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ENDODONTICS

COLLEAGUES FOR EXCELLENCE

In response to your requests...

At the end of each issue of *ENDODONTICS: Colleagues for Excellence,* the American Association of Endodontists (AAE) asks readers to send in their comments and suggestions. The committee of endodontists who edit the newsletter enjoy your comments and appreciate both positive reviews and constructive criticism. To thank you for your valuable commentary, we have dedicated this issue to your most frequently suggested topic—the cracked tooth.

Most readers who request information on cracked teeth mention "cracked tooth syndrome," the name given to the complex and often bizarre set of symptoms typical of cracked teeth. In this issue, however, we attempt to go beyond the elusive "syndrome" and give a clearer picture of the classic symptoms and tried-and-true diagnostic techniques to help "crack the code" for five specific entities—*craze line, fractured cusp, cracked tooth, split tooth, and vertical root fracture.*

We hope that you enjoy this issue and that the *ENDODONTICS: Colleagues for Excellence* newsletter continues to be a valuable publication for the profession of dentistry.

Denis E. Simon III, DDS, MS
President
American Association of Endodontists

Cracking the CRACKED tooth code

Unfortunately, the incidence of cracks in teeth seems to be increasing. People are living longer and keeping their teeth longer. As a result, patients are more likely to have complex restorative and endodontic procedures that remove tooth structure, leaving teeth more susceptible to cracks. People of all ages are also living more stressful lives, which can result in crack-inducing habits, such as clenching and bruxism. Additionally, in recent years, practitioners have been more aware of the existence of cracks and, therefore, diagnose more cracks.

The good news is that many teeth with cracks can be saved! The key to saving these teeth is to know the characteristic signs and symptoms and diagnose the crack as early in its development as possible.

Classic Signs, Classic Confusion

Teeth with cracks tend to have erratic pain on mastication, especially with release of biting pressure, and the patient tends to have trouble explaining the complaint. Sometimes there is pain to temperature extremes, especially cold. Generally, there is no pain to percussion, and radiographs are inconclusive. Often patients will complain of a long history of pain which has been difficult to diagnose and of treatment which has failed to relieve their symptoms.

These have been labeled "classic signs" of cracks. However, depending on the location, direction, and extent of the crack, the patient may present any one or all of these signs and symptoms or a variety of others. This variable combination of signs and symptoms makes diagnosis confusing.

If the pulp is involved, there may be signs and symptoms of irreversible pulpitis or necrosis with periradicular pathosis. If the crack extends to a root surface, there may be a periodontal defect. In fact, cracks are often a contributing factor in pulpal pathosis and should always be carefully considered during endodontic diagnosis, especially in a case without an obvious etiology.

Many times, cracks are not identified until a variety of symptoms are present, a restoration is removed, or a significant periodontal defect is identified. Because diagnosis can be so complicated, a patient with a tooth crack will often end up in the endodontist's office after a long history of uncertain diagnoses. However, just like cracks in a windshield, cracks in teeth often start small and progress slowly. If caught early and treated appropriately, many cracks can be stopped or at least slowed down, preventing loss of the tooth.

Quick action on the part of the dentist can improve the chances of saving the tooth. If a crack is suspected, steps should be taken immediately to confirm the presence of a crack, determine the type of crack, and formulate an appropriate treatment plan.

The Obvious and the Obscure:

Diagnostic Steps for CRACK Confirmation

If a crack is suspected, several diagnostic steps should be taken to confirm the suspicion. The tests performed and results achieved will vary between teeth that have or have not had endodontic treatment. If the suspect tooth has been endodontically treated, symptoms will be limited to those caused by the affected periodontium because the tooth has no remaining vital pulp tissue.

For the tooth that has a vital pulp, the following steps will only confirm the presence or absence of a crack. Further pulpal and periodontal testing will be necessary to determine the need for endodontic treatment.

Dental History

Check for a history of repeated occlusal adjustments with only temporary relief of symptoms or evaluation by several practitioners without a conclusive diagnosis.

Also check for a history of periodontal disease with extensive bone loss in the area. Decreased bone support has been thought to lead to increased stress on dentin, predisposing the roots of a tooth to cracking.

Additionally, check for a history of other cracked teeth, because many of the anatomical and behavioral factors that predispose teeth to cracks often affect more than one tooth.

Subjective examination

Ask the patient to point to the tooth that is sensitive, keeping in mind, however, that patients can be wrong.

Ask if the patient remembers accidentally biting a hard object. Such an incident may correspond to a sudden onset of pain.

Also ask about damaging habits, such as clenching or grinding the teeth, or chewing on ice, pens, hard candy, or other objects.

Visual examination

Start with the face, checking for enlarged jaw muscles, which may indicate a habit of over-stressing the teeth during mastication. Then check for wear facets, which may indicate a history of clenching, bruxism, or biting and chewing with excessive force.

Next, check the teeth for tight cusp-fossae relationships that may cause excessive occlusal stresses. Note any steep cusps or developmental grooves, because these may predispose teeth to cracks.

Finally, check tooth surfaces carefully in a dry field. Note any *craze lines* or darker cracks. Generally, the darker the stain in a crack, the longer the crack has been present. Also check for cracked restorations or unusual gaps between restorations and tooth structure.

Enhanced magnification and illumination can be helpful in visual identification of a crack.

Tactile examination

Scratch the surface of the tooth with the tip of a sharp explorer. The tip may catch in a crack. Palpate the gingiva around the tooth, checking for possible evidence of an underlying dehiscence or fenestration typical of a vertical root fracture.

Bite tests

Use a rubber wheel, wood stick, or other instrument to focus biting pressures on specific cusps to reproduce the patient's complaint. Specially designed instruments are commercially available.

Place the instrument on each cusp or fossa and have the patient bite down with moderate pressure and release. Test several teeth and cusps. Be sure to use controls. Watch the patient's facial expression for response to pain upon biting pressure or release. If the patient has a painful response, ask if the pain is the same as he or she has been experiencing.

Pain during biting or chewing is considered a classic symptom and may be the only conclusive evidence early in the crack's development. The absence of pain during biting, however, does not rule out the possibility of a crack.

Periodontal probing

Thorough probing in small increments around the entire circumference of the tooth may reveal a narrow periodontal pocket. The narrow pocket that forms along a crack will restrict side-to-side motion of the probe, making it easy to differentiate from the broad-based defect characteristic of a periodontal disease pocket.

Radiographs

Cracks rarely show up on radiographs. Mesial-distal cracks can never be seen, and buccal-lingual cracks will only appear if there is actual separation of the segments or the crack happens to be at exactly the same angle as the x-ray beam (Figure 1).

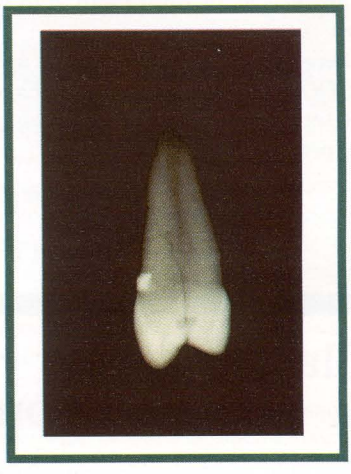


Figure 1
This radiograph of a mesial-distal crack could be taken only after extraction.

Changes in the pulp chamber, canal, or periradicular space, however, may suggest the presence of a crack. Radiographic evidence tends to be more likely as the crack progresses and a bony defect develops. Taking periapicals from more than one angle and taking bite-wings may increase the chance of catching a crack-induced defect early in its development.

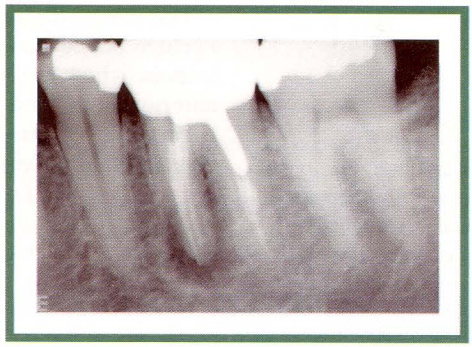


Figure 2
The diffuse longitudinal radiolucency along the mesial root of #19 exhibits the distinctive J shape typical for a crack that extends to the root surface.

A thickened periodontal ligament space or a diffuse longitudinal radiolucency, especially one with an elliptical or J-shaped appearance apically, may indicate a crack (Figure 2). Check also for restorations held in place by pins, which can predispose teeth to cracking.

In endodontically treated teeth, rare but significant findings include a radiopaque line where gutta-percha or sealer has been expressed into the crack during obturation. A consistent radiolucent line along the length of the root canal filling material may indicate space caused by a crack but should not be considered conclusive, because it could be caused by other entities.

Because the size, design, and placement of posts often contribute to cracks, check endodontically treated teeth for long posts, short-wide posts, custom metal posts, or posts with threads that bind with tooth structure.

Radiographs can also help rule out other possible diagnoses. Look for evidence of perforations or internal or external resorption. Also check for signs that previous endodontic treatment may be failing.

Restoration removal

This allows visual examination of the remaining cavity (Figure 3). Carefully check the mesial and distal marginal ridges, which tend to be weak areas. Magnification can be helpful.

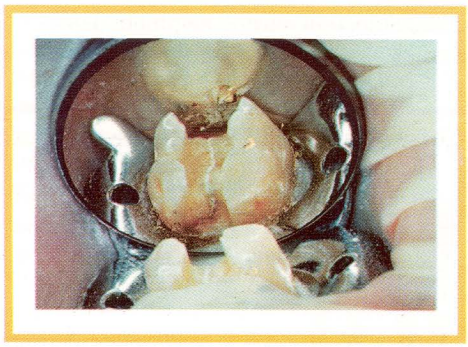


Figure 3
Cracks will sometimes be evident across the floor of the cavity after restoration removal.

Staining

Cracks may be disclosed through staining. A dye, such as methylene blue, can be applied to the external tooth surface, in the cavity after restoration removal, or on a surgically exposed root.

Transillumination

In transillumination, a fiberoptic or other similar light source is applied directly to the tooth surface. The light beam is positioned perpendicular to the plane of the suspected crack. A crack will block the light (Figure 4). Structurally sound teeth, including those with *craze lines,* will transmit the light throughout the crown.

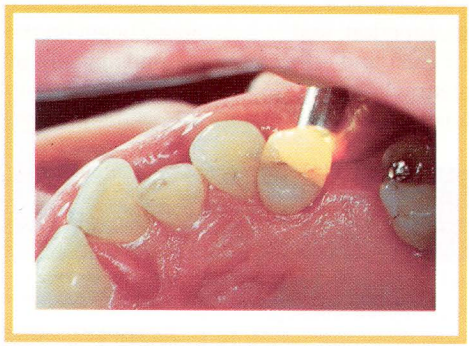


Figure 4
A crack will block and reflect the light when transilluminated.

Surgical assessment

Surgical exploration allows for visual examination of the root surface for the appearance of a crack and should only be used if the crack is highly suspected and cannot be confirmed by all other possible diagnostic means (Figure 5). Performing diagnostic surgery, however, can help early detection of untreatable situations, sparing the need for endodontic or restorative treatment on an ultimately hopeless case. A consultation with an endodontist or periodontist may be advisable prior to surgical assessment. Whenever surgery is performed to detect a crack, the patient should be fully informed that it is a diagnostic procedure.

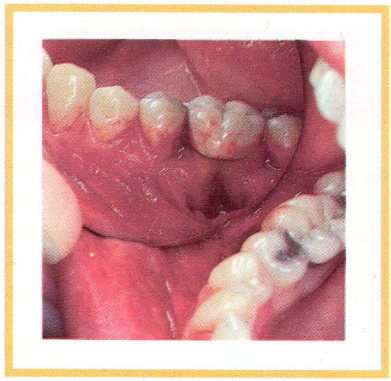
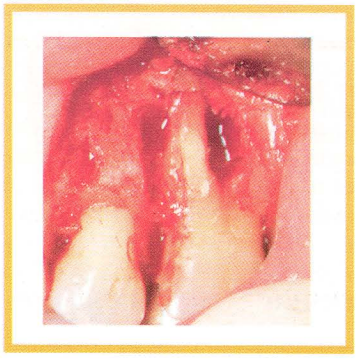


Figure 5
As a last resort, surgery may reveal a crack along the root surface.



Crack types

One factor that contributes to the confusion surrounding the issue of cracked teeth is that various authors have suggested a number of inconsistent terms to describe tooth cracks. For instance, "complete" and "incomplete" have been used to refer to a variety of crack features, including degree of pulpal involvement, degree of root involvement, or extent of the crack.

Because the location, direction, and extent of a crack have a profound effect on the choice of treatment, clarity is important. For consistency in this article, the five types of tooth cracks are described as follows:

- Craze line
- Fractured cusp
- Cracked tooth
- Split tooth
- Vertical root fracture

Craze lines affect only the enamel. *Fractured cusp, cracked tooth,* and *split tooth* begin on the occlusal surface and extend apically, affecting enamel and dentin, and possibly the pulp. *Vertical root fracture* begins in the root. *Fractured cusp, cracked tooth, split tooth,* and *vertical root fracture* are found most often in posterior teeth.

The cracks discussed in this article exclude cracks caused by impact trauma, which are more common in the anterior teeth, tend to result in more horizontal fractures, and require considerably different treatment.

For purposes of clarity, we will use the term "crack" throughout this article, although the terms "crack," "fracture," and "fracture line" tend to be used interchangeably in the literature.

Craze lines

When examining teeth for cracks, keep in mind that most adult teeth will have *craze lines*. In posterior teeth, *craze lines* are usually evident crossing marginal ridges and extending along buccal and lingual surfaces (Figure 6). Long vertical *craze lines* commonly appear on anterior teeth. Because they affect enamel only, they cause no pain and are of no concern beyond the aesthetic.

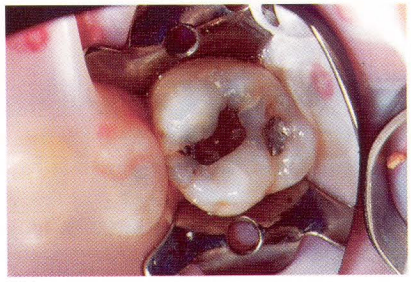


Figure 6
Craze lines, such as those on the occlusal surface of this tooth, are sometimes mistaken for other types of cracks.

Differential diagnosis

Craze lines are frequently confused with cracks but can be differentiated by transillumination. If the tooth is cracked, the light will be blocked by the crack, allowing only a segment of the crown to light up (see Figure 4 on page three). If the tooth only has a *craze line,* the entire crown will light up during transillumination.

Fractured cusp

Of all cracks affecting dentin, *cusp fractures* are the easiest to identify and treat. Their treatment also has the best prognosis, especially when the crack does not extend below the gingival attachment.

The *fractured cusp* usually results from a lack of cusp support due to a weakened marginal ridge. Occlusally, it is common for the crack to have both a mesial-distal and a buccal-lingual component. The crack will cross the marginal ridge and continue down a buccal or lingual groove to the cervical region. It may terminate parallel to the gingival margin or slightly subgingivally (Figure 7). Generally, only one cusp is affected. It may be necessary to remove a restoration, stain the tooth, and/or transilluminate to locate the crack. Magnification may be helpful in determining the extent of the crack.

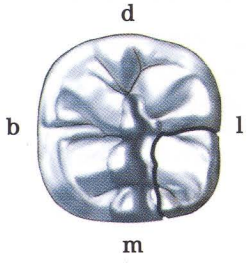


Figure 7a
Occlusal view of *fractured cusp.*

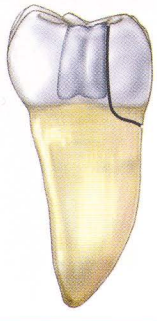


Figure 7b
Mesial view of *fractured cusp.*

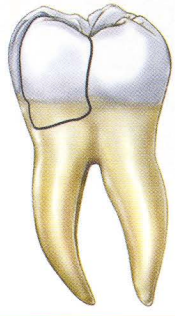


Figure 7c
Lingual view of *fractured cusp.*

Diagnostic clues

Class II restorations or extensive caries can contribute to weakened marginal ridges. Pain is mild and occurs only to stimulus. Generally, bite tests will elicit brief, sharp pain, especially with release of biting pressure. Tapping on selective tooth margins and cusps may help identify the area of the crack. The pulp is usually vital. Radiographs are inconclusive. The affected cusp may break off during restoration removal, possibly resulting in relief of symptoms when the cusp breaks off.

Treatment

The tooth is treated by removing the affected cusp and restoring the tooth with a full crown that covers the crack margin. Root canal treatment is only necessary in the rare event that the crack affects the pulp chamber or has resulted in irreversible pulpitis.

A word about prevention—

Prompt restoration with full cuspal coverage can help prevent *fractured cusp, cracked tooth,* and *split tooth* in endodontically treated molars and premolars.

Cracked tooth

This crack extends from the occlusal surface of the tooth apically without separation of the two segments. Occlusally, the crack is more centered than a *cusp fracture* and, therefore, more likely to cause pulpal and periradicular pathosis as it extends apically (Figure 8). *Cracked tooth* occurs most commonly in mandibular molars, followed by maxillary premolars.

The crack may cross one or both marginal ridges and is most often mesiodistal, shearing toward the lingual root surface. The crack may be buccal-lingual in mandibular molars. *Cracked tooth* does not occur in anterior teeth and rarely in mandibular premolars.

The signs and symptoms of a *cracked tooth* will vary significantly depending on the progress of the crack.

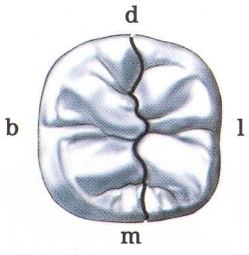


Figure 8a
Occlusal view of *cracked tooth* affecting both mesial and distal marginal ridges.

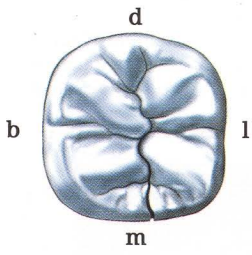


Figure 8b
Occlusal view of *cracked tooth* affecting only the mesial ridge.

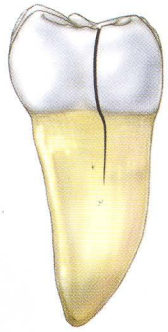


Figure 8c
Mesial view of *cracked tooth.* While the crack shown here extends to mid-root, *cracked tooth* cracks may or may not extend into the root. They may extend more apically than shown here but do not completely separate the tooth into two segments.

Differential diagnosis

In its early stages, the crack will probably be invisible to the naked eye and impossible to disclose with staining. The *cracked tooth* may only exhibit acute pain on mastication or, possibly, sharp, brief pain to cold. Unless the crack has progressed to involve the pulp or periodontal tissues, it may be impossible to distinguish from a *cusp fracture. Craze lines* may be differentiated by transillumination. (In the case of *craze lines,* light will be transmitted throughout the tooth. In the case of *cracked tooth,* the crack will block and reflect the light. See Figure 4 on page three.)

The restorative history of the tooth, while diagnostically helpful for *cusp fracture,* is not as helpful with *cracked tooth.* Restorations can contribute to *cracked tooth,* and the crack may be evident across the cavity floor after a restoration is removed (see Figure 3 on page three). However, unrestored teeth that are free of caries and teeth with conservative restorations frequently experience these cracks. Teeth with class I restorations crack as frequently as those with class II restorations.

If a crack can be detected, test for movement of the segments to differentiate a *cracked tooth* from a *fractured cusp* or *split tooth.* A *fractured cusp* may break off under slight pressure, while the segments will remain in place, but will separate if the diagnosis is *split tooth.*

Position of the crack may also help differentiate a *cracked tooth* from a *fractured cusp.* The *cracked tooth* crack occurs more toward the center of the occlusal surface than the *cusp fracture.* More centered cracks tend to go deeper toward the apex before completely separating the tooth into two segments.

If the crack has progressed to involve the pulp or periodontal tissue, the patient may have thermal sensitivity that lingers after removal of the stimulus or slight to very severe spontaneous pain consistent with irreversible pulpitis, pulp necrosis, or apical periodontitis. There may even be pulp necrosis with periradicular pathosis.

Treatment planning

The *cracked tooth* treatment plan will vary depending on the location and extent of the crack. Even when the crack can be located, the extent is still difficult to determine. Endodontic treatment is often indicated, followed by a full crown to bind the cracked segments and protect the cusps. However, many factors can affect prognosis, and each of these must be carefully considered before proceeding with treatment:

Periodontal probing:

- Absence of a defect does not rule out the presence of a crack.
- Deep probing indicates an adverse prognosis.

Radiographic examination:

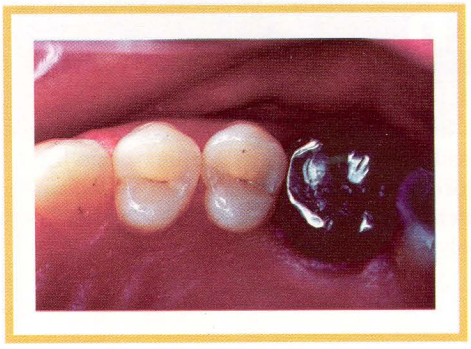
- Findings will depend on pulpal and periradicular status but are usually not significant.
- Vertical or furcal bone loss may indicate a severe crack.

Pulp and periradicular tests should be performed:

- If pain to chewing is the only symptom, a tight-fitting band or temporary crown may be cemented to help confirm a *cracked tooth* diagnosis (Figure 9). The band serves as a splint, holding the crack together. If banding resolves pain to chewing, a full coverage restoration may keep the tooth pain free. If pain continues after banding, further evaluation of the extent of the crack and pulpal and periradicular status should be performed.
- Any thermal sensitivity probably indicates that the crack extends near or into the pulp, and root canal treatment will be necessary prior to restoring the tooth with a crown.

Endodontic access—the practitioner may choose to create an endodontic access to determine whether the pulpal floor is cracked. However, the practitioner should not try to chase down the extent of the crack with a bur, because the crack becomes invisible long before it terminates and sound dentin will be sacrificed unnecessarily. Staining the access cavity may help disclose the crack. Magnification and illumination may help confirm the presence of a crack on the pulpal floor.

- If the crack is visible only partially across the chamber floor, the dentist may choose to band the crown or place a temporary crown to protect the cusps until root canal treatment can be completed and a permanent restoration placed.
- If the crack extends the full width of the chamber floor, the prognosis is very poor and the practitioner should consider extraction. In rare cases, resection along the crack may be considered for strategically important maxillary molars.
- If the crack is visible across the chamber floor and there is a deep periodontal defect, prognosis is generally hopeless.



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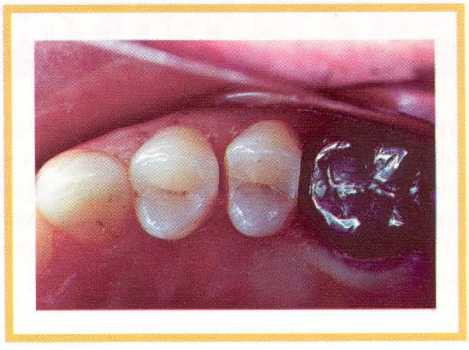

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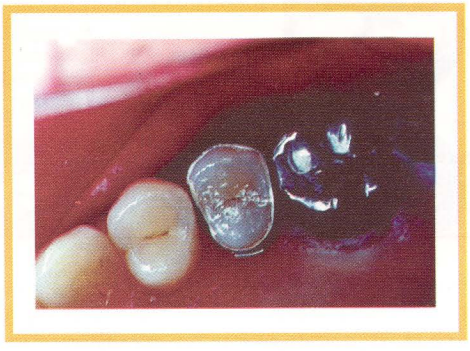
Figure 9 A cracked second premolar (a) is prepared for banding (b). A band is cemented in place (c) and the tooth is monitored for relief of symptoms. If the crack has not yet reached the pulp chamber, banding should relieve the patient's discomfort. If symptoms persist, the pulpal status of the tooth should be evaluated, and root canal treatment may be necessary (d).



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9d

Endodontic and restorative safety precautions

If a crack has been diagnosed, the practitioner may consider protecting the tooth with a band or temporary crown prior to endodontic treatment. In addition, care should be taken during root canal obturation to avoid excessive wedging forces that may cause the crack to spread. Cores of dentin bonding materials may help prevent the crack from spreading. Posts can exert wedging forces and should be avoided.

Prognosis

In all cases of *cracked tooth,* the patient should be fully informed that the prognosis is questionable at best.

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. Patients should be advised, however, that cracks may continue to progress and separate. Although treatment will succeed in many cases, some *cracked teeth* may eventually evolve into *split teeth* and require extraction. Placement of a full crown, while providing optimum protection for the tooth, does not guarantee success.

Split tooth

These cracks are usually mesiodistal, cross both marginal ridges, and split the tooth completely into two separate segments (Figure 10). A crack that is more centered on the occlusion will tend to extend more apically. Most often, the *split tooth* is the result of long term progression of a *cracked tooth.*

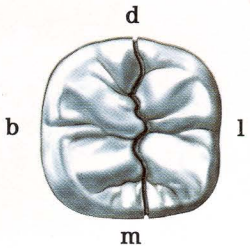

Figure 10a
Occlusal view of *split tooth.*

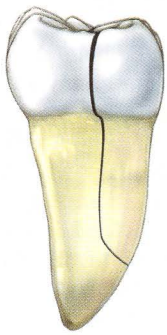

Figure 10b
Mesial view of *split tooth.*

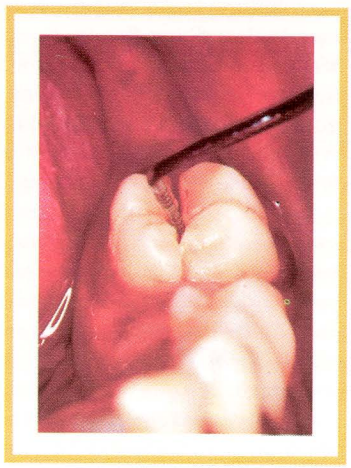

Figure 11
The segments of a *split tooth* are generally easy to separate with a probe.

A *split tooth* is identified by a readily apparent or easily disclosed crack with segments that separate when probed with an explorer (Figure 11). Patients will usually complain of marked pain to chewing and significant soreness of the jaw or gums. Periodontal involvement, however, may result in a mistaken diagnosis of periodontal abscess.

Split teeth can never be saved intact, but the position of the crack and its extent apically will determine the prognosis and treatment. An extremely mobile segment may indicate that the split surfaces in the middle to coronal third of the root. In many of these cases, the smaller segment can be removed and the remaining segment restored. If the crack extends more apically, treatment would result in a deep periodontal defect, and extraction is indicated.

Vertical root fracture (VRF)

Figure 12a
Lingual view of a *vertical root fracture*

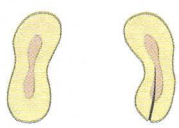

Figure 12b
Horizontal cross section of a *VRF* affecting only the lingual root surface.

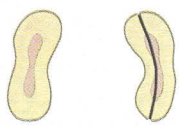

Figure 12c
Horizontal cross section of a *VRF* affecting both the buccal and the lingual root surfaces.

Vertical root fractures begin in the root, usually in the buccal-lingual plane. A VRF may extend the length of the root or occur as a shorter crack at any level along the root. The crack may or may not extend to both buccal and lingual surfaces (Figure 12).

Because *VRFs* present minimal signs and symptoms, they generally go unnoticed until periradicular pathosis occurs. Then, they are very difficult to diagnose because they mimic other conditions. Because the recommended treatment is almost exclusively extraction or removal of the cracked root, care must be taken to avoid incorrect diagnosis. However, because *VRF* may mimic periodontal disease or failed root canal treatment, these cases often result in referral to a periodontist or endodontist for evaluation.

Etiological factors

Many causes for vertical root fracture have been suggested. Two have been demonstrated—post placement and excessive compaction force during root canal obturation. Roots that are wide facially and lingually but thinner mesially and distally tend to fracture more often. Examples would be—mandibular incisors and premolars, maxillary second premolars, mesiobuccal roots of maxillary molars, mesial and distal roots of mandibular molars. Roots of maxillary central incisors, lingual roots of maxillary molars, and maxillary canines tend to be rounder and more resistant to VRF.

Diagnostic clues

Patients typically present with only mild signs and symptoms. The tooth may or may not be mobile. A periodontal abscess may be present or in the patient's dental history. Virtually all *VRFs* have a history of root canal treatment.

Periodontal probing can be helpful. Because the crack may occur at any level along the root and may not reach from apical to cervical, some *VRFs* show normal probing patterns. However, most will allow deep probing in narrow or rectangular patterns typical of *cracked tooth* lesions. Deep probing may be only on the facial or lingual aspect or on both. Percussion and palpation tests may be inconclusive.

Radiographic evidence varies. Only rarely will there be visible separation of the segments. Marked bone resorption from the apex along the lateral root surface can indicate a *VRF (Figure 13)*. Such resorption may or may not extend to the cervical region. The appearance of a radiolucency may be mistaken for root canal treatment failure.

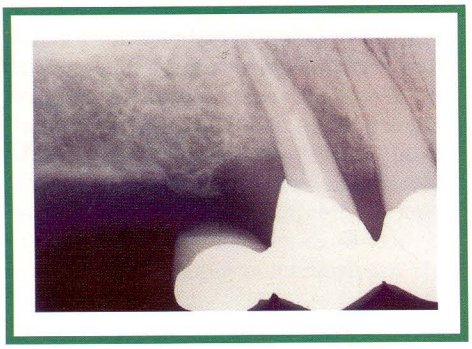

Figure 13 Marked bone resorption from the apex along the lateral root surface(s) may indicate a *vertical root fracture.*

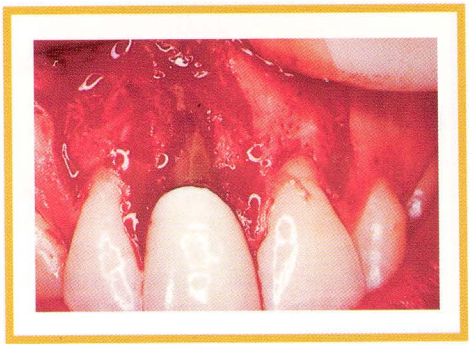

Figure 14 When the inflammatory tissue was removed from this dehiscence, the *vertical root fracture* was easy to see.

Surgical assessment

Vertical root fracture may require surgical inspection for conclusive diagnosis. When soft tissue is reflected, a "punched-out" oblong bony defect filled with granulomatous tissue overlying the root is characteristic. The defect may be a dehiscence or a fenestration. When the inflammatory tissue is removed, the crack is usually evident (Figure 14). In some cases, a crack may be detected when a resected root end is examined under magnification. Even if the crack is not readily detectable, the characteristic bony defect is usually considered conclusive evidence.

Treatment

Depending on the type of tooth affected, *VRF* treatment may involve extraction, root resection, or hemisection. Researchers are looking into new treatments, but, as yet, no method of saving the cracked root has proven practical or effective long term.

Summary

The American Association of Endodontists (AAE) hopes this issue of *ENDODONTICS: Colleagues for Excellence* will help resolve some of the confusion surrounding tooth cracks. In addition to clearly describing five tooth crack types, we have reviewed in detail the steps involved in crack confirmation. Our goals are to help individual practitioners with diagnosis and treatment planning and to foster clearer communication.

The AAE neither expressly nor implicitly warrants any positive results nor expressly nor implicitly warrants against any negative results associated with the application of this information. Practitioners must always use their best professional judgment in individual situations. There is no guarantee of success in every case.

If you would like more information about tooth cracks, call your local endodontist or contact the American Association of Endodontists, 211 E. Chicago Ave., Ste. 1100, Chicago, IL 60611-2691, 312/266-7255, fax 312/266-9867, e-mail esargis@aae.org.

References are available upon request.

New posts may reduce stress on root, help prevent vertical root fracture

Studies have confirmed that root stress caused by post and core restorations can predispose endodontically treated teeth to vertical root fracture. In the last twenty years, passive prefabricated metal posts—usually stainless steel or titanium — have become the most popular method when insufficient coronal tooth structure remains to retain the core. Passive prefabricated posts of the proper length, size, and design for the tooth in question generally place less stress on the surrounding dentin than cast posts and cores or threaded posts that engage dentin.

However, metal posts respond differently to occlusal stresses than natural tooth structure does. Even when passively placed, these posts can cause added stress on surrounding dentin. In addition, when post and tooth respond differently to occlusal forces, the cement interface can be compromised, resulting in loosening of the post.

Researchers are experimenting with new post materials and designs that may solve or minimize these problems. Several studies reporting on the properties and performance of carbon fiber posts, for instance, demonstrate that promising exploration is underway.

Made from microscopic strands of carbon embedded in an epoxy resin, carbon fiber posts are bonded to tooth structure and a composite resin core with resin cement. Manufacturers claim that the post and complete restoration respond similarly to dentin under certain occlusal stresses.

Independent scientific research indicates that carbon fiber posts may be a suitable alternative in some cases. Corrosion is not an issue, and, especially when serrated, retention can be comparable to stainless steel posts of similar design. If failure of carbon fiber post restorations does occur, it may be more likely to affect the coronal tooth structure or cement interface, rather than the root, leaving the tooth in suitable condition for endodontic and restorative retreatment.

While initial research indicates that carbon fiber posts may become an important addition to the dental armamentarium, further scientific and clinical studies of this and other alternatives are needed to demonstrate long-term effectiveness. In all cases where sufficient tooth structure remains, however, restoring the tooth without a post is still the best option.

Comments? Did you enjoy this issue of *ENDODONTICS*? Did the information have a positive impact on your practice? Are there topics you would like *ENDODONTICS* to cover in the future? We want to hear from you! Please take two minutes to complete and mail the enclosed postage-paid response card so that we can make the *ENDODONTICS* newsletter even more helpful in the future. Thanks.

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