Cracked teeth—treatment rationale and case management: Case reports

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The treatment rationale for, and successful management of, six teeth with cracks in the form of incomplete vertical fractures are reported. Further crack propagation was prevented by placement of either stainless steel orthodontic bands or aluminum or acrylic resin provisional crowns, and endodontic treatment was subsequently carried out. The teeth were restored with intraradicular amalgam cores and complete veneer crowns. The teeth were reexamined periodically for up to 3.5 years after treatment. During the period of review, all teeth remained asymptomatic. (Quintessence Int 1995;26:485-492.)

Introduction

It is not uncommon to find cracks in restored teeth, but they may also occur in unrestored teeth. The teeth usually reported to be most frequently affected are the mandibular first and second molars, but others consider the mandibular first molars and maxillary premolars to have the highest incidence of cracks.

The task of looking for suspected cracks when making a diagnosis of the cracked-tooth syndrome can often be difficult. First, cracked teeth often remain asymptomatic for a long time and can therefore escape detection. When symptoms do occur, they can range from vague discomfort to unexplainable complaints, depending on the depth and location of the crack, as well as the interval between onset of symptoms and diagnosis. Hence, when a patient presents with vague discomfort and bizarre symptoms that cannot be associated with any obvious cause, it may be prudent to look for a tooth or teeth with cracks.

Second, cracks may be very fine and not easily detected, especially when they propagate along morphologic structures such as anatomic grooves. Moreover, careful visual inspection of teeth for cracks does not usually form part of a routine clinical examination.

Most cracks tend to run vertically; horizontal cracks occur less frequently. These vertical cracks run in a mesiodistal direction along the occlusal surfaces and may involve one or both marginal ridges. They invariably also extend interproximally, hidden from view by adjacent teeth. Staining the occlusal surface of a suspect tooth with methylene blue dye solution, when used with transillumination, usually highlights the crack, and the practice should be encouraged. Long-standing cracks are often detected more easily, because they are usually stained. Unfortunately, even staining and transilluminating the tooth with a fiberoptic light cannot always reveal the extent and depth of propagation of proximal extensions of the crack lines; these factors may influence the course of symptoms and treatment.

There are many ways of managing a cracked tooth, and the clinician may have difficulties deciding on the appropriate treatment option. The sooner treatment is rendered, the more likely irreversible damage may be avoided. Amalgam restorations with grooves or boxes, pin-retained amalgam restorations, bonded amalgam restorations, and posterior resin composite restorations have all been recommended for incompletely fractured teeth to bind the segments together and to...
provide internal stabilization. Other authors, however, have suggested occlusal adjustment to reduce stress on the affected tooth to relieve symptoms. Immediate occlusal adjustment may prevent further extension of the crack. Grinding the tooth out of occlusion, however, is of only limited benefit. More often, the treatment involves initial stabilization and a complete coverage restoration. This not only helps to direct and redistribute occlusal forces over the entire tooth, thereby minimizing any stress on the cracked segments, but also helps to provide the needed permanent fixation and prevent crack propagation.

Doubts have been expressed regarding the prognosis of cracked teeth. For a cracked tooth with irreversible pulpitis requiring endodontic treatment and a cast crown, the prognosis has been considered to be poor. Structural weakness resulting from the crack has been thought to render the tooth more susceptible to crack propagation during subsequent endodontic treatment. Extraction has often been the practical treatment option. However, a clinical survey of 120 symptomatic cracked teeth reported that only a small proportion (16 teeth) were extracted because of treatment failure.

There is a dearth of reports in the literature on the success of root canal treatment in cracked teeth. This paper is a presentation of cases of teeth with cracks, in the form of incomplete vertical fractures, that were treated endodontically as part of the management of the presenting symptoms.

Case reports

Six patients presented with symptoms of pain of various intensities and durations. None of the patients had any relevant medical history. Their past dental history was uneventful. Three of the six patients had undergone some form of previous dental treatment for their complaints prior to presentation. Two of these were given provisional crowns and a third received a replacement for the offending tooth's occlusal amalgam restoration.

Examination of the patients took the form of a general dental examination, followed by an examination of the affected area. This included visual observation and palpation of the area, percussion of the affected tooth or teeth, and radiographs. Examination of cracks in all cases included visual examination, transillumination with a fiber optic light source from the dental chair unit (Kavo Dental) using DialUX 2300 L light probe (Kavo Dental), and radiographic examination. The crack was traced with a bur and electric pulp testing (Analytic Technology) was carried out where relevant. The crack was stained with 1% methylene blue dye (David Bull Lab) in selected patients. The degree of difficulty of detection of cracks and hence diagnosis in these cases varied.

In three of six patients, after careful examination and diagnosis, the management sequence and treatment strategy adopted involved the placement of an orthodontic band followed by review after 1 to 2 weeks. In two patients, some form of stabilization of the cracked tooth was already present at the time of first presentation. In the remaining patient, an unexpected interappointment flareup necessitated endodontic intervention before cementation of the orthodontic band. In all patients, endodontic treatment followed because the crack lines were found to communicate directly with the pulp. The affected tooth in most cases was subsequently restored with a complete-coverage restoration. The period of review from the time of completion of root canal treatments varied from 1 to 3.5 years.

Case 1

A 47-year-old woman complained of spontaneous, lingering pain of 1 week's duration. The pain was localized to the maxillary right second molar and radiated to the maxillary right zygoma. She also reported a history of bruxism. Visual examination revealed the tooth to be free of any restoration or structural crack (Fig 1a). The tooth was tender to touch and responded to electric pulp testing. In view of the history of bruxism and symptoms experienced from a tooth that had no previous restoration, the diagnosis of cracked tooth was suspected. A crack line along the occlusal surface involving distal and mesial marginal ridges was confirmed after the occlusal surface was stained with methylene blue dye solution (Fig 1b) and transilluminated with a fiber optic light. Radiographic examination revealed no observed changes in tooth structure or the surrounding bone area.

An orthodontic band was placed onto the tooth at this first visit. At a subsequent appointment, the patient reported that the symptoms had been relieved since band placement. The crack line was investigated by using a high-speed bur and traced to reveal pulp involvement. Because the proximal crack lines approached but did not traverse the floor of the pulp...
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Fig 1a The maxillary right second molar is free of restorations or any obvious crack.

Fig 1b The occlusal surface is stained with methylene blue dye solution to highlight the occlusal crack.

chamber, the tooth was considered to have a relatively good prognosis, and root canal treatment was selected in preference to extraction.

An occlusal splint was fabricated for the patient at this time to help relieve the problems associated with bruxism. However, this appeared to alleviate the symptoms completely, and the patient did not return for review until 1 year later. At this later date, periapical radiolucent lesions had developed around the palatal and distobuccal roots. Root canal treatment was instituted and proceeded uneventfully. The tooth was eventually restored with an amalgam intraradicular core and a complete gold crown.

At the recall 1.5 years after endodontic treatment, the tooth was asymptomatic, exhibited no periodontal breakdown, and was in function. Radiographically, the periapical lesions that were noted previously had resolved completely.

Case 2
A 25-year-old man presented with severe, spontaneous pain from the maxillary left first molar, and the tooth was very tender to touch. Visual examination revealed an occlusal amalgam restoration and a stained crack line distal to the restoration. The tooth gave no response to electric pulp testing. The periapical radiograph showed the amalgam restoration to be shallow and not encroaching on the pulpal cavity. Periapical radiolucencies involving the palatal and mesiobuccal roots were also noted. Removal of the amalgam restoration and transillumination of the tooth revealed the full extent of the stained crack line, which ran across the cavity floor. The crack line was also found to extend across the distal marginal ridge. The interproximal crack line was traced with a bur and found to have advanced cervically beyond the gingival level.

Because of time constraints, a provisional restoration was placed, and the patient was given an appointment to return for placement of a band and further investigation. However, the patient failed to return until 2 years later, when the tooth became symptomatic to biting hard as well as soft food. Radiographic examination revealed distinct periapical radiolucencies over the palatal and mesiobuccal roots.

An orthodontic band was cemented and the patient was given an appointment for further investigation of the crack. When next seen, the patient reported improvement of his symptoms. Tracing of the crack line with a high-speed bur revealed pulpal involvement (Fig 2a). Because the proximal crack lines along the mesial and distal walls only approached, but did not traverse, the floor of the pulp chamber (Fig 2b), it was considered that root canal treatment should be attempted to save the tooth. Treatment proceeded uneventfully, and the tooth was subsequently restored with an amalgam intraradicular core and a metal-ceramic complete crown.

A post-endodontic treatment recall 2.5 years later indicated the tooth to be asymptomatic and functioning well. The recall radiograph showed complete resolution of the radiolucent lesions.

Case 3
A 48-year-old woman was referred for root canal treatment of the maxillary right first molar, which had been previously diagnosed as a cracked tooth. The tooth had a provisional crown and was tender to
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Fig 2a A crack line is found to run mesiodistally across the occlusal floor of the cavity. An orthodontic band is cemented to prevent further propagation of the crack.

Fig 2b Mesioproximal and distoproximal crack lines along the respective dentinal walls are propagating toward the floor of pulp chamber.

Fig 3a A crack line along the distal surface of a complete-crown preparation of a maxillary right first molar is highlighted by methylene blue dye.

Fig 3b A distoproximal crack line is visible along the distal wall of the pulp chamber after access cavity preparation.

percussion. Radiographic examination revealed an intact lamina dura over the periapices. Removal of the provisional crown and staining of the tooth surfaces with methylene blue dye solution revealed a crack line along the distal surface extending cervically (Fig 3a). This was traced to involve the pulp (Fig 3b). The crack lines that advanced interproximally did not traverse the floor of the pulp chamber.

Root canal treatment proceeded uneventfully, and the tooth was subsequently restored with a complete crown 2 months later.

At the 2-year recall, the tooth showed no signs or symptoms of periodontal breakdown; it was asymptomatic and functioning well. The recall radiograph showed no changes in the periapical area.

Case 4

A 39-year-old woman presented with severe, lingering, throbbing, and diffuse pain from the maxillary right quadrant that radiated to the right temporal area. The onset of the pain was 4 days previous to this visit; treatment rendered by two other dental practitioners did not alleviate the symptoms, which only became worse. Visual examination revealed crowns on the maxillary right first and second premolars as well as the first molar. The maxillary right second molar had an occlusopalatal amalgam restoration and a large buccal glass-ionomer cement restoration. No crack line was evident. The maxillary right third molar, however, had only an occlusal amalgam restoration.
Both the maxillary right second and third molars responded to electric pulp testing, whereas percussion testing was only positive for the maxillary right first and second molars. Radiographically, there was no evidence of periapical involvement (Fig 4a). Each tooth, starting with the maxillary right first premolar and progressing posteriorly, was anesthetized individually; the immediate pain relief associated with anesthesia of the maxillary right second molar indicated that it was the cause of pain. Further investigation with fiberoptic transillumination revealed crack lines, not immediately apparent on examination, across both mesial and distal marginal ridges.

Subsequent removal of the amalgam restoration revealed a shallow occlusal cavity with a faint crack line across the cavity floor that extended across both marginal ridges. A high-speed bur was used to trace the interproximal crack lines, which were found to have advanced cervically beyond the gingival level. Because the buccal cavity was also found not to encroach the pulpal tissue, the two cavities were restored with amalgam and the patient was scheduled for follow-up 1 week later. However, the symptoms worsened on the sixth day, and an emergency elective pulpotomy was carried out, which alleviated the symptoms. An orthodontic band was also subsequently cemented on the tooth.

The full extent of the crack was reinvestigated with the help of stronger illumination from a fiberoptic light source. The proximal crack lines could now be seen to...
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approach, but not traverse, the floor of the pulp chamber. Root canal treatment was completed (Fig 4b), and the tooth was subsequently restored with an amalgam intraradicular core and a metal-ceramic complete crown (Fig 4c).

On recall 3.5 years later, the tooth showed no signs or symptoms of periodontal breakdown, was asymptomatic, and functioned well. Radiographically, the periapices remained unchanged (Fig 4d).

Case 5

A 51-year-old man presented with severe, lingering pain from the maxillary left second molar. Visual examination showed an occlusal amalgam restoration and stained crack lines made obvious under transillumination with a fiberoptic light. Removal of the occlusal amalgam restoration revealed a stained crack line on the cavity floor that extended across both the mesial and distal marginal ridges. Another crack line extending along the buccal groove was also noted to disappear cervically beyond the gingival margin. The tooth in question was tender to percussion and responded to electric pulp testing. Radiographically, the lamina dura of all three roots appeared to be intact.

A diagnosis of cracked tooth was made, and an orthodontic band was cemented on the tooth. The band was only slightly effective in reducing the symptoms. Two days following band cementation, the patient experienced severe, lingering, and diffuse pain over the left side of the face that appeared to be coming from the mandibular left quadrant. Percussion, palpation, cold, and electric pulp tests of all the maxillary and mandibular left posterior teeth did not reveal any possible major contributory factor to the patient’s complaint, except for the presence of tenderness on palpation of the maxillary left second molar itself and the presence of crack lines on the midbuccal and lingual aspects of the mandibular left first molar. An inferior dental alveolar nerve block was administered to ascertain if the mandibular left first molar was the cause of the complaint, but it did not provide any pain relief. It was then decided to continue the investigation on the maxillary left quadrant. This quadrant was selectively anesthetized, and buccal and palatal infiltration anesthesia of the maxillary left second molar tooth brought immediate pain relief. Further investigation of this tooth revealed a stained crack line, which could be traced to involve the pulp directly. Because the staining did not follow the crack to its full depth, transillumination helped to make tracing the deeper reaches of the crack a little easier.

An emergency pulpotomy was carried out. Because the proximal crack lines approached, but did not traverse, the floor of the pulp chamber, it was decided to carry out root canal treatment to be followed by a complete-coverage restoration. Root canal treatment proceeded uneventfully.

A 1-year recall showed the maxillary left second molar to be asymptomatic. The orthodontic band was still in place. Radiographic examination did not reveal any change at the periapices.

Case 6

A 33-year-old man complained of pain from the mandibular left first molar, which was elicited on biting, as well as sensitivity to hot and cold drinks. He had seen his dental practitioner 3 months previously with these same complaints. An aluminum provisional crown was placed over the tooth at that time. The symptoms eventually became less severe but persisted.

At the time of presentation, removal of the provisional crown and transillumination of the tooth revealed a crack line across the occlusal floor. This was traced with a high-speed bur, revealing pulpal involvement. Under transillumination with a fiberoptic light, no crack line could be detected to traverse the floor of the pulp chamber. Radiographic findings revealed a widened periodontal ligament space around the distal root. Root canal treatment was carried out uneventfully.

At recall 2 years later, the tooth was asymptomatic but had not yet been restored with a crown by his practitioner. There was no evidence of periodontal breakdown, and radiographic examination revealed the presence of an intact lamina dura around the mesial and distal roots.

Discussion

According to Cohen and Silvestri, early symptoms associated with incomplete vertical fractures of vital teeth include momentary, acute, and lancinating pain that the patient occasionally experiences when eating hard, crunchy foods. On the other hand, teeth with advanced and long-standing cracks often present with symptoms of acute irreversible pulpitis. It is also quite likely that these symptomatic cracked teeth would have cracks that have propagated deeply into the dentin and pulp chamber, as was observed in the six patients described.
Orthodontic stainless steel bands or provisional crowns were provided, where appropriate, to prevent further propagation of the crack and at the same time accord the patient some relief of his or her symptoms. However, the placement of a band or provisional crown does not and cannot eradicate any pulpal involvement of the crack line, if this is already present. A follow-up with an active investigation into the pattern of the crack propagation for all cracked teeth, regardless of whether the symptoms have abated or not, is necessary and is strongly encouraged. Pulpal involvement will eventually manifest itself by the worsening of symptoms, the persistence of symptoms, or the development of a radiolucent lesion at the root apex, as occurred in case 5, case 6, and case 1, respectively. When this happens, only endodontic intervention can provide permanent pain relief, as in cases 4 and 5.

An interim period of a couple of weeks after initial stabilization of a cracked tooth, as recommended by Guthrie and DiFiore, is also useful because it allows for further evaluation of the need for endodontic treatment. This can help to reassess the treatment options to proceed with the final restoration with or without prior root canal treatment. Nevertheless, a cessation of symptoms after band placement cannot totally exclude the absence of a physical direct communication of the crack line with the pulp.

Staining of the tooth surface with methylene blue dye solution and transillumination of the tooth with a good, strong, fiberoptic light are necessary to highlight crack lines. However, these techniques cannot reveal the extent or depth of propagation of the crack lines interproximally or pulparward. Until such a time when there is a noninvasive method of determining the direction and depth of crack propagation, a more conclusive, albeit radical, approach would be to trace the crack to its depth with a proper high-speed bur, as proposed by Abou-Rass. This can be carried out after it has been confirmed that the crack is the cause of the patient's symptoms. It can be done before or after band placement.

For cracked teeth with milder symptoms, it may still be prudent to be more radical in the management approach and to proceed with tracing the crack line. By tracing the crack, the clinician can decide on the next line of approach. Depending on the extent of the crack, this may include complete occlusal coverage to protect the tooth against masticatory forces or endodontic treatment followed by complete coverage. If the crack is extensive, extraction of the tooth may be the only treatment option.

Although the presence of pulpal involvement of the crack line necessitates endodontic intervention, endodontic treatment may not be the best treatment option. A careful inspection and evaluation of the walls and floor of the pulp chamber is needed before a decision for endodontic treatment can be made. Removal of the roof of the pulp chamber will reveal more clearly the direction and, occasionally, the termination of the proximal crack lines continuing subgingivally along the roots. Good visibility provided by an adequate access cavity preparation into the pulp chamber, aided by strong illumination from a fiberoptic light source, will make this task easier. The clinician should also be aware of the possibility that the proximal crack lines traverse the floor of the pulp chamber and eventually meet and should diligently search for this situation before embarking on endodontic treatment. With the benefit of this additional information, the clinician can then provide a more predictable prognosis to the proposed treatment plan.

If endodontic treatment is necessary for a cracked tooth, Silvestri and Singh recommended that it be carried out through the access opening of a permanently cemented cast crown, thereby lessening the chance that a complete fracture will result from the incomplete vertical crack. However, in all the patients described here, the root canal treatment was completed prior to the provision of a permanently cemented cast crown. Cleaning, shaping, and obturation of the root canals did not complicate treatment or result in further propagation of the crack lines. Although excessive removal of dentin during root canal preparation can structurally weaken the tooth, it is unlikely to jeopardize the cracked tooth, as long as the crack lines do not directly involve the root canal walls and there is some form of binding effect from an orthodontic band or a provisional crown during treatment.

Four of the cracked teeth described in this report received complete-coverage restorations 2 to 15 months following root canal treatment. (The other two teeth were subsequently crowned after the review.) The postendodontic restoration in these teeth involved buildup of an intraradicular amalgam core followed by cementation of a complete cast crown. Because there was adequate dentinal thickness and sufficient width and depth from the pulp chamber, an amalgam core buildup was chosen. This eliminated the need for fabrication of posts and the stresses associated with post
installation, which may result in a more severe crack. Following root canal treatment, a complete-coverage restoration has to be fabricated to replace the orthodontic band. The encircling band of metal from a well-fitting cast crown is needed to provide the ferrule effect, binding the fractured segments tightly and preventing future crack propagation.

Summary

A review of the case histories of six molars indicated that band placement and root canal treatment, followed by buildup of an amalgam intraradicular core and complete occlusal coverage, is a viable treatment option for cracked teeth with pulpal involvement. Prompt attention and treatment should be given to such teeth. Periodic recalls and close monitoring are also necessary in the management of cracked teeth.

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References