Fracture Necrosis: Diagnosis, Prognosis Assessment, and Treatment Recommendations

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Abstract

Introduction: The presence of cracks and fractures in teeth can pose difficulties in diagnosis, prognosis assessment, and treatment recommendations. When a tooth has no significant restorations or caries, whereby the pulp is nonvital in the absence of a luxation injury, it is suggested that this necrosis is likely caused by a significant longitudinal crack that extends from the occlusal surface and into the pulp. This type of presentation has been termed "fracture necrosis." **Methods:** Twenty-seven teeth with nonvital pulps were evaluated that had no restorations or minimally deep restorations and no signs of caries. These teeth were extracted and evaluated as to the depth and location of any potential fracture. **Results:** All evaluated teeth were found to have cracks that extended from the occlusal surface into the pulp and progressed to an external root surface. **Conclusion:** Pulp necrosis, in the absence of restorations, caries, or luxation injuries, is likely caused by a longitudinal fracture extending from the occlusal surface and into the pulp. Based on the available literature, these types of teeth may have a poor prognosis after endodontic treatment, with the potential ramification of extensive periodontal and/or periapical bone loss. Extraction may be considered as the primary treatment option. *(J Endod 2010;36:442–446)*

Key Words

Crown fractures, diagnosis, prognosis assessment, root fractures, vertical root fracture

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Cracks and fractures in teeth have been well documented over the years (1–9). The cause of these fractures may include physical trauma, occlusal prematurities, repetitive heavy and stressful chewing, resorption weakened teeth, and iatrogenic dental treatment (1, 2, 10, 11). The location and direction of the crack or fracture seems dependent on the direction of the causative impact. It has been suggested that the determination of a fractured tooth is often more of a prediction rather than a definitive diagnosis based on a collective analysis of subjective and objective findings (12). In 2008, the American Association of Endodontists developed a classification and definition of terms used to describe these cracks and fractures and recommended potential treatment guidelines (13). Not including crown fractures from traumatic injuries, these fractures have been described as longitudinal fractures that represent vertical extensions of fractures over distance and time, which tend to grow and change.

Five types of longitudinal fractures have been described (13): (1) craze line: affect only the enamel, originate on the occlusal surface, are typically from occlusal forces or thermocycling, and are asymptomatic; (2) fractured cusp: occur on the cusps and cervical margins of the root and can have acute pain to mastication and cold; (3) cracked tooth: occur on the crown and may extend into the root, develop from damaging occlusal forces or weakened tooth structure, and may have variable signs and symptoms; (4) vertical root: occur and originate only in the roots, have variable but a lesser degree of signs and symptoms, and are caused by wedging forces within the roots (ie, root canal obturation or posts); and (5) split tooth: a fracture through the crown and roots, developing from damaging occlusal forces or weakened tooth structure, separating the tooth into two segments, with the tooth typically being painful to mastication

These fracture types are listed from best to worse prognosis. Unfortunately, treatment options are variable for cracked, split, and vertically fractured teeth, with the most variability in prognosis and treatment options being teeth that are cracked, because the extent of the crack is typically not visible and the degree of its extension is unpredictable.

Cracked teeth are thought to occur as a result of parafunctional habits or from weakened tooth structure (3, 11). The fractures are incomplete, tend to present in a mesial-to-distal orientation (14, 15), and are generally centered on the occlusal table (1). The symptoms that develop subsequent to these cracks have been termed a "cracked tooth syndrome" (1). This has been described as acute pain that results during the mastication (or release) of small hard food substances and also exacerbates with cold (1, 13). However, the signs and symptoms of a cracked tooth may also be consistent with an irreversible pulpitis or necrosis. Because the signs and symptoms can be so variable and because the term "syndrome" suggests the presence of more consistent parameters, several authors have suggested that the term "cracked tooth syndrome" should not be used (10, 12, 13).

Determining the appropriate treatment for teeth with cracks of unknown depth may be difficult. Cuspal reinforcement with a crown (4) or bonded restoration (5, 13) has been suggested for cracked teeth with vital pulp, with the understanding that the prognosis may be unpredictable. If a fracture progresses further down the root, the pulp may become nonvital (3, 15). In addition, a radicular fracture can cause a bony dehiscence with a resulting narrow and deep periodontal pocket and/or extensive periapical bone resorption (6, 16).

The recognition of a cracked tooth is paramount for the clinician to adequately determine a proper prognosis assessment and treatment plan. It has been suggested that should the crack extend through the pulpal floor or below the level of the alveolar

bone, the prognosis should be considered poor and extraction should be considered (15).

Cameron (1) claimed that cracks in teeth were most often present in heavily restored teeth. However, one often overlooked and not uncommon form of a cracked tooth is one that is associated with a virgin or minimally restored tooth that has resulted in pulpal necrosis, which, for the purpose of this study, has been termed a "fracture necrosis." These types of cracks have been associated with thermal cycling, parafunctional habits, or damaging horizontal masticatory forces (10, 17–19) and have also been reported in the Chinese population, originating in the root and progressing coronally (19). Because radiographs and even cone beam volumetric tomography (CBVT) scans (7, 20) cannot consistently visualize these fractures, the coronal-apical progression of fractures cannot always be objectively assessed until the tooth has been extracted. Therefore, using the subjective and objective information available, it is incumbent on the clinician to develop at least a "prediction" or "expectation" as to the extent of the crack so that an adequate prognosis assessment and treatment plan can be formulated.

Materials and Methods

Twenty-seven teeth were evaluated, all of which were diagnosed as having nonvital pulp, which was confirmed using an electric pulp tester (Analytic Technologies) and the application and nonresponsiveness to cold test. Fifteen of the teeth were from males, and 12 were from females. There were 10 mandibular second molars, five mandibular first molars, five maxillary second molars, four maxillary first molars, and three maxillary second premolars. All of the teeth were either virgin teeth (ie, teeth with no restoration, caries, or cuspal fractures) or had only a minimally invasive restoration defined as a restoration that was radiographically estimated to be no greater than 1 mm into dentin. (Fig. 1) All of the teeth had some suggestion of an occlusal mesial-to-distal crack as visualized by direct observation of the occlusal table using a dental operating microscope at 10× (Carl Zeiss, Stuttgart, Germany) and by transillumination; none of the teeth exhibited any objective sign of a split tooth. Sixteen of the teeth were symptomatic, having either spontaneous pain, pain to percussion, or pain to heat that was relieved by cold, and 11 of the teeth were asymptomatic. Radiographically, all of the teeth had either a significant widening of the apical periodontal ligament or distinct evidence of periapical bone loss. Four of the teeth, all mandibular second molars, had a narrow isolated periodontal defect that probed more than 8 mm. After these patients were advised of a potentially poor prognosis, all of these teeth were extracted. Subsequently, the crowns were reduced to the depth of the pulp chamber using a model trimmer (Ray Foster, Huntington Beach, CA), and the extent of the crack was observed and photographed using a dental operating microscope at 10× magnification. Micro-CT imaging (Model Actis 150/130 desktop CT/DR Scanner; Varian Medical Systems, Lincolnshire, IL) with digital reconstruction (VGStudio MAX 2.0; Volume Graphics GmbH, Heidelberg, Germany) was also used, digitally sectioning teeth in increments of 6.5 μm to more objectively determine the internal extent of these cracks. Coronal-apical, mesial-distal, and buccal lingual scanning was performed to assess the proximity of the cracks with respect to the pulp and external root surface.

Results

On macroscopic evaluation, upon the occlusal reduction of the crowns of all of the teeth, a mesial-to-distal fracture line became evident. In all of the teeth examined, a fracture was observed that extended into the pulp chamber and to an external root surface (Fig. 2). On microscopic evaluation, the micro-CT scans revealed objective evidence of an occlusal crack extending from the coronal surface to the pulp, progressing further apically, and continuing to a lateral root surface. This was readily apparent, especially in the coronal-apical (Fig. 3) and mesial-distal sections of the micro-CT scans (Fig. 4).

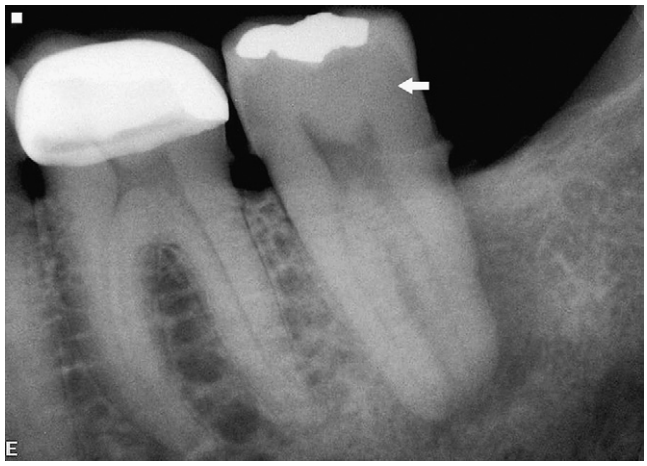

Figure 1. Mandibular second molar (arrow) with a nonvital pulp, periapical bone resorption, and a minimal restoration.

Discussion

The diagnosis, prognosis assessment, and treatment recommendations of a cracked tooth are often difficult. There are many parameters that must be evaluated including symptoms, pulpal status (reversible pulpitis, irreversible pulpitis, or necrosis), restorative and caries history, evaluation of the periodontal status, direct visualization, and patient history of any direct dental trauma or parafunctional habits. Studies have offered treatment recommendations based on what might result in the best prognosis for a tooth with a reversible pulpitis, including a full-coverage crown (4) or a bonded restoration (5). One study (21) showed an 85.5% survival rate of endodontically treated cracked teeth; however, these teeth were all vital, and the investigators did not suggest if the need for the endodontic treatment was primarily because of the presence of the crack. Presently, there are no studies that make any specific recommendations as to the best treatment plan for a tooth having a nonvital pulp with a crack being the most objective cause for necrosis.

The determination of the extent of a crack is often more of a prediction rather than a diagnosis (12). When a longitudinal crack is observed,

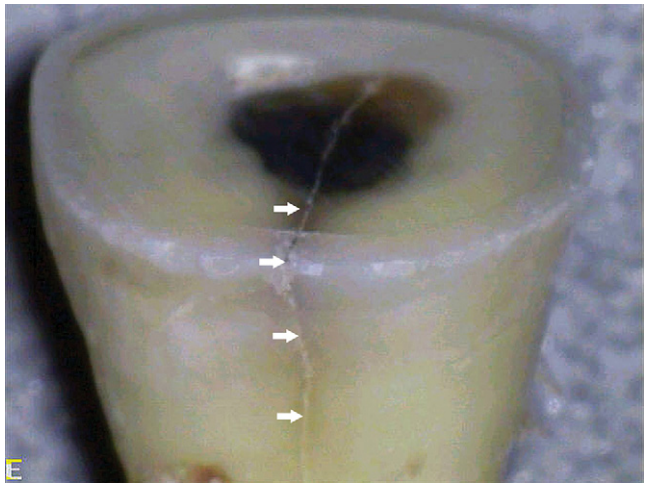

Figure 2. Visualization after crown reduction; note mesial-to-distal fracture extending through pulp chamber and extended to external root surface (arrows).

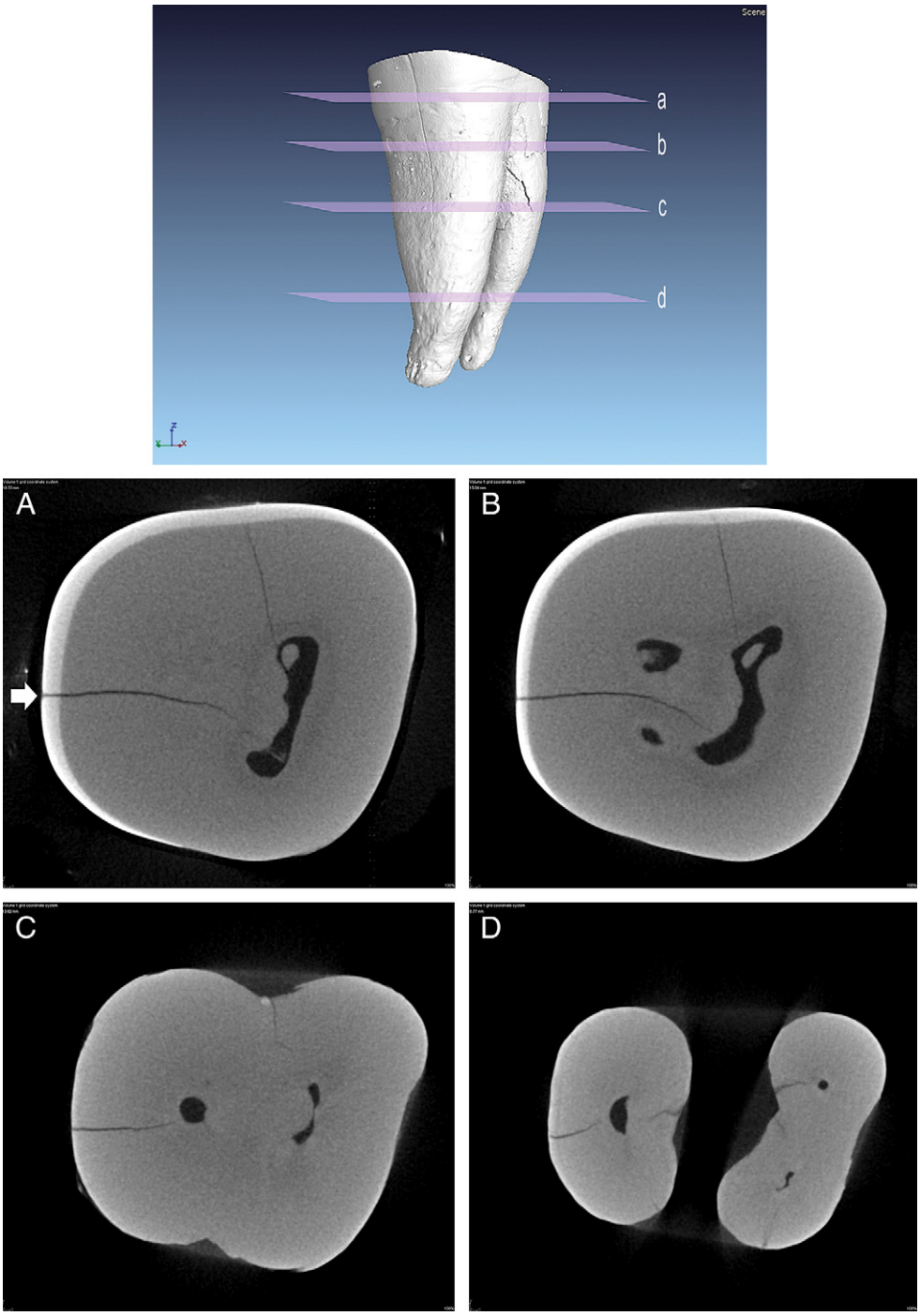

Figure 3. Representative sample of micro-CT three-dimensional scan of cracked tooth, with indications of where coronal-apical scanned sectioned are shown. (*A*) The section through the pulp chamber revealing a crack down the distal root (arrow). (*B*) The section through the floor of the pulp chamber revealing a crack further down distal root. (*C*) The section below the pulp chamber and presence of a crack. (*D*) The section below furcation and 4 mm coronal to the apex, with crack still visualized.

most of the time they are subsequent to the placement of extensive restorative procedures or subsequent to endodontic treatment (8–10). However, in the event that the pulp is determined to be nonvital with no objective or obvious cause for the necrosis (ie, no caries or deep restoration present), then it may be concluded that there is a very high probability that a crack is the cause for the necrosis (ie, "fracture necrosis") as evident from the observations in this investigation.

It has been suggested that if a crack is determined to extend into the pulp, the prognosis for the tooth is poor (12, 15). Unfortunately, many teeth are probably endodontically treated and restored without the speculation that the necrosis was caused by an extensive longitudinal crack. Although some of these teeth may anecdotally survive long-term, the treatment success is generally not considered favorable (15). In addition, as the crack persists further apically and to a lateral root

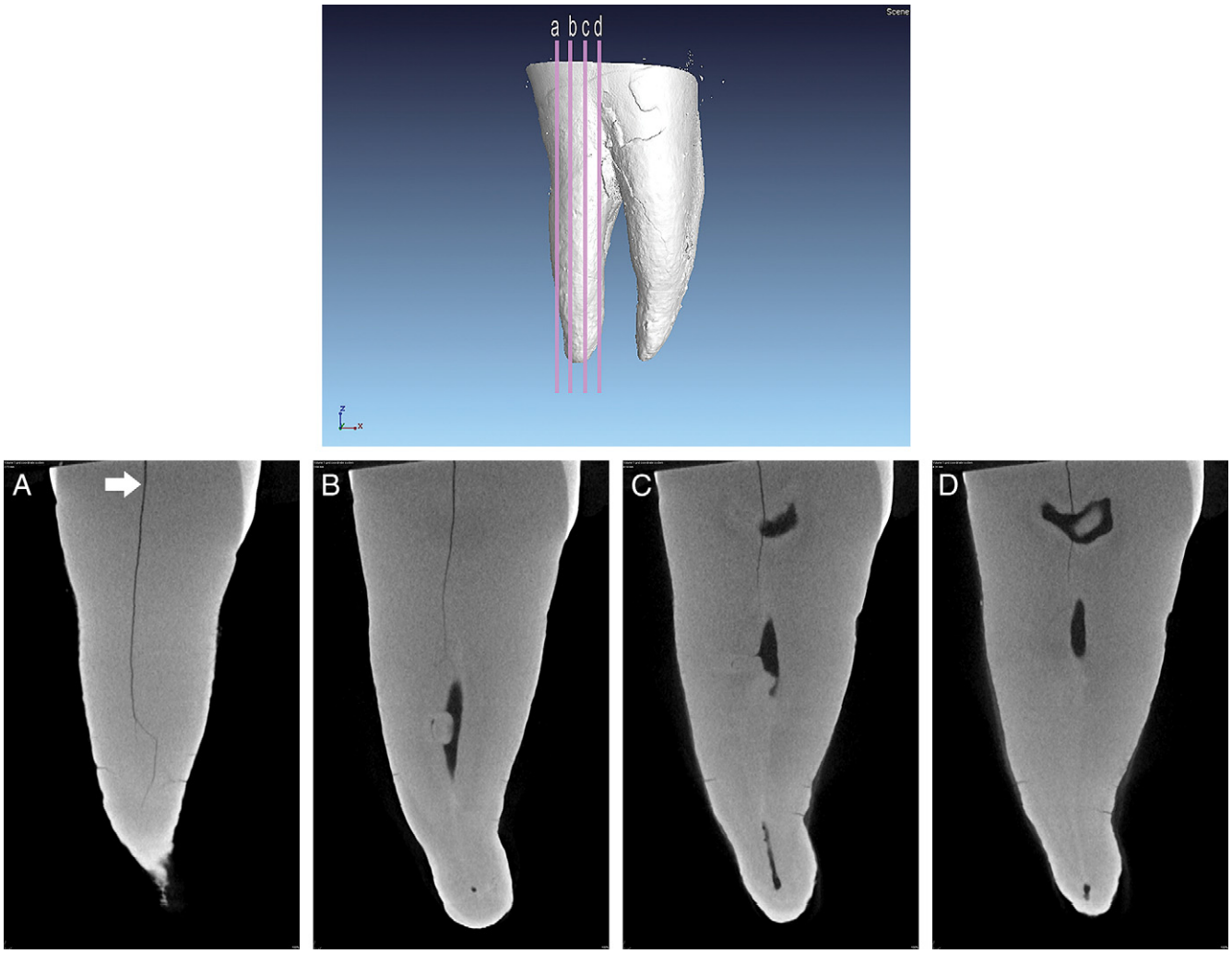

Figure 4. A representative sample of micro-CT three dimensional scan of a cracked tooth with indications of where the mesial-distal scanned sections are shown. (*A*) The section through the distal root 1.5 mm from the external root surface with the crack observed (arrow). (*B*) The section through the distal root approaching the canal space with the crack observed. (*C*) The section through the distal root approaching the pulp chamber with the crack observed. (*D*) The section through the distal root 3.7 mm from the external root surface with the crack observed in the pulp chamber.

surface, associated bone resorption typically occurs in the furcation, lateral root surface, crestally and/or apically (Fig. 5) (6, 10). This is caused by bacteria from the oral cavity and periodontal ligament space entering the crack and progressing down the root and into the bone subjacent to the crack (16). Left undetected, or in the event that the tooth subsequently becomes split (Fig. 6), the periodontal bone loss may be so extensive that bone grafting may be necessary before the placement of a dental implant or a fixed bridge. Depending on the extent of bone loss, the site might not even be conducive to the adequate placement of a dental implant.

Conclusion

Endodontics has evolved into a specialty that is concerned with the repair and preservation of the roots of teeth. However, our ultimate goal is not just the maintenance of tooth structure and occlusion but rather the preservation of associated bone. In the event whereby extensive periapical and/or periodontal bone resorption occurs, especially crestal bone, its recovery may be difficult or impossible.

As seen in this investigation, fractures appeared to originate coronally and extend into the pulp and to a lateral root surface of all evaluated teeth. It is speculated that the cause of pulpal necrosis in these cases was because of the presence of longitudinal fractures; this assumption is predicated by the findings that these teeth had no other recognizable insults to the pulp, such as caries or extensive restorations. Based on the available literature and investigations on root cracks and fractures, it is also assumed that the endodontic prognosis for teeth with these types of cracks is poor, with a high potential for unfavorable posttreatment sequelae.

Although only 27 teeth were evaluated in this investigation, all of these teeth had nonvital pulp with minimal or no caries or restorations. It is proposed that the pulp necrosis in these teeth were secondary to a longitudinal fracture that extended from the occlusal surface and into the pulp and has been termed a "fracture necrosis." Based on the findings of this investigation and the currently available literature on root fractures, it is suggested that the prognosis for teeth having a fracture necrosis may be considered hopeless. It is incumbent on the clinician to properly advise patients as to this potentially decreased prognosis, whereby the patient may elect extraction rather than the possible clinical and financial ramifications of endodontic failure.

To possibly better evaluate the potential for healing, or the lack thereof, in cases of fracture necrosis, a randomized prospective study may be possible for determining the long-term success of endodontic and restorative treatment for these types of cases. However, patients

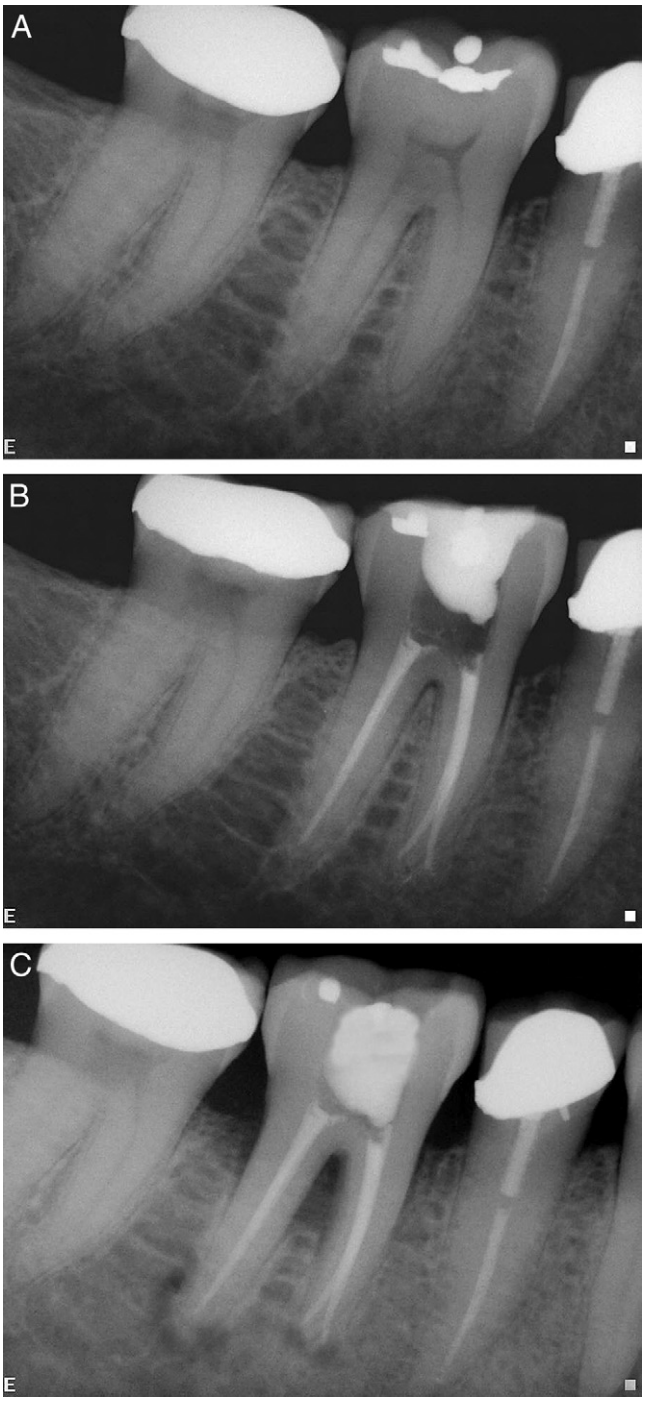

Figure 5. Endodontic treatment without the suspicion of an extensive longitudinal crack as the cause of the tooth necrosis. (*A*) A mandibular first molar (not from this study) with nonvital pulp before endodontic treatment. Note the minimally deep occlusal restoration. (*B*) A postendodontic treatment radiograph. (*C*) Re-evaluation 3 months later. Note the extensive furcation, crestal, and periapical bone resorption. After extraction, a vertical root fracture was observed.

selected for such an investigation should be advised of potential treatment ramifications such as nonhealing endodontic treatment, the development of isolated or diffuse periodontal defects (ie, bony dehiscence and crestal bone resorption), potential subsequent pain, swelling, unnecessary expense to the patient, and potentially compromising the prognosis for pending tooth replacement procedures such as a fixed bridge or dental implant. In addition, it should be understood that

Figure 6. A maxillary second premolar (not from this study). Note the extensive periapical and periodontal bone loss subsequent to the split root.

success must be measured not in just months or years but rather in decades. Understanding the limitations, practicality, and difficulties in undertaking such a prospective investigation, at this time the management of cases with fracture necrosis must be based on the currently available limited studies and sound clinical judgment.

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