

Fractographic Analysis of a Split Tooth Presenting Radiographically as a Horizontal Root Fracture in an Unrestored Mandibular Second Molar

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Abstract

Introduction: Spontaneously catastrophic fracture of intact unrestored molar teeth is not common. Nevertheless, cracks do occur that progress apically, resulting in the complete splitting of the tooth and root. This report describes a catastrophic fracture that occurred in an unrestored mandibular second molar resulting in a previously unreported combination of a longitudinal and horizontal root fracture, appearing radiographically as a single horizontal root fracture. **Methods:** Tooth fragments were examined clinically, stereoscopically, and by scanning electron microscopy. Fractographic analysis was used to investigate the dynamics involved in fracture initiation, structural resistances encountered during progression of the fracture, and reasons for direction changes culminating in the unusual radiographic appearance. **Result:** The uniqueness of this report is that it describes fractographic evidence of factors contributing to the initiation and progression of an *in vivo* crack. It shows fracture markings that are evidence of the energy dissipation mechanisms. The topographic location of these markings confirmed that cracks occur *in vivo* in stages with different rates of progression. **Conclusion:** This analysis helps to explain why split teeth are uncommon and highlights some of the multitude of factors that have to coincide for a tooth to catastrophically fracture. The report describes the mechanism of fracture and should stimulate clinicians and researchers to investigate cracking of teeth by undertaking fractographic analysis of extracted cracked teeth. (*J Endod* 2017; ■:1–8)

Key Words

Cone-beam computed tomography, cracked tooth, fractography, root fracture, split tooth

The term split tooth is used to define a complete fracture of the crown and root initiated from a crack in the crown and extending apically, usually through both the marginal ridges and proximal surface, ultimately resulting in separation of the tooth fragments (1, 2). A complete split is most commonly associated with endodontically treated teeth without cuspal coverage or with nonendodontically treated teeth weakened because of restorative treatment (1). In contrast, it has been reported that 34%–48% of the cracks, not splits, occur in intact teeth (2–4).

Fractography characterizes fractured specimens or components and mainly involves pattern recognition, which documents the origin, development, and progression of the fracture process (5). Stereomicroscopy, scanning electron microscopy, and cone-beam computed tomographic (CBCT) imaging were also used to examine fracture mechanics and to explore the fracture pathways. Fractographic analysis was used to investigate the dynamics involved in fracture initiation, structural resistances encountered during progression of the fracture, and reasons for the directional changes culminating in the unusual radiographic appearance.

The purpose of this case report was to describe a previously undocumented pattern of a combined longitudinal and horizontal crown and root fracture in an unrestored mandibular second molar. The extracted fragments were examined to determine if fractography could shed insight on the cause and progression of the crack.

Case Report

A 45-year-old otherwise healthy woman was referred for endodontic consultation. The patient's primary complaint was pain and an inability to chew on her mandibular right molar region. The symptoms had been present for a few days and were getting worse. She stated that she had previously avoided using that side because of occasional sensitivity to cold. She did not recollect chewing recently on a hard object nor was she aware of clenching her teeth during sleep. There was no history of trauma or assault. The referring dentist reported radiographic evidence of a horizontal root fracture associated with her symptomatic mandibular right second molar.

An extraoral examination was noncontributory. There was no evidence of temporomandibular joint and masticatory muscle tenderness, masseteric hypertrophy, cheek

Significance

Fracture initiation factors, intrinsic mechanisms that slow down its progression and the possible role of root canal anatomy in a split tooth, are shown. The life cycle of tooth fracture is illustrated to focus research on early diagnosis and conservative treatment approaches.

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<https://doi.org/10.1016/j.joen.2017.10.009>

Case Report/Clinical Techniques

ridging, or tongue scalloping. An intraoral examination under a surgical operating microscope (OPMI pico; Carl Zeiss, Oberkochen, Germany) revealed that an unrestored right mandibular second molar was split mesiodistally and that the tooth fragments could be minimally displaced with digital pressure. This tooth was unresponsive to thermal and electric pulp sensibility tests and was tender on palpation. A 6-mm probing depth was present on the mesiobuccal aspect. No draining sinus tract was evident. Marked wear facets were present on the right mandibular first molar. Intraoral periapical radiography (VistaScan; Durr Dental, Bietigheim-Bissingen, Germany) revealed a partially obliterated pulp chamber, crestal bone loss, and a radiolucency apicocrestally surrounding the mesial root of the second molar. The apical third of the distal root appeared to be horizontally fractured (Fig. 1A–D).

Considering the unusual radiographic appearance, a small field of view CBCT image was taken using the Carestream 9000 3D scanner (Carestream Health Inc, Rochester, NY) using the following parameters: 70 Kvp, 8 mA, and 10.8 seconds. The images revealed a fused single root with a “C-shaped” root canal configuration. A longitudinal fracture could be seen running mesiodistally in a coronal direction and changing course horizontally in the apical third, resulting in separation of the apical fragment from the rest of the tooth. There was a circumradicular radiolucency and loss of the coronal third of both the buccal and lingual cortical plates (Fig. 2A–E).

The clinical diagnosis was pulp necrosis with symptomatic apical periodontitis and a split tooth. The tooth was extracted atraumatically using forceps under local anesthesia. The fragments were rinsed in distilled water and then cleaned in an ultrasonic bath for evaluation using stereomicroscopy and scanning electron microscopy.

Stereomicroscopic Findings

Both buccal and lingual fractured segments were examined with a stereomicroscope (Carl Zeiss Microscopy LLC, Thornwood, NY). Steep cuspal angulation, deep occlusal fissures with areas of brownish discoloration, and minimally cavitated fissure caries and enamel defects at the base of the central and distal pits were noted. An important observation was the lack of a well-defined distal marginal ridge. Instead, a “V”-shaped notch, as described by Lucas and van Casteren (6), was present. At several locations along the depth of the occlusal fissure, whitish areas of demineralization similar in appearance to white spot lesions were observed (Fig. 3A–D). The enamel on both the mesial and distal surface showed the typical wavy pattern of Hunter-Schreger bands (7).

The dentin-enamel junction (DEJ) on the disto-occlusal aspect was less discernible than the rest of the region, and the crack propagated in an undulating pattern. Closer examination revealed a wavy progression of 2 major cleaves (fracture markings) in the dentin, one at the base of the distal pit and another at the base of a central pit near the DEJ

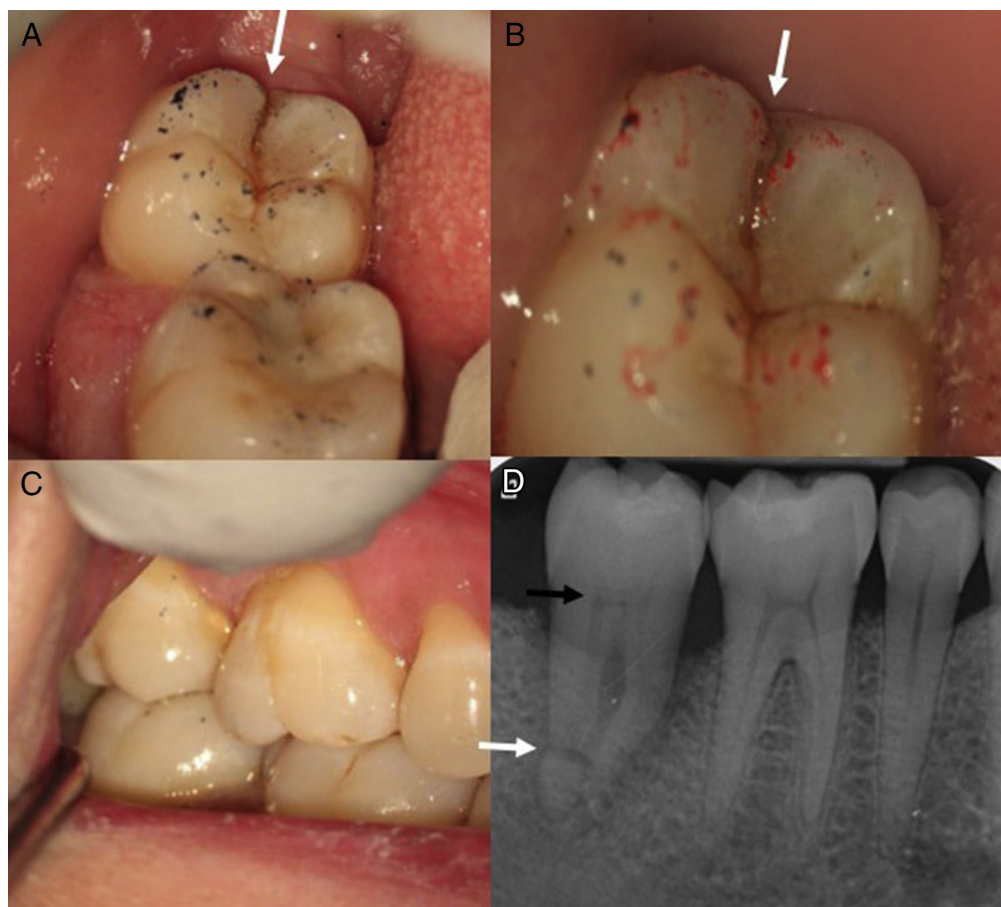


Figure 1. (A) Clinical presentation of a mandibular right second molar (31) with a stained distal fissure (arrow) and blue marks indicating centric contacts. (B) A magnified view of 31. Note the fracture extending over the distal marginal ridge (arrow) and the red marks indicating working and nonworking contacts. There is evidence of occlusal surface wear on the steep portions of the distal margins. (C) A right buccal view showing good intercuspation typically seen in cracked teeth. (D) A periapical radiograph showing apparent horizontal root fracture associated with unrestored 31. Note the calcification in the pulp chamber (black arrow) in 31 and marginal bone loss.

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