

Cracked tooth syndrome: Overview of literature

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ABSTRACT

Pain is defined as an “unpleasant sensory and emotional feeling which is associated with actual or potential injury of tissue or expressed in terms of such injury.” Tooth pain usually refers to pain around the teeth or jaws mainly as a result of a dental condition. Mostly, toothaches are caused by a carious cavity, a broken tooth, an exposed tooth root or gum disease. The toothache may sometimes be the result of radiating pain from structures in the vicinity of tooth and jaws (cardiac pain, ear, nose, throat pain, and sinusitis). Therefore, evaluation by both dentists and physicians are sometimes necessary to diagnose medical illnesses causing “toothache.” Cracked tooth syndrome is a major diagnostic challenge in clinical practice. Accurate diagnosis and appropriate treatment are complicated due to lack of awareness of this condition and its bizarre clinical features. Early diagnosis has been linked with successful restorative management and good prognosis. This article provides a detailed literature on the causes, classification, signs and symptoms, diagnosis, and treatment planning of cracked tooth syndrome.

Key words: Cracked tooth syndrome, diagnosis, tooth pain

Submission: 03-12-2014 **Accepted:** 12-04-2015

INTRODUCTION

Cracked tooth syndrome may be defined as a fracture plane of unknown depth, which originate from the crown, passes through the tooth structure and extends subgingivally, and may progress to connect with the pulp space and/or periodontal ligament.^[1,2]

Gibbs in 1954, was the first to describe the clinical symptoms of incomplete fracture of posterior teeth involving the cusp and termed it as “cuspal fracture odontalgia.”^[3] Cases of incomplete fracture with subsequent pulpitis were reported by Ritchey *et al.* in 1957.^[4] Cameron in 1964 coined the term “cracked tooth syndrome.” Here, the signs and symptoms were not apparent, and the teeth showed painful response to

cold or pressure applications and became necrotic, however, the pulp and periodontium were apparently healthy.^[5]

Ellis defined, incomplete tooth fracture as a “fracture plane of unknown depth and direction passing through tooth structure, and may advance to connect with the pulp and/or periodontal ligament.”^[6,7]

In the late 1970s, Maxwell and Braly advocated the use of the term incomplete tooth fracture.^[8] According to Luebke, fractures are either complete or incomplete, although, other terms such as split-root syndrome, hairline fracture, hairline tooth fracture, enamel infraction, crown craze, craze lines, and tooth structure cracks are also known.^[9]

CLASSIFICATION

Several classifications have been proposed based on: (a) The type or site of the crack, (b) the direction and degree of the crack, (c) the risk of symptoms, (d) pathological processes.

The American Association of Endodontists,^[10] in a document titled “cracking the cracked tooth code” identified five types of cracked teeth [Table 1].

Craze lines are visible fractures and contained within the enamel. In posterior teeth, craze lines are usually seen to

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Access this article online	
Quick Response Code:	Website: www.ijabmr.org
	DOI: 10.4103/2229-516X.165376

Table 1: American Association of Endodontists classification of a cracked tooth

Classification	Origin	Direction	Symptoms	Pulp status	Prognosis
Craze line	Crown	Variable	Asymptomatic	Vital	Excellent
Fractured cusp	Crown	Mesiodistal or faciolingual	Mild and mostly on biting and cold	Usually vital	Good
Cracked tooth	Crown and/root	Mesiodistal often central	Acute pain on biting, occasional sharp pain to cold	Variable	Questionable: Depends on depth and extent of crack
Split tooth	Crown and root	Mesiodistal	Marked pain on chewing	Often root filled	Poor unless crack has terminated just subgingivally
Vertical root fractures	Roots	Faciolingual	Vague pain mimicking periodontal disease	Mainly root filled	Poor: Root resection in multi-rooted teeth

cross the marginal ridges and/or extend along buccal and lingual surfaces. Long vertical craze lines usually occur in anterior teeth [Figure 1a].

Fractured cusps begin at the crown of the tooth, extend into dentin, and the fracture ends in the cervical part of the tooth. They are usually seen in heavily restored teeth, causing unsupported cuspal enamel [Figure 1b].

A cracked tooth is indicative of a crack extending from the occlusal surface of the tooth apically without separation of the two fragments. The crack is generally located at the center of the tooth in a mesiodistal direction and may involve one or both marginal ridges [Figure 1c].

A split tooth is indicative of a crack extending through both marginal ridges usually in a mesiodistal direction splitting the tooth completely into two individual fragments. The crack is generally located at the center of the tooth and this entity occurs due to crack propagation [Figure 1d].

Vertical root fractures commence in the root generally in a bucco-lingual direction. The crack is generally complete though may be incomplete and involve only one surface. The crack may involve either the entire root or only a portion of the root [Figure 1e].

ETIOLOGY

Cracked tooth syndrome has a multi-factorial etiology. Geurtsen showed that “excessive forces applied to a healthy tooth or physiologic forces applied to a weakened tooth results in an incomplete fracture of the enamel or dentine.”^[1]

Lynch and McConnell^[12] subdivided the etiology into 4 major categories-restorative procedures, occlusal factors, developmental factors, and miscellaneous factors [Table 2].

EPIDEMIOLOGY

The occurrence of cracked tooth syndrome is unknown, but an incidence rate of 34–74% has been documented.^[5,13] It occurs

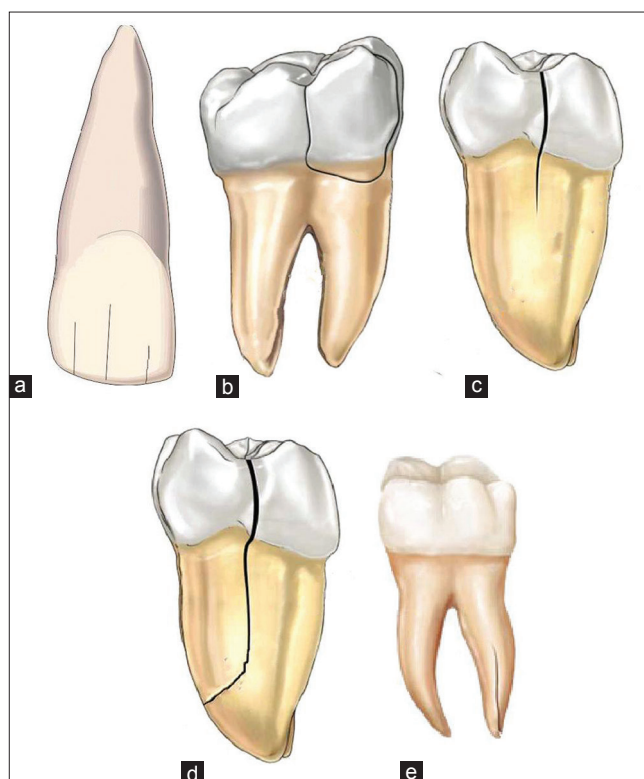


Figure 1: (a) Depicting visible fracture lines within the enamel suggestive of Craze lines; (b) Fractured cusp terminating in the cervical part of the tooth; (c) Cracked tooth extending from the occlusal tooth surface without separation of tooth fragments; (d) Separated tooth fragments suggestive of a split tooth; (e) Vertical root fracture

frequently in individuals within the age range of 30–50 years,^[14] with a female predilection.^[2] Most commonly affected tooth is mandibular molar followed by maxillary premolar, maxillary molar, and mandibular premolar.^[13] Mandibular first molars are the first permanent teeth to erupt into the dental arch, hence, they are more prone to dental caries and subsequent restorative intervention. Thus, they are more susceptible to fracture. The “wedging effect” upon lower first molar teeth from the prominent mesio-palatal cusp of maxillary first molar teeth may also be contributory.^[11]

CLINICAL FEATURES

Cracked tooth syndrome presents with varied clinical signs and symptoms, according to the position and extent of the

Table 2: Etiological factors in cracked tooth syndrome

Classification	Factors	Examples
Restorative procedures	Inadequate design features	Over-preparation of cavities (excessive tooth removal) Deep cusp-fossa relationship Insufficient cuspal protection in inlay/onlay design
	Stress concentration	Pin placement (friction lock or self-threading dentin pins) Non-incremental application of composite resins (tensile stress on cavity walls) Pressure exerted during the seating of tightly fitting cast restorations Physical forces during placement of restoration, e.g., amalgam or soft gold inlays (historical)
Occlusal factors	Masticatory trauma	Sudden and excessive cutting force on a piece of hard object (bone)
	Trauma from occlusion	Eccentric contacts and interferences (especially mandibular second molars)
	Functional forces	Large untreated carious lesions Cyclic forces
	Parafunctional habits	Bruxism and bruxomania
Developmental factors	Incomplete fusion of areas of calcifications	Occurrence of cracked tooth syndrome in unrestored tooth or teeth with minor restorations
Miscellaneous factors	Thermal cycling	Enamel cracks
	Foreign body	Lingual barbells
	Dental instruments	High speed rotary instruments associated crazing and cracking

incomplete fracture.^[11,15,16] History of the discomfort of several months and sharp pain when biting or when consuming cold food/beverages may be elicited.^[17] “Rebound pain” - pain on the release of pressure upon intake of fibrous foods is a consistent feature.^[18] Pain may be elicited by the consumption of sugar containing substances,^[19] and also by the act of tooth grinding or during excursive mandibular movements.^[20] Patients may or may not be able to locate the offending tooth (there are no proprioceptive fibers in the pulp chamber). The absence of heat-induced sensitivity may also be a feature. Chronic pulpitis with no clinical symptoms may be seen as a result of micro-leakage of bacterial by-products and toxins. Cracks with pulpal involvement may result in pulpal and periodontal symptoms.^[21,22]

Brännström and Aström^[23] proposed the physiological basis of pain on chewing. When the fractured portions of the tooth move independently of each other, it causes sudden movement of fluid present in the dentinal tubules. This causes activation of myelinated A-type fibers within the dental pulp and results in acute pain. Hypersensitivity to cold may occur due to the seepage of toxic irritants through the crack. This leakage of toxic irritants cause the release of neuropeptides, and a concomitant lowering in the pain threshold of unmyelinated C-type fibers within the dental pulp.^[24] Other author states that the symptoms are caused by the alternating stretching and compressing of the odontoblast processes located within the crack.^[25]

DIAGNOSIS

Because of the variable and bizarre clinical signs and symptoms, cracked tooth syndrome is a diagnostic challenge for even the most experienced dental operators.^[26] The importance of an early diagnosis has been linked with successful restorative

management and prognosis.^[27] Wide variety of dental conditions may present with similar features and misdiagnosed as a cracked tooth syndrome, thus complicating the diagnosis. Such conditions include acute periodontal diseases, reversible pulpitis, dentinal hypersensitivity, galvanic pain associated with silver amalgam restorations, sensitivity following micro leakage from recently placed composite resin restorations, areas of hyper occlusion from dental restorations, occlusal trauma from parafunctional habits, orofacial pain arising from conditions such as trigeminal neuralgia and psychiatric disorders such as atypical facial pain.^[2]

Dental history

A thorough and detailed dental history may help in eliciting certain distinct clues.^[12] The patient may have a history of long-term dental treatment, multiple replacements of restorations, and occlusal adjustments. There may be a history of parafunctional habits (clenching or grinding, chewing on hard objects).^[28] History of cold sensitivity and sharp pain on biting hard or tough foods which ceases when the pressure is released is an important indicator. Symptoms may vary according to the depth and orientation of the crack.^[29]

Clinical examination

The application of a sharp straight probe to the margins of the heavily restored tooth (suspected to have an incomplete fracture) may evoke sharp pain, thus indicative of the presence of underlying crack. Sometimes exploratory excavation may be needed to obtain a visual diagnosis. Patient’s consent is mandatory for excavation as it is not guaranteed that a fracture will be seen beneath the removed restoration. On removal of the existing restorations, fracture lines may be revealed. Clinical examination may also reveal the presence of wear facets on the occlusal tooth surfaces (identifies teeth in eccentric contact and at risk from damaging lateral

forces), occurrence of localized periodontal defects (where cracks extend subgingivally) or the evocation of symptoms by sweat or thermal stimuli. The use of rubber dam enhances the probability of visualizing these cracks by isolating the tooth, emphasizing the crack with a distinct background, keeping the area saliva free, and reducing peripheral disruptions.

Periodontal probing

Cracked tooth and a split tooth may be differentiated by periodontal probing. The localized periodontal defect is the result of a fracture line extending below the gingiva. Isolated deep probing reveal the presence of a split tooth, indicating a poor prognosis.

Dye test

Special stains such as methylene blue or gentian violet are frequently used to highlight the cracks.^[26] However, a long time (at least 2–5 days) is needed to be effective and may require placement of a provisional restoration. This may weaken the tooth integrity and further spread the crack. Another disadvantage is difficult esthetic restoration.

Bite tests

Pain on biting that ceases after the pressure has been withdrawn is a classical sign. Symptoms may be elicited when pressure is applied to an individual cusp.^[3,30,31] This forms the basis of so-called “bite tests.” Here, the patient is asked to bite on various items such as a toothpick, cotton roll, rubber abrasive wheels such as burlow wheel, orange wooden stick^[15,18,31] or the commercially available Tooth Slooth (Professional Results Inc., Laguna Niguel, CA, USA).^[15]

Vitality tests

Vitality tests for individual teeth are usually positive.^[19] Sometimes the affected teeth may show signs of hypersensitivity to cold thermal stimuli due to the presence of pulpal inflammation; a feature that may help to confirm a diagnosis of cracked tooth syndrome. Teeth affected by the condition may be seldom tender on apical percussion.

Radiographs

Diagnosis of cracked tooth syndrome by radiographs is usually questionable, as fractures propagate in a mesiodistal direction; parallel to the plane of the film.^[12] Fractures occurring in a bucco-lingual direction is more readily noticed on radiographs. Radiographs may be helpful in assessing the status of the pulp and periodontium, and for excluding other dental pathology.^[2]

Transillumination

Transillumination is an important aid in diagnosing the cracks, whether it is an incomplete crack (as in cracked tooth syndrome) or a complete vertical root fracture.^[32]

In transillumination, the tooth is cleaned and a fiber-optic or other light source is applied directly on the tooth. A crack will block the transmission of light, and structurally sound teeth (including those with craze lines) will transmit the light throughout the crown. Two main disadvantages of using transillumination without magnification are: (a) Transillumination dramatizes all cracks to the point that craze lines appear as structural cracks. (b) Subtle color changes are indistinguishable. Transillumination with a fiber-optic light and use of magnification will aid in visualization of a crack.^[33]

Microscopic detection

Use of clinical microscope ($\times 16$) provides an ideal magnification level for the evaluation of enamel cracks, with a range from $\times 14$ to $\times 18$.^[34]

Ultrasound is also capable of imaging cracks in the simulated tooth structure and can be used as a future diagnostic aid.^[35]

Indirect diagnostic measures, such as the use of copper rings, acrylic provisional crowns, and stainless steel orthodontic bands, may also be used to detect cracked tooth syndrome.^[15]

Another indirect diagnostic method is an unauthenticated technique by Banerji *et al.*^[36] Composite resin is placed over the tooth without etching and bonding. The patient feels marked improvement in discomfort on biting, as the material acts as a splint.

MANAGEMENT

The treatment of a cracked tooth depends on the site, direction, size or the degree of the crack. Superficial cracks are easy and early to detect, and hence simple to manage. Minor cracks are often restored with a filling or a crown.

Deep cracks with pulp involvement require root canal treatment and a crown to protect the tooth.

In the worst case scenario, a cracked tooth cannot be repaired. This occurs when the crack extends into the root of the tooth beneath the bone. These cases require the removal of the tooth and replace with a dental implant or a dental bridge.

According to Clark and Caughman,^[37] the prognosis of cracked teeth can be excellent, good, poor, and hopeless.

- Excellent: (a) Cuspal fractures within the dentin that angle from the faciopulpal or linguopulpal line angle of a cusp to the cemento-enamel junction or slightly below. (b) Horizontal fracture of a cusp not involving the pulp
- Good: A coronal vertical fracture that runs mesiodistally into the dentin but not into the pulp

- **Poor:**A coronal vertical fracture that runs mesiodistally into the dentin and pulp, but is limited to the crown
- **Hopeless:**A coronal vertical fracture that runs mesiodistally through the pulp and extends into the root.

CONCLUSION

Cracked tooth syndrome is a common and well-documented entity in the clinical practice. Patients usually present with a wide variety of signs and symptoms, thus making the diagnosis difficult and complicated. Detailed history and thorough clinical examination may help in establishing a correct diagnosis and hence that an appropriate treatment plan can be instituted.

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How to cite this article: Hasan S, Singh K, Salati N. Cracked tooth syndrome: Overview of literature. Int J App Basic Med Res 2015;5:164-8.
Source of Support: Nil. **Conflict of Interest:** None declared.