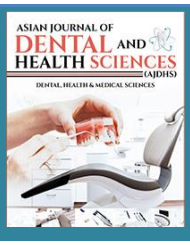

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Cracked Tooth Syndrome: An Endodontic Triumph

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Abstract

A cracked tooth is one where a partial or complete fracture exists within the stress plane. Such fractures are more prevalent in patients over 40 years of age, with an incidence rate of 9.7% for cracks or incomplete tooth fractures with vital pulps. The average biting force in humans ranges from 45.7 kg/mm^2 in males to 36.4 kg/mm^2 in females, with the force ratio between molars, premolars, and incisors being 4:2:1, respectively. Occlusal forces commonly impose stress on a tooth, potentially causing higher energy instances within the stress plane during the mastication cycle. The functional prognosis and periodontal treatment requirements for a cracked or incompletely fractured tooth depend on the location and the extent of tooth structure intersected, along with its involvement in the stress plane. This case report highlights the diagnosis and management of a cracked maxillary first molar and identifies prognostic indicators, which largely depend on the extent of the fracture within the tooth structure.

Keywords: Crack tooth, Orthodontic banding, CBCT, Longitudinal fractures, Endodontic treatment

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INTRODUCTION

A cracked tooth refers to a tooth with a partial or complete fracture along a stress plane, often occurring in commonly affected teeth. Cracked tooth syndrome (CTS) can be defined as an incomplete fracture of unknown depth, originating in the crown, traversing the tooth structure, and potentially extending subgingivally to involve the pulp space and/or periodontal ligament. The fracture may pass through one or both marginal ridges and the proximal surfaces, and it may be confined to the crown or extend from the crown into the proximal root surface. The location, orientation, and severity of the crack significantly influence treatment decisions.[1] Central and apical occlusal cracks are more likely than fractured cusps to result in pulpal or periapical complications.[2]

Gibbs first described the clinical symptoms of incomplete fractures in posterior teeth in 1954, calling it “cuspal fracture odontalgia.”[3] Subsequently, Ritchey et al. documented cases of incomplete fractures leading to pulpitis in 1957.[4] In 1964, Cameron coined the term "cracked tooth syndrome" to describe an incomplete fracture of a posterior tooth that involves the dentin and may extend to the pulp.[5] This definition was later refined by Ellis as "a fracture plane of unknown depth and direction traversing the tooth structure, which, if not already involved, has the potential to progress and connect with the pulp and/or periodontal ligament."[6]

The prevalence of CTS is unclear, but incidence rates between 34% and 74% have been reported.[7] It most commonly affects individuals aged 30–50, with a higher prevalence in females.[7] The mandibular molar is the tooth most often involved, followed by the maxillary premolar, maxillary molar, and mandibular premolar. In 2006, Roh and Lee observed that cracks were more frequent in maxillary molars (57.2%) than mandibular molars (36.3%).[8]

CTS can be classified into five categories, generally ranked from least to most severe: craze lines, fractured cusp, cracked tooth, split tooth, and vertical root fractures.[9] The etiology of CTS is multifactorial. Lynch and McConnell identified four major contributing factors:

restorative procedures, occlusal factors, developmental factors, and miscellaneous factors.[10]

Early diagnosis of cracked teeth is crucial, as delayed detection increases the risk of pulpal complications.[11] Additionally, associated bone defects may complicate future implant placement if the tooth is eventually lost.[12]

The clinical signs and symptoms of CTS vary based on the location and extent of the fracture. Patients often report discomfort lasting several months, along with sharp pain when biting or consuming cold foods, beverages, or sugary substances. Rebound pain, felt when releasing pressure after biting fibrous foods, is a characteristic feature, although one study found chewing pain to be more common than rebound pain.[13] Chronic pulpitis without clinical symptoms may develop due to microleakage of bacterial by-products and toxins. In cases where the crack involves the pulp, both pulpal and periodontal symptoms may arise.

This case report provides an overview of the clinical features, diagnosis, and endodontic treatment of cracked teeth.

CASE REPORT

A 50-year-old male presented to the Department of Conservative Dentistry and Endodontics, complaining of pain in the upper right posterior region during chewing. He reported a history of traumatic bite a few weeks earlier. He had a cervical abrasion on a buccal surface of 16. Upon clinical examination, crack lines were observed on the mesial and buccal surfaces of the tooth crown. (Fig.1a) The tooth responded positively to percussion and bite tests, and probing revealed a depth of 3 mm on the mesiobuccal aspect. Vitality testing with an electric pulp tester indicated no response in tooth 16. Radiographic imaging revealed a fracture line extending through the enamel, dentin, and pulp; however, the radiograph could not determine the exact extent of the fracture or provide significant additional findings (Fig. 1b).

The patient was informed about the option of cone beam computed tomography (CBCT) to assess the fracture's depth and its impact on the tooth's prognosis. The benefits of CBCT were explained, and assurances were given regarding minimal radiation exposure. After obtaining informed consent, CBCT (Vatech, PaX-Reve 3D Plus, pulse-type generator, 5 × 5 cm field of view, and 0.08 mm voxel size) was performed to evaluate the fracture's apical extension and its proximity to the pulp (Figures 4(a) and 4(b)). The imaging revealed that the fracture extended mesially and buccally, involving the mesiobuccal pulp horn, but did not extend apically below the alveolar bone level. (Fig. 1c & 1d) The prognosis was deemed favourable. Root canal treatment followed by crown placement was determined to be the most suitable treatment plan. The presence of acute pain and the suspected extension of the fracture to deeper areas of the root justified the use of CBCT for a precise diagnosis and treatment plan. The case was diagnosed as pulp necrosis with symptomatic apical periodontitis in tooth 16 due to a crack.

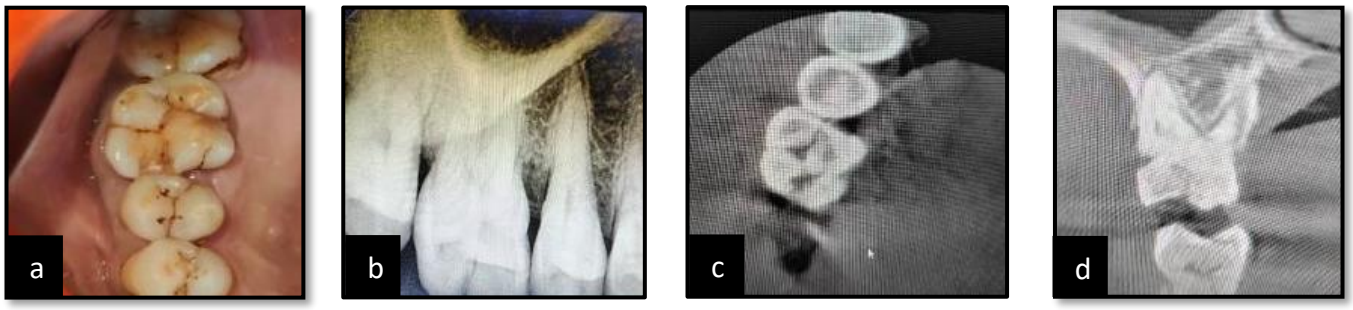

Figure 1: (a) Preoperative picture, (b) Preoperative radiograph, (c) Cone beam computed tomography (CBCT) showing the fracture line extending mesially and buccally, and (d) cracked line also towards the pulp space

Treatment procedure:

Occlusal reduction was performed before initiating root canal therapy on tooth 16. Upon access opening, necrotic pulp tissue was observed. The tissue was extirpated, and the tooth was visually examined using a magnifying loupe with LED illumination. A buccal crack line was identified extending into the dentin, terminating just above the pulp floor. Another crack line was seen on the occlusal fourth of the mesial wall. These cracks were removed with a no. 1/4 round bur to a depth sufficient to eliminate the lines. The crack regions were etched and sealed with a flowable composite resin (COMPO-flo, D-tech). Orthodontic molar banding (0.180″ × 0.006″) was applied to stabilize the tooth. (Fig. 2)

Canal instrumentation began with hand files using minimal force, followed by rotary instrumentation up to 20/6% Neoendo Flex files. Irrigation was performed with 3% sodium hypochlorite and saline. Calcium hydroxide intracanal medication was placed between appointments. Obturation was completed with gutta-percha and zinc oxide sealer using the lateral condensation technique. Minimal force was applied during condensation to prevent further damage. The gutta-percha was trimmed at the orifice level, and post-endodontic restoration was performed one week later using a glass ionomer cement liner, fiber-reinforced composite, and bulk-fill dentin bonding composite. (Fig.3 a&b)

Figure 2: Clinical photograph after molar band placement.

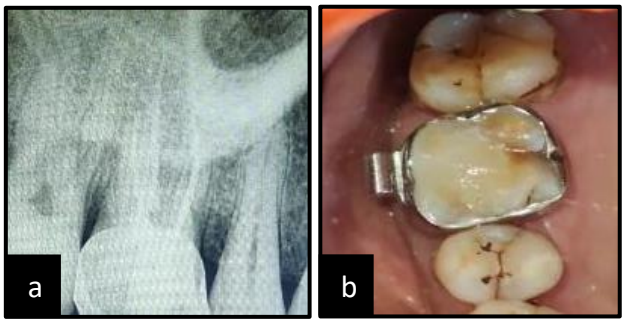

Figure 3: (a and b) Postoperative radiograph and photograph.

Follow-up evaluations at one and three months showed no pathological changes upon clinical and radiographic examination. The orthodontic molar band was removed by creating a groove with a diamond bur and splitting it. The tooth was minimally prepared, and prosthetic rehabilitation was completed with a full-ceramic crown. A review at ten months confirmed that tooth 16 remained asymptomatic and functional, with an intact periapical area (Fig. 4&5).

Figure 4: After crown placement

Figure 5: Review after 10 months

DISCUSSION

Cracked tooth syndrome presents a diagnostic challenge, even for experienced dental professionals, due to its diverse and often atypical clinical signs and symptoms.[14] Early diagnosis is crucial, as it is associated with better restorative outcomes and prognosis.[15] Various diagnostic methods are used to confirm cracks in teeth, such as visual examination under magnification, staining, transillumination, bite tests, autofluorescence, optical coherence tomography, quantitative percussion diagnostics, and laser detection. Radiographic techniques, particularly cone beam computed tomography (CBCT), are often superior to periapical radiographs for assessing crack extent. However, CBCT may still have limitations, especially in detecting cracks in endodontically treated teeth.[16] With a resolution of approximately 80 µm, CBCT is not ideal for diagnosing cracks or detecting early vertical root fractures (VRFs).[17] An in vitro study by Yuan et al. showed that using meglumine diatrizoate as a contrast agent with CBCT enhances detection of hidden cracks compared to conventional methods.[18]

In this case, the fracture line was visible on radiographs, and the treatment objective was to prevent further crack propagation. This was achieved through occlusal height reduction, crack sealing, and tooth stabilization using a stainless-steel band. Pane et al. demonstrated that stainless steel bands significantly reduce cuspal flexure and increase fracture resistance compared to teeth without bands.[19] These bands act as a protective measure during treatment by absorbing forces and ensuring uniform stress distribution. As stainless steel has an elastic modulus higher than tooth structure, it transfers stress to the band material, thereby protecting the tooth. Care must be taken to avoid occlusal interference when applying bands. In this case, the crack's etiology was attributed to traumatic bite, as reported by the patient.

The prognosis for a cracked tooth is more favourable when the crack is not visible or does not extend to the pulp chamber floor. In this case, visual examination under a 2.5× magnification loupe (Admetec) revealed a crack terminating just above the pulp floor. The tooth was diagnosed as non-vital, necessitating root canal treatment followed by prosthetic restoration. Treatment began with a guarded prognosis. Minor cracks can often be managed with bonded restorations or crowns, while deeper cracks with pulpal involvement require root canal therapy and crowns for structural reinforcement. Indirect composite onlays may also be an option, but full crowns are typically preferred for treating cracked tooth syndrome.

Following banding and root canal therapy, the patient experienced relief from symptoms. Post-endodontic restoration included sealing the orifice with glass ionomer cement, replacing dentin with fiber-reinforced composite (EverX posterior, GC Europe), and applying a nanohybrid composite (Tetric EvoCeram, Ivoclar Vivadent, Inc.) for the occlusal laminate layer. Bonded restorations are effective in reinforcing weakened tooth structures. Fiber-reinforced composite has high flexural

strength, minimal shrinkage, and the ability to arrest crack progression. The banding was retained for one month before being replaced with a full-ceramic crown. Full coverage restorations bind the tooth together, providing external compressive forces similar to banding, thus ensuring uniform stress distribution. Studies indicate that cracked teeth restored with full crowns after root canal treatment have higher survival rates and fewer complications compared to other restorations.[20]

Clark and Caughman categorized cracked tooth prognosis into four groups based on the extent of the fracture:[21]

- Excellent:
  (a) Cuspal fractures within the dentin angling from the faciopulpal or linguopulpal line angle of a cusp to the cemento-enamel junction or slightly below.
  (b) Horizontal fractures of a cusp not involving the pulp.
- Good: Coronal vertical fractures running mesiodistally into dentin but not involving the pulp.
- Poor: Coronal vertical fractures extending mesiodistally into dentin and pulp but confined to the crown.
- Hopeless: Coronal vertical fractures passing mesiodistally through the pulp and into the root.

A 10-month follow-up revealed that the treated tooth remained asymptomatic and functional, with an intact periapical area.

Clinical Significance:

Diagnosing cracked tooth syndrome is complex due to its varied signs and symptoms. A range of techniques can be used to manage cracked teeth effectively, focusing on preservation, stabilization, and protection. In this case, a combination of restorative procedures, banding, endodontic treatment, and prosthodontic intervention resulted in a favorable outcome.

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Conflicts of interest: There are no conflicts of interest.

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