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Colleagues for Excellence

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Cracking the Cracked Tooth Code: Detection and Treatment of Various Longitudinal Tooth Fractures

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This newsletter is intended to help resolve some of the confusion surrounding tooth cracks and fractures from a specialist's perspective. The goal is to help general practitioners with diagnosis and treatment planning, and to foster clearer communication between members of the dental team. This review investigates diagnostic and treatment challenges related to tooth fractures primarily in the long axis of the crown and/or root. This includes how to determine the extent of longitudinal fractures, when a coronal restoration should be placed, when root canal treatment is needed, and when a tooth or root should be extracted based on the location and extent of the fracture.

The term longitudinal fracture is used because it typically represents vertical extensions of fractures over distance and time. These linear fractures tend to grow and change as opposed to those resulting from impact trauma, thus there are often problems with diagnosis and treatment. Cracks in teeth are findings that are to be detected in terms of location and extent. Crack detection is one aspect of a thorough diagnostic evaluation, but the presence of a crack alone does not provide information on the status of the pulp or periapical tissues; other diagnostic tests must be performed to determine a diagnosis. Practitioners must be aware that the major problem with having a crack in a tooth is the potential for bacterial penetration, which could lead to inflammation and disease. Therefore, cracks present in teeth are findings only; they are not to be considered a pulpal or periapical diagnosis.

With these considerations, many teeth with cracks can be saved! The keys to saving these teeth are to know:

1. How to identify and classify cracks;
2. The characteristic signs and symptoms; and
3. How to detect the crack as early in its development as possible.

Defining Crack Types

The location, direction and extent of a crack have a profound effect on the choice of treatment, so clarity is important. For consistency in this newsletter, the five types of longitudinal tooth fractures are described as follows:

- Craze Lines
- Fractured Cusp
- Cracked Tooth
- Split Tooth
- Vertical Root Fracture

Lack of knowledge concerning the type, characterization and variety of fractures may lead to misunderstanding with incorrect diagnosis and inappropriate treatment. These five categories of longitudinal fractures have been devised to provide global definitions that researchers and clinicians can use to decrease this confusion. Only after these fractures have been defined and characterized can there be a better understanding of their epidemiology; this review will show how each longitudinal fracture classification is different, especially related to prognosis and treatment modalities.

Craze lines affect only the enamel, while fractured cusps, cracked teeth and split teeth begin on the occlusal surface and extend apically, affecting enamel, dentin, and possibly, the pulp. Vertical root fractures begin in the root. All types except craze lines are found most often in posterior teeth. Unlike a broken

bone, the fracture in a cracked tooth will never heal.

Each of the cracks and fractures discussed in this review have all been referenced in dental literature as "vertical fractures;" particularly those that involves the tooth root, whether originating from the coronal (enamel) or apical (root) portion of the tooth. The interchangeable use of these terms is not appropriate because it causes significant confusion clinically. There are distinct delineations as fractured cusps and vertical root fractures imply a complete or incomplete break of the tooth; craze lines and cracked teeth are only incomplete breaks in teeth; and split teeth are only complete breaks in teeth. Note too that the terms "crack," "fracture" and "fractured line" tend to be incorrectly used in place of each other throughout literature (see Online Bonus Materials A and B for more information).

Classic Signs, Classic Confusion

Cracks in teeth often manifest as the so-called "cracked tooth syndrome." This syndrome is characterized by acute pain on mastication (pressure or release) of grainy, tough foods and sharp, brief pain with cold. These findings are also related to cusp fracture. However, cracked teeth may present with a variety of symptoms ranging from slight to very severe spontaneous pain consistent with irreversible pulpitis, pulp necrosis or apical periodontitis. Even an acute apical abscess, with or without swelling or a draining sinus tract, may be present if the pulp has undergone necrosis. In other words, once the fracture has extended to and exposed the pulp, severe pulp and/or periapical pathosis will likely be present. This explains the variation in signs and symptoms, and therefore, should not be termed a syndrome.

The Obvious and the Obscure: Steps for Crack Detection and Confirmation

If you do not look for cracks and fractures in teeth, you will likely not find them. If a crack is suspected, several steps should be taken to confirm the suspicion.

These steps include (see Online Bonus Material C for more details):

- Dental History
- Subjective Examination
- Objective Visual Examination
- Tactile Examination
- Periapical Tests
- Bite Tests
- Vitality Testing
- Periodontal Probing
- Radiographic Examination
- Restoration Removal
- Staining
- Transillumination
- Wedging Forces
- Surgical Assessment

Fig. 1. Craze lines, such as those on the occlusal surface of this tooth, are sometimes mistaken for other types of cracks.

Classification of Longitudinal Tooth Fractures

Craze Lines

When examining teeth for cracks, keep in mind that most adult teeth have craze lines. In posterior teeth, craze lines are usually evident crossing marginal ridges and extending along buccal and lingual surfaces (Figure 1).

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Long vertical craze lines commonly appear on anterior teeth. As they only affect the enamel, they cause no pain and are of no concern beyond the aesthetic.

Diagnostic Clues Craze lines are frequently confused with cracks, but can be differentiated by transillumination. If the tooth is cracked, the light will be blocked, allowing only a segment of the tooth structure to light up; if the tooth only has a craze line, the entire tooth structure will light up. (See Online Bonus Material D for more information on transillumination.)

Cuspal Fracture

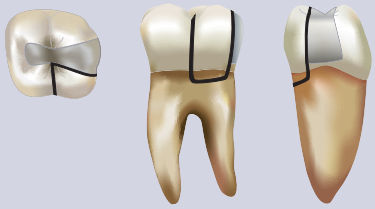

Fig. 2. Occlusal, lingual and distal/proximal views of a fractured cusp involving the distolingual cusp of the mandibular right molar. A restoration is typically present; usually one cusp is involved and the fracture is not centered as viewed from the proximal.

Fractured Cusp The term fractured cusp is defined as a complete or incomplete fracture initiated from the crown of the tooth and extending subgingivally, usually directed both mesiodistally and buccolingually. The fracture usually involves at least two aspects of the cusp by crossing the marginal ridge and also extending down a buccal or lingual groove. The fracture will extend to the cervical third of the crown or root (Online Bonus Material A and Figure 2).

Treatment Planning Depending upon the amount of remaining tooth structure, the tooth is treated by removing the affected cusp and restoring with a direct or a cuspal-reinforced restoration (full crown or onlay) that covers the crack margin. Dentin and enamel bonding with adhesive resins, if placed with special techniques, have been shown to reinforce a weakened tooth structure and provide cuspal protection. Root canal treatment or vital pulp therapy is only necessary in the event that the crack affects the pulp chamber or has resulted in irreversible pulpitis.

Cracked Tooth Progression To Split Tooth

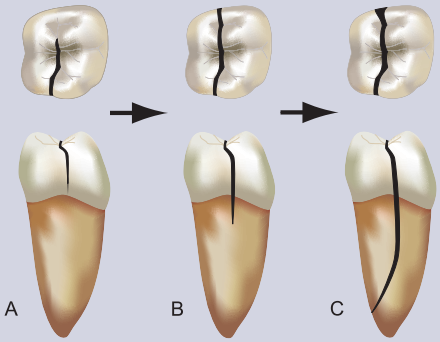

Fig. 3. (A) Occlusal and distal/proximal views of a cracked tooth affecting the distal marginal ridge of the mandibular right molar; the crack has not yet extended onto the root. (B) Growth/propagation of the crack to include both mesial and distal marginal ridges and extending onto the distal root surface; a restoration is usually not present and the crack is more centered as viewed from the proximal. (C) Further propagation results in a split tooth in which a separable segment is detected; mesial and distal marginal ridges are involved and the fracture extends deeply in the root.

Cracked Tooth A cracked tooth is defined as an incomplete fracture initiated from the crown and extending subgingivally, usually directed mesiodistally. The fracture may extend through either or both of the marginal ridges and through the proximal surfaces. The fracture is located in the crown portion of the tooth only or may extend from the crown to the proximal root (Online Bonus Material A and Figure 3). Cracked teeth are described as incomplete (greenstick) fractures, which also describes their form. Occlusally, the crack is more centered and apical than a fractured cusp and, therefore, more likely to cause pulpal and periapical pathosis as it extends apically (Figure 3).

Diagnostic Clues If a crack can be detected, use wedging to test for movement of the segments to differentiate a cracked tooth from a fractured cusp or split tooth. No movement with wedging forces implies a cracked tooth. A fractured cusp may break off under slight pressure with no further mobility. A split tooth will show mobility with wedging forces and the mobile segment extends well below the cemento-enamel junction.

Treatment Planning The cracked tooth treatment plan will vary depending on the location and extent of the crack, which can be difficult to determine. Performing root canal treatment must be dependent on

the determination of pulpal and periapical diagnosis. A tooth with a minimal crack requires root canal treatment only if the diagnosis indicates a need for it; a tooth with an extensive crack of long duration is more likely to require root canal treatment, but only if the diagnosis indicates. Therefore, pulpal and periapical diagnosis (not just crack detection) determines the treatment plan.

If a crack is evident on the cavity floor and/or proximal external surface, the following should be considered:

- **Cavity Floor—**Removal of the fracture line only in the area of the cavity floor that would include the initiation of an ideal endodontic access opening is helpful in determining the apical extent of the crack and whether the pulp is involved (Figure 4). However, keep in mind that the fracture is small and invisible at its furthest extent (even after staining), and likely continues deeper into the dentin than can be visualized.
- **Proximal Surface—**Removal of the fracture line on the proximal external surface portion of the tooth below the level of the cement-enamel junction is not usually indicated. More information on the extent of the crack may be obtained, but it also is likely to cause the tooth to become nonrestorable. Removal of the proximal marginal ridge and tooth structure associated with the fracture takes away sound tooth structure, thereby decreasing tooth strength and resistance to fracture. However, keep in mind that not removing the crack on the proximal surface may allow bacterial penetration to continue, which could eventually lead to the need for root canal treatment or extraction.

Prognosis

In cases of cracked teeth, the patient should be fully informed that the prognosis is questionable. This is not yet based on research evidence, but is based on the principle that it is better to inform and prepare patients for the potential for failure, especially since these fractures have a tendency to grow with time. 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 cuspal-reinforced restoration, while providing optimum protection for the tooth, does not guarantee success, but is certainly beneficial in most cases.

Only recently have studies been published that outline chances for successful outcomes for cracked teeth, but they have been limited and only for specific conditions. One 2006 study evaluated a small number (n=50) of root-filled cracked teeth with a diagnosis of irreversible pulpitis and determined a two-year survival rate of 85.5 percent. This study indicated that the only significant prognostic factors were teeth with multiple cracks, terminal teeth in the arch and pre-root filling pocketing. Another study done in 2007 evaluated 127 patients with teeth diagnosed with reversible pulpitis that had a cracked tooth. The treatment was placement of a crown restoration without performing root canal treatment. Twenty percent of these cases converted to irreversible pulpitis or necrosis within six months and required root canal treatment, with none of the other teeth requiring root canal treatment over a six-year evaluation period.

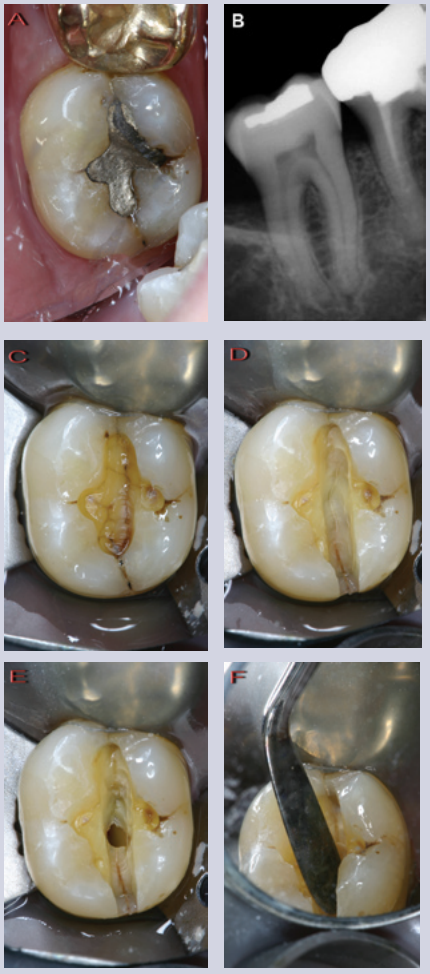

Fig. 4. A cracked tooth involving the mesial and distal marginal ridges of a mandibular second molar (A). Radiograph (B) confirms a small restoration, but no evidence of the crack since this is a two-dimensional representation of a three-dimensional object. After removal of the amalgam restoration, the crack is visualized on the floor of the cavity preparation (C). Removal of dentin along the crack is continued (D) resulting in exposure of the pulp (E). Wedging forces (F) resulted in no movement of the tooth segments indicating an incomplete fracture. *Reprinted with permission from Torabinejad and Walton, Endodontics: Principles and Practice 4th ed, Saunders/ Elsevier 2009.*

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Prognosis is more variable with cracks than with other types of longitudinal fractures. Determining the position and extent may be helpful in determining when to recommend extraction with replacement by a fixed or removable bridge, or an implant.

Treatment of Extensively Cracked Teeth

A crack that is not separable and extends deeply in the root and/or involves the furcation remains one of the most difficult sitations for determining treatment. A cuspal-reinforced restoration (full crown or onlay) to bind the cracked segments and protect the cusp is indicated unless the tooth is to be extracted. Again, pulpal and periapical diagnosis (not just crack detection) determine the final treatment plan. Many factors (i.e., periodontal probing, radiographic examination, need for banding to evaluate reduction of symptoms, etc.) can affect prognosis, and each of these must be carefully considered before proceeding with treatment. While the final determination of the extent of a crack is difficult in these situations, the authors recommend informing the patient of the findings and prognosis, and providing all treatment alternatives.

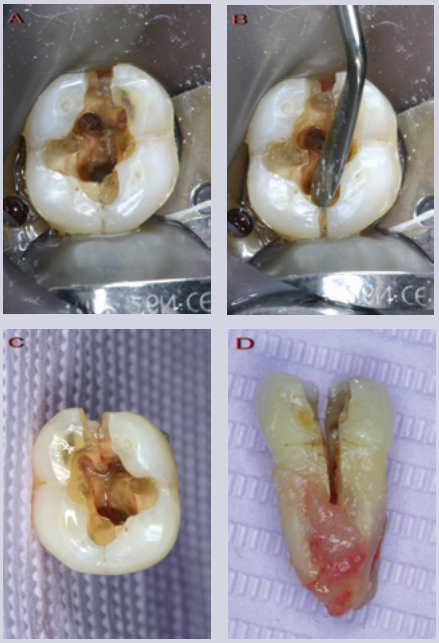

Fig. 5. Split tooth is visualized (A) and confirmed by using wedging forces (B), which resulted in separation of the tooth segment. The extracted tooth (C) highlights the fracture line extending from the mesial marginal ridge, through the floor of the cavity preparation, also involving the distal marginal ridge. The proximal view of the extracted tooth (D) shows a complete fracture that extends deeply to the root surface with infiltration of granulomatous tissue. *Reprinted with permission from* Endodontic Topics.

Split Tooth The term split tooth is defined as a complete fracture initiated from the crown and extending subgingivally, usually directed mesiodistally through both of the marginal ridges and the proximal surfaces. The fracture is located coronally and extends from the crown to the proximal root (Online Bonus Material A and Figure 3). A crack that is more centered on the occlusion will tend to extend more apically. A split tooth is the evolution (end result) of a cracked tooth; the fracture is now complete and extends to a surface in all areas. The root surface involved is in the middle or apical third, usually extending toward the lingual. There are no dentin connections; tooth segments are now entirely separate (Figure 5). The split may occur suddenly, but it more likely results from long-term growth of an incomplete cracked tooth (Online Bonus Material A).

Treatment Planning Split teeth can never be saved intact, but the position of the crack and its extent apically will determine the prognosis and treatment. If the fracture is severe (that is, deep apically), the tooth must be extracted. If the fracture shears to a root surface that is not too far apical (middle to cervical third of the root), the smaller segment will be very mobile. Then there is a good possibility that the small segment can be removed and the remainder of the tooth salvaged.

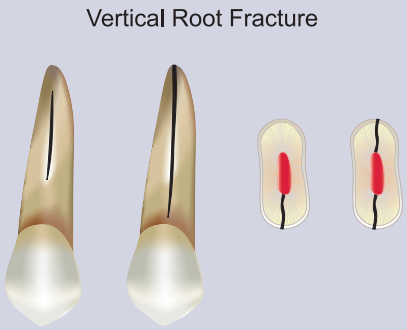

Fig. 6. Facial view of a vertical root fracture, a horizontal cross-section of a VRF affecting only the lingual root surface, and a horizontal cross section of a VRF affecting both the buccal and the lingual root surfaces; root canal-filling material is shown in the canal space.

Vertical Root Fracture A "true" vertical root fracture is defined as a complete or incomplete fracture initiated from the root at any level, usually directed buccolingually. The fracture may involve one proximal surface (buccal or lingual) or both buccal and lingual proximal surfaces. The fracture is located in the root portion of the tooth only, and may extend coronally toward the cervical periodontal attachment (Online Bonus Material A and Figure 6). A review of vertical root fractures has been recently published. 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 6).

Diagnostic Clues Patients with VRFs typically present with minimal signs and symptoms, so they generally go unnoticed until periapical pathosis occurs. Then they are very difficult to diagnose because they mimic other conditions. The recommended treatment is almost exclusively extraction or removal of the cracked or fractured root, but 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. Virtually all VRFs have a history of root canal treatment. Some show normal probing patterns, however, most will allow deep probing in narrow or rectangular patterns typical of cracked tooth lesions. Radiographic evidence varies; only rarely will there be visible separation of the segments (Figure 7).

Fig. 7. Classic appearance of a vertical root fracture, although rarely visualized so evidently on the radiograph, showing a tooth that has been root-filled with post placement, separation of the distal root into segments, and a large radiolucency involving the apex, mid-root and furcation of the distal root.

Newer methods of analysis are currently being studied, such as cone beam-computerized tomography, in order to help identify longitudinal fractures in a nondestructive fashion. Having a sinus tract and a narrow, isolated periodontal probing defect in association with a tooth that has had root canal treatment, with or without a post placement, is considered to be pathonomonic for the presence of a VRF.

Treatment Planning The only predictable treatment is removal of the fractured root or extraction of the tooth. In multirooted teeth, removal of the fractured root may be performed by root amputation (root resection) or hemisection. Researchers are looking into new treatments, but no method of saving the fractured root has proven practical or effective as yet.

Prevention Because the causes of VRF are well known, prevention is not difficult. The cardinal rules for safety are to:

1. avoid excessive removal of intraradicular dentin; and
2. minimize internal wedging forces.

Compaction/condensation of root canal filling materials should be carefully controlled. Posts weaken roots and should not be used unless they are necessary to retain a foundation. (See Online Bonus Materials E and F for more information.)

Summary The American Association of Endodontists hopes this issue of *ENDODONTICS: Colleagues for Excellence* will help resolve some of the confusion surrounding tooth cracks. Quick action on the part of practitioners can improve the chances of saving the tooth. If a crack is suspected, the steps outlined above and detailed in the bonus materials should be taken immediately to confirm the presence of a crack, determine the type and formulate an appropriate treatment plan. If you have any additional questions or concerns, your local endodontist is always available as an ongoing resource. To access an extensive reference list, please visit the AAE Web site at *www.aae.org/dentalpro/clinicaltopics*.

AAE COLLEAGUES ONLINE

Exclusive Bonus Materials

This issue of the *ENDODONTICS: Colleagues for Excellence* newsletter is available online at *www.aae.org* with the following **exclusive bonus material:**

A. Classification of Longitudinal Tooth Fractures Table

B. Clinical Determination of Cracks and Fractures Based on Location and Separable Segments (Including Treatment) Chart

C. The Obvious and the Obscure: Steps for Crack Detection and Confirmation

D. Transillumination: The "Light Detector"

E. More Information on Post Placement in Endodontically Treated Teeth With Longitudinal Tooth Fractures

F. Reference List

G. A detailed, unabridged version of this newsletter

H. "Ask the Authors" Discussion Board for all of your questions and comments

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Do you have questions for the author? Visit the Dental Professionals section of the AAE Web site at *www.aae.org/dentalpro/clinicaltopics,* and click on the link for this issue of *ENDODONTICS: Colleagues for Excellence.* Questions and comments for the author can be posted to a special discussion board dedicated to this topic.

The information in this newsletter is designed to aid dentists. Practitioners must use their best professional judgment, taking into account the needs of each individual patient when making diagnosis/treatment plans. The AAE neither expressly nor implicitly warrants against any negative results, associated with the application of this information. If you would like more information, consult your endodontic colleague or contact the AAE.

Did you enjoy this issue of *ENDODONTICS*? Are there topics you would like *ENDODONTICS* to cover in the future? We want to hear from you! Send your comments and questions to the American Association of Endodontists at the address below.

Endodontists
the root canal specialists

American Association of Endodontists
211 E. Chicago Ave., Suite 1100
Chicago, IL 60611-2691
info@aae.org • www.aae.org