ARTICLE 3

MANAGING INCOMPLETE TOOTH FRACTURES

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A B S T R A C T

Background. The author presents an evidence-based protocol for the diagnosis and treatment of incomplete tooth fractures. It is designed to help dentists recognize fractures, distinguish between restorable and nonrestorable fractures, and follow a rational approach to treatment.

Overview. An incomplete tooth fracture is a frequently encountered problem that dentists need to assess carefully to arrive at the correct treatment decision. The author presents a review of representative literature corroborating the assertions made in the evidence-based protocol. Treatment approaches are presented for each of two major fracture types.

Clinical Implications. Dentists need to be aware of the classic symptoms of incomplete tooth fracture, the methods used in formulating a differential diagnosis, criteria for determining pulpal status and restorability, iatrogenic factors involved in the etiology of incomplete fracture, and the consequences of inadequate diagnosis or treatment.

An incomplete tooth fracture is a source of pain and dysfunction for patients and presents diagnostic, restorative and endodontic challenges to dentists. Incomplete fractures may present as asymptomatic fracture lines visible in or through enamel, or be highly symptomatic and either visible or invisible to inspection. If they are allowed to progress to their natural conclusion, such fractures may result in sequelae ranging from cuspal fractures—requiring a simple cusp replacement restoration—to partial or complete root fractures, the more serious of which will render the tooth nonrestorable. Unless the dentin involvement is fairly superficial, incomplete fractures usually cause teeth to become highly symptomatic, with a typical response being extreme thermal sensitivity and pain on biting. Determining the exact nature and extent of the fracture, the restorability of the tooth, and the reversibility of the pulpal response are the dentist's challenge.

DIAGNOSIS OF INCOMPLETE FRACTURES

Symptoms. A vital tooth with an incomplete dentin fracture typically will exhibit a sudden onset of acute sensitivity to thermal changes, always to cold and sometimes to heat. Patients will complain of pain when chewing on the side of the mouth where the fractured tooth is, especially when chewing tough foods and often something as innocuous as salad. The pain will not be relieved by the application of desensitizers. On occasion, the pain will follow placement of a new restoration.

An endodontically treated tooth with a dentin fracture may exhibit only symptoms of a vague tenderness when chewing. Because these symptoms tend to occur only after involvement of the periodontal ligament, most fractured endodontically treated teeth are nonrestorable by the time symptoms occur. To eliminate confusion, the following discussions in this article will relate only to vital teeth or nonvital teeth that have not received endodontic treatment.

Differential diagnosis. Symptoms related to incomplete tooth fracture can be confused with symptoms of a fractured restoration or caries under a restoration, both of which can be detected by radiographic or visual examination. Microleakage also may produce thermal sensitivity, which may be associated with pain on biting as the restoration deforms under loading.[1-3] A radiograph normally will not show an incomplete dentin fracture unless the fracture is severe and is oriented in the buccolingual direction. Incomplete fractures most commonly occur in teeth

Figure 1. Premolar with a vertical fracture (arrows) extending over both marginal ridges and across the pulpal floor.

that have been restored with nonbonded metallic restorations.[4,5] A simple test for locating a fractured tooth is to have the patient bite on a cotton roll. A tooth with an incomplete dentin fracture may respond with pain when biting, when releasing or both. Individual cusps can be tested for underlying fracture by having the patient bite on a fracture detector such as Tooth Slooth (Professional Results Inc.) or Fracfinder (Denbur).[6] Testing cusps for pain response also may serve to differentiate pain caused by fracture from pain caused by microleakage; the latter type of pain is more likely to be elicited by applying pressure to the restoration. Fractures sometimes are visible over the marginal ridges on the proximal surfaces, vertically between cusps or horizontally through the enamel on the facial or lingual aspects.

Fractures may be vertical or oblique in nature. Vertical fractures are located midtooth, usually running in a mesiodistal direction (Figure 1), although buccolingual vertical fractures do occur. Oblique fractures normally originate at the internal line angles of intracoronal preparations and result in cuspal fracture, with or without root involvement, if they are permitted to progress to a natural conclusion. Both types of fractures produce similar symptoms and will respond similarly to pressure tests; vertical fractures, however, may cause all cusps on the tooth to be pressure-sensitive. Vertical fractures are more likely than oblique fractures to cause direct pulpal involvement and, without timely intervention, are more likely to render the tooth nonrestorable as root involvement occurs.

While teeth with mesiodistal vertical dentin fractures normally display a vertical fracture in the marginal ridge enamel, not all teeth with fractures in the marginal ridge enamel have accompanying vertical dentin fractures. The distinction is important, as proximal enamel fractures are relatively common, often do not have symptoms and may not require treatment in the absence of dentin fracture or caries. An effective way to distinguish between a proximal enamel fracture and a vertical dentin fracture with enamel involvement is to transilluminate the tooth using a fiber-optic light.[7,8] A vertical dentin fracture causes the light beam to bend, and light does not pass through to the other side of the tooth. Light passes freely through a tooth without dentin fracture. Presence of deep metallic restorations can make the use of this test problematic, because they block light transmission.

Diagnostic aids. Common aids used to diagnose incomplete tooth fractures include vision enhancers, symptom reproducers and radiographs.

Vision enhancers are devices, materials or methods that enhance dentists' ability to see a fracture or visually determine the extent of a fracture. Magnifying loupes are needed to inspect both the external and internal surfaces of teeth with suspected fractures. If available, microscopes can be used to inspect endodontic access cavities of teeth with fractures. Transilluminators and fiber-optic light sources are excellent fracture detectors, as light bends across fractures and refracts along fracture lines. Dyes, such as methylene blue, can be useful to clearly delineate fractures if the light-assisted examination of the assessment cavity is inconclusive; the light examination should be conducted first. Assessment cavities created by removing existing restorations or by obtaining endodontic access provide the best opportunity to directly view and assess

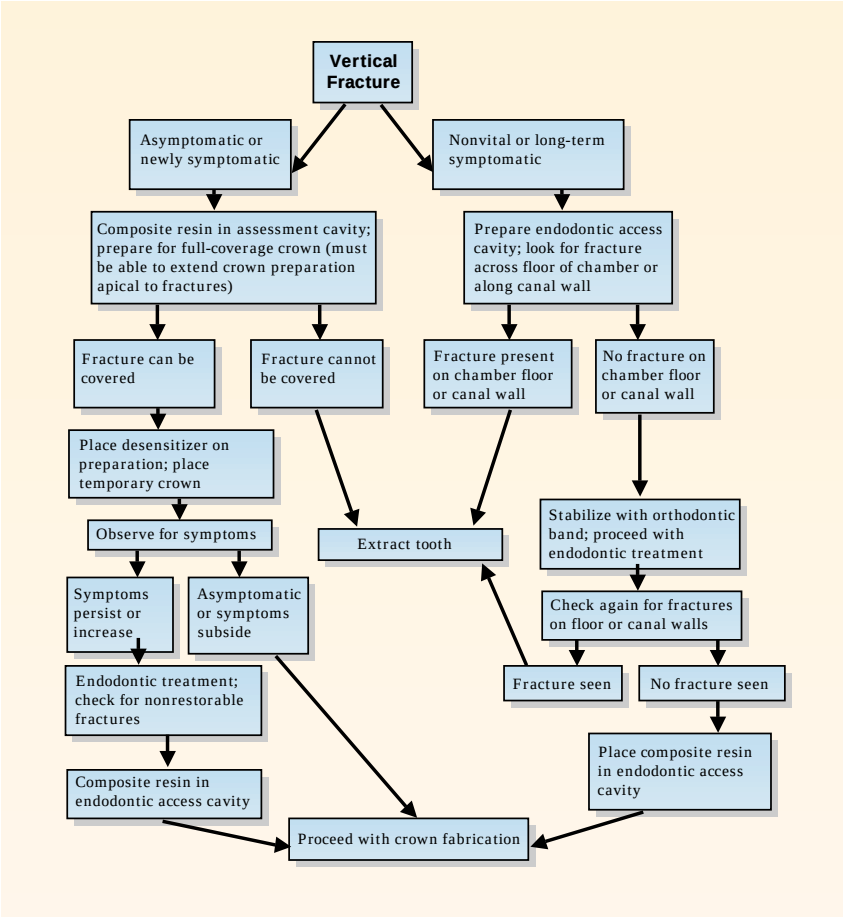

Figure 2. Management of incomplete vertical fractures.

the restorability of fractures. A periodontal probe or a tissue flap can be used to determine the extent of fractures onto root surface. Fractures extending to or beyond the alveolar crest usually are nonrestorable.

Symptom reproducers are devices used to locate fractures by intentionally opening them or to assess pulpal status once the fracture is located. Having the patient bite on a cotton roll is the simplest method for locating a fractured tooth. Various fracture detection devices test individual cusps to localize fractures to specific cusps. Cold sources, such as thermal pulp tester tetrafluoroethane refrigerant, are useful in locating the tooth causing the chief complaint if more than one tooth in the area tests positive for fracture. The tooth that is most acutely sensitive to cold usually is the source of the patient's chief complaint and should be addressed first. Electric pulp testing is especially useful in the case of asymptomatic vertical fractures to determine pulp vitality.

A radiograph is not a primary diagnostic aid for locating fractures. Most coronal tooth structure fractures are not visible on radiographs. A severe buccolingual fracture may be visible on a radiograph, but it also should be clearly visible on intraoral inspection. Radiographs are most useful in ruling out caries or a broken restoration as the pain source.

Confirmation of diagnosis and immediate treatment. Once noninvasive diagnostic tests have indicated the likelihood of incomplete dentin fracture, the diagnosis can be confirmed with an assessment cavity. Removing an existing occlusal or occlusal-proximal restoration along with its liner and any caries present normally is all that is required to directly visualize fractures. Old fractures may appear accentuated by the presence of stain. New fractures can be made visible by reflecting light into the cavity when it is wet but not flooded. Oblique fractures usually will be visible at internal line angles of the preparation and normally will appear light as the result of light refraction along the fracture. Vertical fractures in the mesiodistal orientation will be clearly visible to buccolingual transillumination once the restoration has been removed. Disclosing dyes also can be used to delineate fracture lines more clearly.[8,9]

If the fracture is vertical, the course of treatment and prognosis are determined based on vitality and symptoms (Figure 2). If the tooth is nonvital or long-term symptomatic, immediate endodontic intervention is indicated. While obtaining endodontic access, we must examine the tooth carefully for any fracture extending through the floor of the pulp chamber or for any fracture along a canal wall extending apically. Either type of fracture will render the tooth nonrestorable.[10,11] If, however, neither type of fracture is present, the tooth should be stabilized immediately with an orthodontic band to prevent the existing fracture from in-

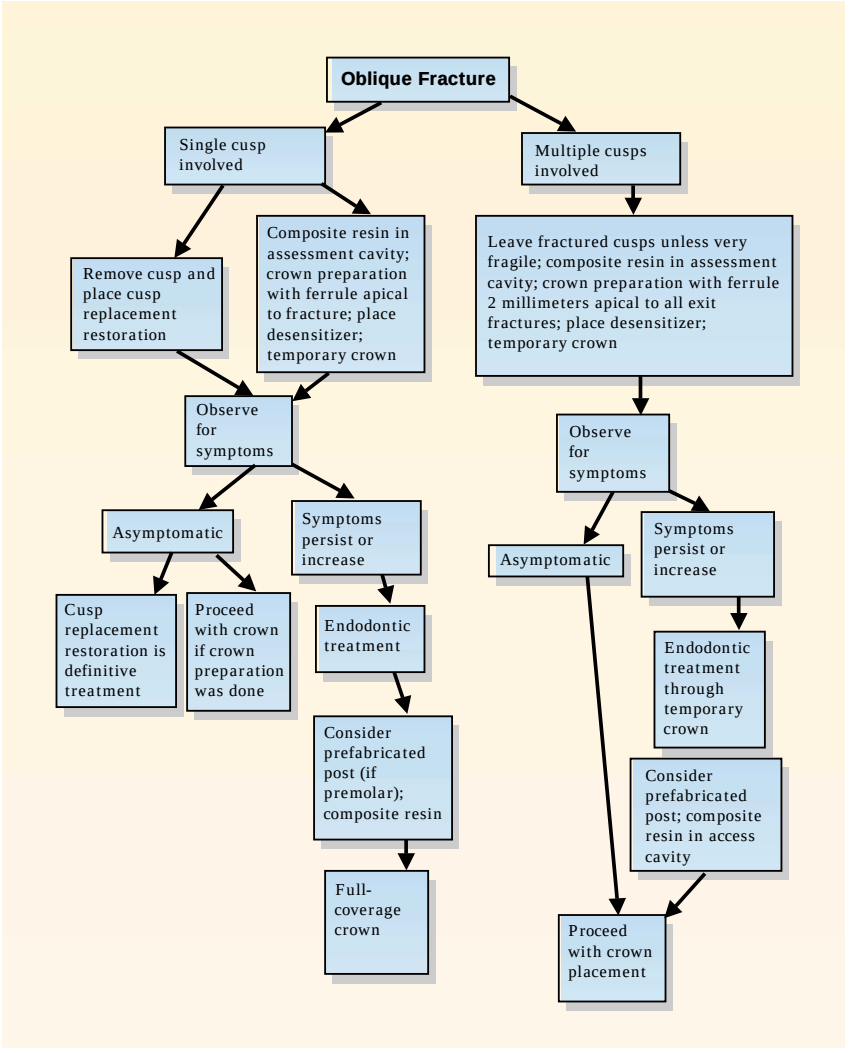

Figure 3. Management of incomplete oblique fractures.

creasing during endodontic treatment.[8]

If a tooth with a vertical fracture is vital and either asymptomatic or newly symptomatic, endodontic intervention is not immediately indicated. A bonded composite resin restoration should be placed in the assessment cavity, and a crown preparation should be performed immediately. If the crown margin can be placed apical to any fracture, the tooth should be restorable. Being able to cover all fractures with a full-coverage restoration is essential to restorability. The need for endodontic treatment is determined on the basis of the presence or absence of symptoms while the patient is wearing a temporary crown.

Oblique fractures usually are treated by eliminating a fractured cusp and placing a cusp replacement restoration or, if multiple fractured cusps exist, by placing a bonded composite resin restoration followed by a full-coverage crown (Figure 3). Again, determination of the need for endodontic treatment is based on the presence or absence of symptoms after the restoration is placed.

Factors contributing to incomplete tooth fracture. To profile patients who are most susceptible to incomplete tooth fracture and to be aware of the iatrogenic factors that may start or increase fracture problems, it is important to recognize the factors that contribute to incomplete tooth fracture.

There appears to be an age-related susceptibility to incomplete fractures. It may be due to a combination of a change in the structure and character of the dentin, more and larger restorations, and the development of pathological occlusal habits as patients age.[9]

While unrestored teeth may fracture, susceptibility to fracture is far greater in teeth with nonbonded metallic restorations, especially in preparations with a wide or deep isthmus.[12] Differences in the performance of various bonding agents and restorative materials notwithstanding, evidence shows that teeth with bonded restorations demonstrate greater fracture resistance than do similarly prepared teeth with nonbonded restorations.[13-15]

Teeth with occlusal interferences, especially in patients with pathological occlusal habits, are more likely to develop fractures due to nonaxial forces directed on cuspal inclines. Other habits, especially ice chewing, eating pretzels or hard candy, or even gum chewing contribute to tooth fracture formation.

Dentists should exercise caution when preparing teeth with high-speed handpieces, since high-speed vibration has been shown to introduce fractures in tooth structure.[7,16] Every posterior preparation made with a high-speed handpiece should be checked closely for fracture before the restoration is placed. Failure to observe and properly

manage iatrogenic fractures is a major cause of acute postoperative sensitivity in newly restored teeth.

Threaded pin placement has been well-documented as producing microfractures in dentin.[7,17] While the normal pin locations do not make a vertical or oblique fracture a likely, immediate consequence of pin placement, pins should be used cautiously, if at all, in teeth in which fractured segments cannot be eliminated.

Endodontic manipulation, especially condensation techniques, may easily convert a restorable fracture to nonrestorable status.[7,8,10,17] Teeth with vertical fractures should be stabilized with an orthodontic band or a temporary crown before extensive endodontic manipulation takes place.

TREATMENT APPROACHES

Once a fracture has been identified, and the tooth has been determined to be restorable, the overall treatment approach is determined by the type, number and severity of the fracture. If an assessment cavity has been used to verify the fracture, the initial phase of treatment takes place immediately and is directed toward stabilizing the tooth until more definitive care is provided. The following scenarios are examples of typical fractures encountered and recommended treatment approaches.

Mandibular second molar, occlusal amalgam, oblique fracture undermining distolingual cusp. If careful examination shows no other fracture, definitive care is provided by removing the fractured cusp, removing all fractured dentin and placing a disto-occlusolingual restoration. The distal surface is involved because the fracture almost certainly extends from the lingual midline to the distal midline of the tooth. Before placing the restoration, any wear facets on occlusal inclines of the remaining cusps are reduced to minimize forces likely to produce additional fractures. Intracoronal retention is a better choice than a threaded pin for retention if amalgam is to be used, and retention is enhanced using a bonded amalgam technique. The restoration has no contact in excursive movements. Assuming that adequate steps are taken to prevent microleakage, this treatment normally corrects both the fracture and the pulpal response to the fracture.[18]

Failure to observe and properly manage iatrogenic fractures is a major cause of acute postoperative sensitivity in newly restored teeth.

Maxillary first molar; mesio-occlusodistal, or MOD, amalgam; oblique fracture undermining mesiofacial, distolingual and mesiolingual cusps. To provide minimum immediate care, an MOD-bonded composite restoration is placed to bond together the fractured tooth segments. Fractured cusps are not removed unless they are very fragile. If time permits, a crown preparation is performed at this visit, and a temporary crown is placed. If the crown preparation cannot be done at this visit, all fractured cusps are reduced from occlusal contact and arrangements are made to prepare and temporize the tooth as soon as possible. When preparing a tooth with multiple oblique fractures, care is taken to extend the crown margin at least 2 millimeters apical to the anticipated exit fractures. These exit fractures often are visible after enamel removal. It is imperative to have this 2 mm ferrule on intact tooth structure. As teeth with multiple fractures tend to be acutely temperature-sensitive, the prepared surface is treated with an effective desensitizer before placing the temporary crown. The temporary crown must fit well at all margins and provide only maximum intercuspation contact with no excursive contact. If high levels of sensitivity persist, endodontic treatment is conducted before the permanent crown is placed.

Mandibular first molar, occlusal amalgam, mesiodistal vertical fracture, recent onset of acute sensitivity. To provide minimum immediate care, a bonded composite restoration is placed in the assessment cavity, and a crown preparation is performed. The goal of the crown preparation is to determine the apical extent of the fracture. If a crown margin cannot be placed apical to any fracture line, the tooth cannot be restored. If margin placement is successful in covering all fracture lines, the tooth is coated with a desensitizer, and a temporary crown is placed. If symptoms subside, crown fabrication can proceed. If symptoms persist, endodontic treatment is initiated through the temporary crown to protect the tooth

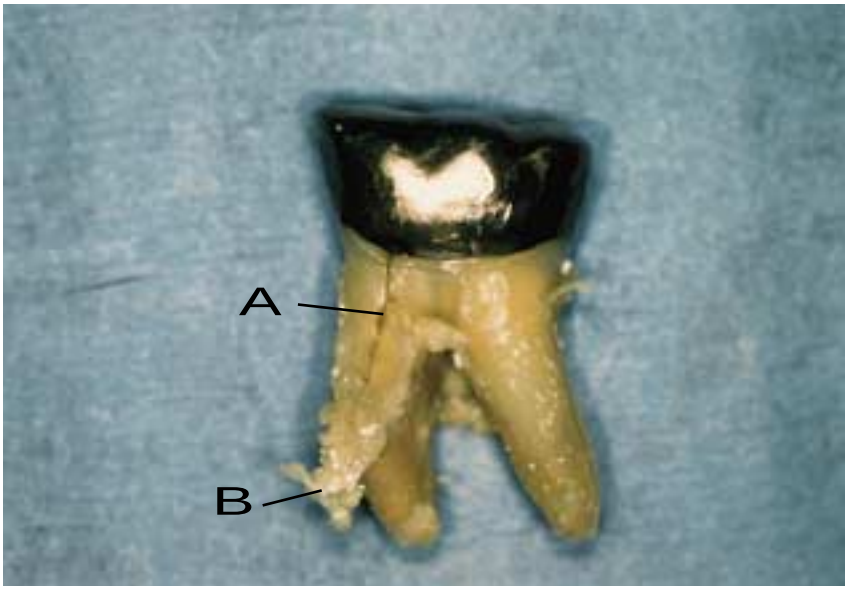

Figure 4. Extracted tooth illustrating fracture management failure. The tooth required extraction within four months of endodontic treatment and crown placement. Note the unusual buccolingual orientation of the fracture (A) and the formation of a fistulous tract (B) at the apical extent of the fracture.

from further fracture during endodontic manipulation. The endodontic access cavity must be inspected carefully with adequate light and magnification to check for fractures extending through the floor of the pulp chamber or extending along a canal wall. Either type of fracture will render the tooth nonrestorable. If no additional fractures are found, endodontic treatment proceeds, and a similar inspection occurs at the completion of endodontic treatment. The endodontic access cavity is restored with a bonded composite, and a permanent crown is fabricated as soon as possible.

Mandibular second molar, MOD amalgam, mesiodistal vertical fracture, long-term history of symptoms. To provide immediate treatment, an endodontic access cavity preparation is performed, and it is examined closely for the extent of the fractures. If proximal fractures extend along canal walls or if the fracture extends across the chamber floor, the tooth is nonrestorable. If the tooth appears restorable, an orthodontic band is placed around the tooth, and the proximal box preparations are filled with bonded composite resin. With the tooth now protected from further fracture, endodontic treatment is completed. The access cavity is reinspected for fractures, and a bonded composite is placed. Crown preparation is performed as soon as possible, again with care taken to extend margins apical to any fracture line. Crown fabrication and placement should proceed expeditiously.

CONCLUSION

Failure to adequately and expeditiously diagnose incomplete fractures or to maintain a rational approach to treatment can lead to unnecessary patient discomfort and even tooth loss. In the worst case, tooth loss may occur after extensive restorative and endodontic treatment has been performed on a tooth that should have been deemed unrestorable in the original diagnostic process (Figure 4).

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In conclusion, I recommend the following process to manage incomplete fractures.

Initial diagnosis is directed toward determining the presence and extent of incomplete fracture. The tooth should be assessed at this time to determine if it can be restored. Unless symptoms are severe or the pulp has become nonvital, it may be difficult to assess if the pulpal response is reversible until after the fracture is stabilized.

Initial treatment is directed toward stabilizing or eliminating cusps undermined by fractures. Since an assessment cavity is used in diagnosing most incomplete fractures, placement of a bonded composite in the cavity is the most common form of initial stabilization. Depending on the type and number of fractures encountered and the time available, other methods used are occlusal adjustment, temporary crown placement and orthodontic band placement.[8,19] Eugenol-containing palliative restorations have no place in the treatment of fractures; they do not bind together the fractured segments, which leaves the tooth susceptible to

further fracture.

After fractures are stabilized or the fractured cusps are eliminated, the tooth is observed for pulpal symptoms. If sensitivity subsides, definitive treatment can proceed without endodontic treatment. If symptoms persist or intensify, endodontic treatment should be initiated.

Whenever endodontic treatment is initiated on a tooth with an incomplete fracture, the chamber and canal walls must be inspected thoroughly for fractures that may render the tooth nonrestorable. Teeth with vertical fractures must be stabilized with an orthodontic band or temporary crown before endodontic manipulation takes place to guard against extending the fracture. Access cavities are re-examined after endodontic treatment to ensure that no additional fracture has occurred.

A permanent crown should be placed as soon as possible after the pulp has either been determined to be healthy or is eliminated by endodontic treatment. A crown definitively binds fractured segments together. Crown margins must extend apical to all fractures. ■

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