walton and Walsh[27] presented three cases with crown originating subgingival fractures of the palatal cusps in maxillary premolars. They were treated with 'cuspidizing' the teeth and creating a canine type of appearance and function. Endodontic treatment was needed only if pulpal exposure occurred. These teeth would traditionally have required either extraction or crown lengthening. Instead, this treatment approach provides an alternative route to tooth (and sometimes, pulpal) preservation.

Prognosis

The outcome of treatment for teeth with COF has not been extensively reported, but clinical data is accumulating. Cameron[18] reported a 75% success after ten years following placement of crowns. Brynjulfsen *et al.*[4] achieved pain relief in 90% of their patients after protective restorations were placed on teeth with fractures (endodontic therapy was included when indicated), and Tan *et al.*[28] had an 85% survival rate two years after protective crowns were placed. Sim *et al.*[20] reported the 5-year survival of teeth with COFs that were restored with full coverage crowns and had root canal treatment when indicated. They found that teeth with fractures confined to the crowns survived at a rate of 99%, while those with fracture extensions to the pulpal floor had an 88% survival rate. More recently, Wu *et al.*[21] found that 71% of teeth with COF and reversible pulpitis were asymptomatic and functioning after three years.

A recent study following teeth with COF after one, five and eleven years, found variable survival rates of 98.6%, 94.9%, and 55.9%, respectively. There was no influence of the direction (mesiodistal or buccolingual) of the fracture lines on survival of the tooth. Teeth were lost at a higher rate when onlay restorations were used versus full crown placements. The use of posts was also associated with less favorable outcomes.[29]

The available data is insufficient to use as a basis for giving individual patients specific odds on a tooth's survival. The reports, however, suggest that a large number of treated teeth with COF can function for many years. Patients must be fully informed of the uncertainty based on lack of data. One must recognize that in certain situations the prognosis is poor: teeth in a terminal position within the dentition; teeth with periodontal involvement related to the fracture, and teeth with multiple fractures.[28] It is recommended that the clinician search the current literature regarding the type of clinical situation that exists, include his/her own experience and seek the patient's preferences when creating treatment recommendations and obtaining informed consent.

There is growing evidence that cracked teeth (COF) requiring root canal treatment, may benefit from modification of their access cavity preparations. Reducing the size of the coronal access cavities and conserving as much coronal dentin as possible may improve fracture resistance. Santosh *et al.*[30] compared those with conventional access cavities versus teeth with more conservative ones in forty mandibular molars. They reported that those with conventional access cavities showed less fracture resistance and led more often to non-restorable teeth than those with reduced size access cavities.

Patient Information

Teeth with COF often present both patients and dentists with a number of challenges. Patients may have difficulty in describing symptoms and pointing out the location of the problem tooth. Dentists may be able to collect only limited clinical and radiographic data to establish a definitive diagnosis. Such a combination can result in frustration for everyone involved. Involving the patient in the problem-solving process may be helpful. Gathering all the pertinent information (history, symptom descriptions-regardless of how unusual they may be and past similar dental experiences) can provide a framework for suspicion of a COF. This gives the clinician an opportunity to share the complexity of establishing a definitive diagnosis with the patient. Such teamwork – patient and their dentist working together to solve the problem – may reduce the possibility of later conflicts.

Educating patients about COF begins with an explanation about the factors that create symptoms. Early stages of the development may involve the pulp only (explaining both the often unusual-symptoms and the inability to localize the tooth); such teeth may respond to biting tests but not percussion tests. Only when the fracture line has progressed to involve the root can localization be expected because of periodontal ligament involvement.

Additional patient education can occur during discussion about treatment options and prognosis. The ideal outcome of such discussions is that the patient clearly comprehends the situation prior to making treatment choices. A patient will generally rely on his/her dentist's recommendations, but the better informed the patient is, the better he/she will grasp the possible treatment consequences. Teeth with COF must be considered to have limited survival expectancy since these fractures cannot be eliminated and usually continue progressing in the root. Lack of available data on survival of teeth with a COF makes it important to prepare a patient for the likelihood of eventual tooth loss.

The fact that prognosis for teeth with a COF is fair at best, does not mean that immediate replacement with a dental implant is the best treatment choice. Long-term prognosis for dental implants is reasonably good, but data points to increasing numbers of problems, such as peri-implantitis after ten years.[31] A reasonable approach to providing clinical guidance to a patient with a COF may be to recommend retaining such teeth for as long as practical.

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POST-TEST

Internet Users: This page is intended to assist you in fast and accurate testing when completing the "Online Exam." We suggest reviewing the questions and then circling your answers on this page prior to completing the online exam.

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

1. **The presence of bacteria in crown-originating fractures is responsible for?**
   a. pulp generated pain.
   b. failure to arrest the progress of the fracture.
   c. cuspal fractures.
   d. painful responses to tooth percussion.

2. **The available data on crown-originating fractures indicates:**
   a. Dental implants provide a better treatment option.
   b. Tooth survival time after treatment is unpredictable.
   c. Delaying treatment is not detrimental to the outcome.
   d. Fractures can be prevented from progressing.

3. **Early developing crown originating fractures:**
   a. usually involve the periodontal ligament before the pulp
   b. pain to biting often before pain from percussion
   c. involve the periodontal ligament before progression of the crack down the root
   d. always lead to pulp necrosis

4. **Treatment of crown originating fractures may lead to any of the following outcomes, EXCEPT:**
   a. 75% success of symptom resolution and retaining teeth after placement of a crown
   b. 90% pain relief after placement of protective restorations on teeth with fractures (including endodontic therapy when indicated)
   c. 99% retention of teeth with fractures that extended only to the coronal 1/3 of the root.
   d. 71% retention of teeth with crown originating fractures and reversible pulpitis after three years.

5. **Crown-originating fractures occur primarily in which direction?**
   a. Facial-lingual
   b. Mesio-distal
   c. Multidirectional
   d. Horizontal

6. **Determining the prognosis for a tooth with crown-originating fracture can be aided by:**
   a. adjusting occlusal contact.
   b. prescribing antibiotics.
   c. stabilizing the crown with a stainless-steel band.
   d. recommending a soft diet.

7. **Which of the following symptoms of crown-originating fractures is MOST common?**
   a. Pain similar to trigeminal neuralgia
   b. Ear-ache type pain
   c. Pain to chewing
   d. Continuous ache

8. **Which of the following diagnostic procedures has only a MINOR role in identifying teeth with crown-originating fractures?**
   a. Radiography
   b. Percussion
   c. Biting test
   d. Transillumination

9. **Periodontal pockets associated with crown-originating fractures differ from those associated with vertical root fractures in that they:**
   a. typically extend to the tooth apex.
   b. can be painlessly explored.
   c. are very narrow.
   d. readily visible on radiographs.

10. **The pain experienced upon opening the mouth after a biting test, is called:**
    a. "relief pain"
    b. "chronic pain"
    c. "acute pain"
    d. "neurological pain"

Registration/Certification Information (Necessary for proper certification)

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Preferred Dentist Program ID Number: _____ ☐ Check Box If Not A PDP Member

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Evaluation - Diagnosing and Managing the Cracked Tooth Part One 3rd Edition

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10 **9** **8** **7** **6** **5** **4** **3** **2** **1** **0**

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