

## Diagnosis and Management of Cracked Tooth- Decision Analysis

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### ABSTRACT

Cracked tooth refers to an incomplete fracture of a tooth that may involve the pulp. Both vital and non vital teeth can develop cracks. The causative factors include previous restorative procedures, excess occlusal forces, developmental conditions that result in the formation of weakened tooth structure, trauma, etc. Most commonly involved teeth are the mandibular molars mainly due to the wedging effect of the maxillary mesio-palatal cusp onto the central fissure of the mandibular molar. The crack can involve the crown or the root of the tooth or both. It may be limited to the enamel, may involve dentin or can extend upto the pulp also. Diagnosis of this condition becomes challenging due to varied clinical features. Common symptoms involve pain on releasing the bite due to snapping of the segments or due to independent movement of the fractured segments. The patient has difficulty in identifying the offending tooth and may give a history of numerous dental procedures being performed which fail to relieve pain. This write up deals with the classification, epidemiology, diagnosis and management of cracked teeth, evaluation of crack, nature of symptoms, determining the prognosis and using current, short and long term strategies for successful management.

**KEY WORDS:** CRACK TOOTH SYNDROME, TOOTH FRACTURES, SPLIT TOOTH, CRAZE LINE, CRACKED CUSP, BITE TEST.

### INTRODUCTION

Crack is a line on the surface along which it has split without breaking apart while fracture is cracking or breaking of the material (Ellis, 2001; Banerji, Mehta and Millar, 2017). Cracked tooth has been defined as “A fracture plane of unknown depth and direction passing through tooth structure that, if not already involving, may

progress to communicate with the pulp and or periodontal ligament” (Ellis, 2001).Cracks on the teeth range from craze lines on the enamel to a split tooth to the vertical root fracture. This condition mostly occurs in patients aged 30 years to 50 years with an equal frequency of occurrence in males and females (Hiatt, 1975; Snyder, 1976; Ellis, Macfarlane and McCord, 1999). The most commonly affected teeth are mandibular second molars, followed by mandibular first molars and maxillary premolars (Braly and Maxwell, 1981; Ehrmann and Tyas, 1990; Ellis, Macfarlane and McCord, 1999).While the crack tends to orient mesiodistally in most teeth, it is seen extending buccolingually in mandibular molars (Türp and Gobetti, 1996).

Two patterns of crack formation have been put forth. The first occurs when the crack develops centrally and

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follows the dentinal tubules to extend into the pulp, the second occurs when the crack is peripherally located resulting in cuspal fracture. When pressure is applied to such cracks, the fractured segments separate resulting in movement of dentinal fluid, stretching and stimulating the odontoblastic process, thereby stimulating the nociceptors in the pulp. Five types of cracked teeth have been identified by The American Association of Endodontists in a document titled “cracking the cracked tooth code”. They are- craze lines, fractured cusp, cracked tooth, split tooth, vertical root fractures.

We have numerous highly cited publications on well designed clinical trials and lab studies (Govindaraju, Neelakantan and Gutmann, 2017; Azeem and Sureshbabu, 2018; Jenarthanan and Subbarao, 2018; Manohar and Sharma, 2018; Nandakumar and Nasim, 2018; Teja, Ramesh and Priya, 2018; Janani and Sandhya, 2019; Khandelwal and Palanivelu, 2019; Malli Sureshbabu et al., 2019; Poorni, Srinivasan and Nivedhitha, 2019; Rajakeerthi and Ms, 2019; Rajendran et al., 2019; Ramarao and Sathyanarayanan, 2019; Siddique and Nivedhitha, 2019; Siddique et al., 2019; Siddique, Nivedhitha and Jacob, 2019). This has provided the right platforms for us to pursue the current study. Our aim is to review the various clinical features that help in the diagnosis of cracked tooth and also discuss the various protocols for its management.

**Clinical Features:** Cracked teeth show varied clinical signs and symptoms based on the position and extent of fracture (Ritchev, Mendenhall and Orban, 1957; Ehrmann and Tyas, 1990; Hasan, Singh and Salati, 2015). The patient gives a history of discomfort, pain on biting or on consuming cold beverages. ‘Rebound pain’ on releasing the bite after chewing fibrous food is the most common feature (Cameron, 1964). The patient may have difficulty identifying the affected tooth as there are no proprioceptive fibres in the pulp chamber. The tooth is normally not tender to percussion and vitality testing shows a positive response (Ehrmann and Tyas, 1990; Lynch and McConnell, 2002). This crack may result in chronic pulpitis due to microleakage of bacterial toxins. Cracks with pulpal involvement may result in pulpal and periodontal symptoms. On clinical examination, a cracked tooth may show extensive intracoronal restorations (Geurtsen, 1992). The patient may also give a history of extensive dental treatments followed by occlusal adjustments or replacement of restorations which failed to relieve the pain.

**Diagnosis:** Since cracked teeth present with variable signs and symptoms, it becomes challenging to diagnose the case. Early diagnosis helps in successful restorative management with good prognosis. Crack tooth syndrome can be misdiagnosed as acute periodontal disease, reversible pulpitis, dentinal hypersensitivity, galvanic pain, sensitivity due to microleakage following composite resin restorations, pain due to hyperocclusion or parafunctional habits and orofacial pain.

**Dental History:** A thorough dental history may point

towards the diagnosis of cracked tooth syndrome. The patient may give a history of long term dental treatment with repeated occlusal adjustments and replacement of restorations that failed to relieve the pain. The patient may also give a history of parafunctional habits and may show sensitivity to cold (Chong, 1989; Geurtsen, 1992). Sharp pain on releasing the bite is an important finding.

**Clinical Findings:** Running a sharp straight probe into the margins of a heavily restored tooth may elicit a sharp pain indicative of an underlying crack. Exploratory excavation of a restoration can be done to reveal an underlying crack. Clinical examination may show the presence of wear facets on the occlusal surfaces of the tooth, localised periodontal defects (when crack extends subgingivally). Rubber dam can be used to isolate the tooth to be examined for better visualisation of the crack with a distinct background and keeping the area saliva free. Other clinical methods of diagnosis are:

- **Periodontal Probing:** Helps in differentiating between cracked tooth and a split tooth. Localised periodontal defect is indicative of fracture line extending subgingivally. Split tooth can be revealed by isolated deep probing. Split tooth indicates a poor prognosis (Cameron, 1976).
- **Bite Tests:** Patients are made to bite on various items such as toothpick, cotton roll, rubber abrasive wheels, orange wooden sticks or commercially available tooth sloth (Ehrmann and Tyas, 1990). Biting causes the fractures segments to separate. On releasing the bite, the segments snap together eliciting pain.
- **Radiographs:** Use of radiographs for the detection of cracked tooth is questionable as fractures propagate parallel to the film in a mesiodistal direction. Fracture lines can be captured on the radiograph when they are in a buccolingual direction. Radiographs are used to evaluate pulpal and periapical status to rule out other dental pathology (Türp and Gobetti, 1996).
- **Vitality Tests:** Cracked teeth usually show positive results to vitality testing (Stanley, 1969). The tooth may sometimes show signs of hypersensitivity to cold stimuli due to underlying pulpal inflammation.
- **Dye Test:** Stains like methylene blue or gentian violet are used to highlight the cracks (Goose, 1981). After staining the tooth, it is temporarily restored. On removal of the restoration after 2-5 days, staining of the crack can be seen. Disadvantage of this technique is weakening of the tooth due to crack propagation and compromise in esthetic restorations.
- **Transillumination:** It is a very important diagnostic aid in the detection of an incomplete crack or complete vertical root fracture (Davis and Overton, 2000). This involves cleaning of the tooth followed by application of fiber optic light source. Cracks will block transmission of light and sound teeth will allow transmission of light throughout the crown. Transillumination has to be used with magnification because transillumination used alone will dramatize all cracks to an extent that craze lines will end up

appearing as cracks (Homewood, 1998).

- **Microscopic Detection:** Use of a clinical microscope with a magnification range between 14x to 18x will help evaluate enamel cracks (Trushkowsky, 1991).

Ultrasound is also capable of detecting cracks in the tooth structure and is coming up as a diagnostic aid (Liu and Sidhu, 1995). Indirect diagnostic techniques for the detection of cracked tooth syndrome are by using copper rings, stainless steel orthodontic bands and acrylic provisional crowns (Ehrmann and Tyas, 1990). Another indirect diagnostic method put forth by Banerji et al was placement of composite resin over the tooth without etching and bonding. The patient experienced improvement in discomfort on biting as the composite resin acted like a splint (Davis and Overton, 2000). Optical coherence tomography is a non invasive imaging modality which is being used for the detection of cracks. It is more reliable, accurate and a safer alternative compared to X-ray radiography. This is a newly proposed technology for accurately detecting the cracks. The limitation of this technique is that it can be used for detection of cracks in the coronal portion in which laser light can be irradiated (Lubisich et al., 2010).

### Management

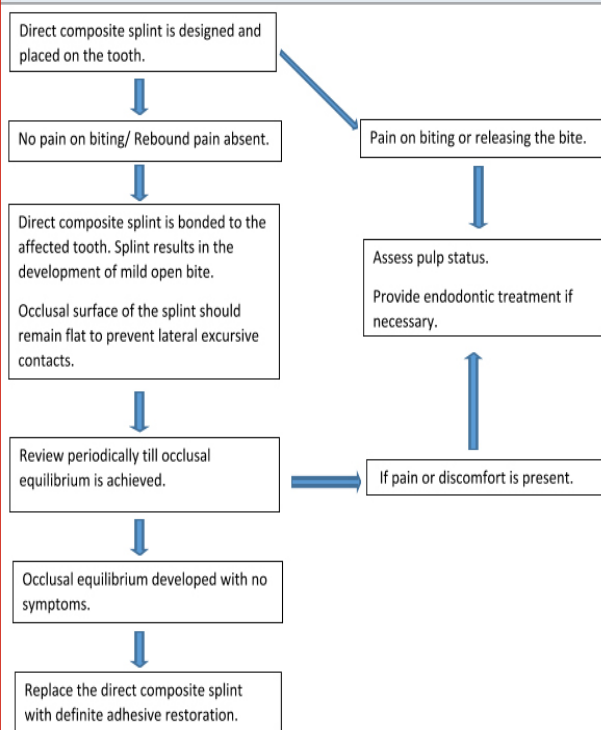
**A novel ultra conservative approach for the management of cracked tooth syndrome:** This method involves the placement of bonded, direct supra coronal resin onlay restoration for the treatment of incompletely fractured teeth (Banerji, Mehta and Millar, 2017) [Figure 1].

- Supra occlusal restoration prepared should be contoured flat to limit lateral loading.
- This non bonded composite splint has to be tried intraorally and confirmed for alleviation of symptoms of rebound pain from the diagnosed tooth.
- The tooth is cleaned and conditioned with 37% phosphoric acid prior to placement and curing of the composite resin.
- The occlusal surface of this restoration should result in slight disocclusion. Upon lateral excursion, posterior teeth are no longer in contact.
- Periodic evaluation is carried out every week.
- Once occlusion is equilibrated and no symptoms are present, the direct composite splint is replaced with definitive restoration.
- Further follow up is carried out to check for outcome.

This technique provides conservative, effective, predictable, efficient and economical approach for short to medium term management of cracked tooth syndrome. With the advent of CAD/CAM technology, these onlay splints can be designed chairside once the diagnosis of cracked tooth syndrome has been established. Different protocols have been advocated for the management of cracked tooth syndrome which involve removal of the fractured cusp followed by restoration of the defect, subtractive occlusal adjustment to splinting or immobilisation of the affected tooth (Banerji, Mehta and

Millar, 2017) [Figure 2]. While removing the fractured cusp, care has to be taken as there is a risk of attenuation of the fracture plane. Subtractive occlusal disocclusion will not avoid flexing of the tooth on occlusal loading. Cusp reduction followed by restoration with an overlay will serve as an ideal treatment option.

Figure 1: Ultra conservative approach for the management of cracked tooth (Banerji et al 2017)



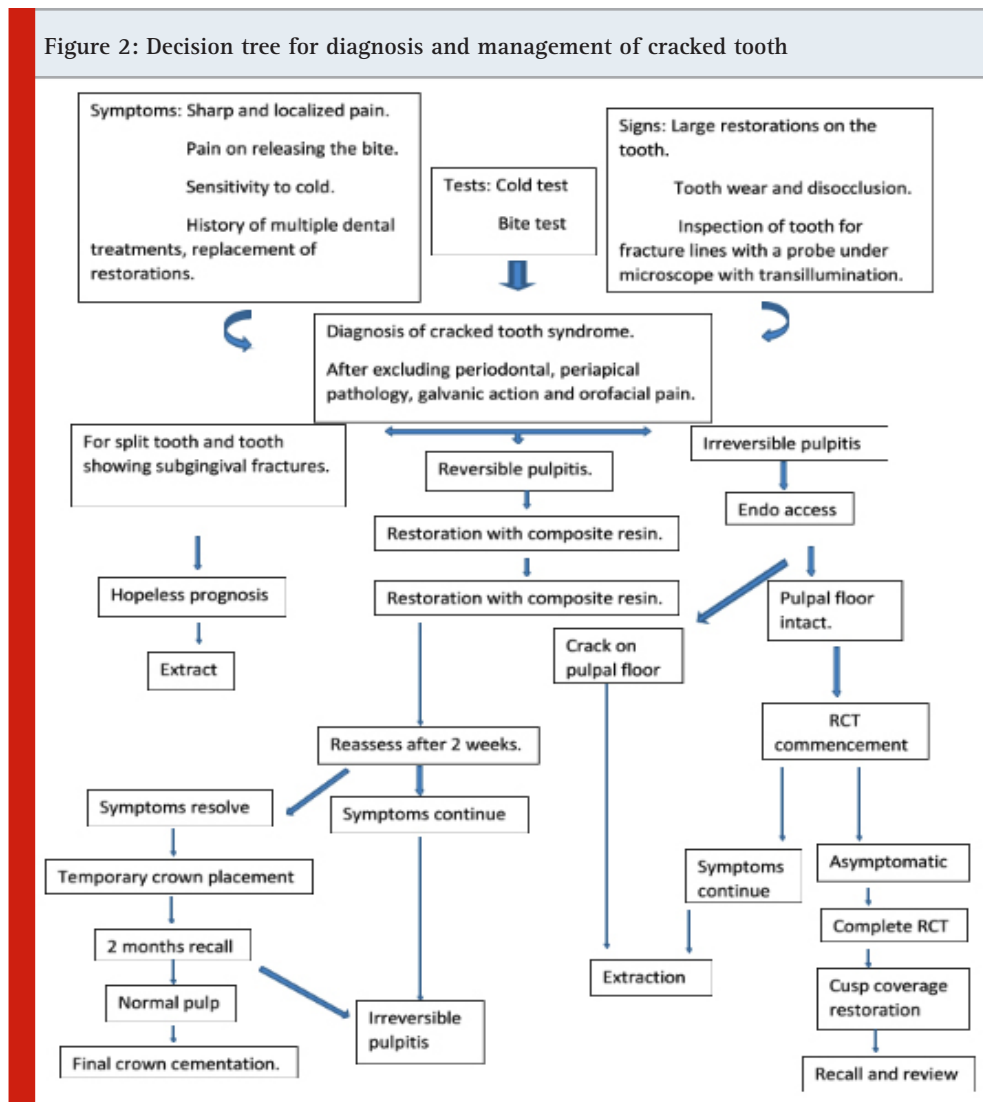
**Immediate Management of Cracked Tooth syndrome:** Unless the affected cusp has been separated off during removal of an existing restoration, acute management generally involves the use of immediate extra coronal circumferential splints (copper rings, orthodontic bands, provisional crowns) or by the application of direct intracoronal or extracoronal splints following tooth preparation (Ehrmann and Tyas, 1990; Clark, Sheets and Paquette, 2003). Acute splints like copper rings and orthodontic bands when used, should be well contoured, adapted circumferentially and should not interfere with the occlusion (Ehrmann and Tyas, 1990).

### Advantages of using acute splints are:

- They are economical
- Minimally invasive
- Provision for carrying out endodontic treatment when in situ.
- Disadvantages:
- Not always available with the practitioner
- Placement may cause discomfort
- Unesthetic
- Requires good skills and sound knowledge for correct placement.
- Causes food trapping within the bands.

Provisional crowns and inlays when used for splinting can provide effective means of immobilisation. Since the fabrication of these are time consuming, the delay can cause progression of the crack. Using these splints can cause pulpal trauma since the technique used is invasive.

Using intracoronal restorations in an incompletely fractured tooth will prevent independent movement of the fractured segments by anchoring the restoration to the cavity walls on either side of the fractured plane. It also helps in restoring intrinsic fracture toughness of the tooth.



Adhesively retained silver amalgam restoration has been advised for successful management of cracked syndrome (Culjat et al., 2005). Some authors have even prescribed the use of direct resin bonded restoration for the same (Culjat et al., 2005; Banerji, Mehta and Millar, 2010). Intracoronal direct resin restorations have been proved less successful due to progressive breakdown of the adhesive interface with cyclical functional load. Cuspal contraction may also be seen as a result of polymerisation shrinkage which may result in further progression of the crack. Use of flexible polymer resins have been instituted for intracoronal restoration of an incompletely cracked tooth as it reduces contraction stresses and the risk of cuspal fracture.

fracture toughness of the tooth will have been reduced. Hence a restoration should be designed such that it provides both cuspal protection and limits the cuspal flexure (Banerji, Mehta and Millar, 2017). This is achieved by designing an onlay, overlay or crown (Hood, 1991; Imai et al., 2012). These restorations can be fabricated both by direct and indirect methods.

**Direct Onlay Restorations:** Direct onlays to treat incompletely fractured teeth can be formed using silver amalgam or composite resin (Davis and Overton, 2000; Opdam et al., 2008). With the advent of adhesively retained materials, silver amalgam overlays have been out of practice. Use of direct resin onlays have shown long term successful outcomes. It is esthetic and less invasive when compared to silver amalgam overlays (Opdam et al., 2008; Banerji, Mehta and Millar,

Long term management of cracked tooth syndrome: For a tooth with a crack that has extended into dentin, the

2010). Cusp reduction prior to the placement of resin restorations will reduce the leverage placed on it during occlusal loading and diverts the occlusal loads from the crack towards the axial walls contributing to longevity of the restoration.

**Indirect Restoration:** Provides superior mechanical properties within the oral cavity and requires less operator skills when compared to placement of direct onlay restoration (Azeem and Sureshbabu, 2018). The cusp angle should be reduced prior to the placement of occlusal coverage restorations to reduce the risk of lateral loading. The use of ceramic onlays to treat cracked tooth syndrome should be undertaken with caution because ceramic materials are brittle with increased tendency to fracture on loading. It has lower elastic modulus compared to composite resin which makes it absorb less compressive stresses when compared to composite resins. Hence it does not provide optimum shock absorbing properties, does not completely alleviate the pain and carries the risk of further crack propagation. Further intraoral adjustments with ceramics are also difficult.

Intraoral composite inlays provide good esthetics along with the merit of ease of adjustment and repair. The use of indirect composites has shown long term successful outcomes. They also provide more conservative preparation when compared to full coverage restorations. However, full coverage crowns have been suggested to be the most suitable form of treatment for the management of cracked tooth syndrome. It provides resistance form that helps to dissipate occlusal forces over the entire prepared tooth as well as retention form that provides effective immobilisation.

**Prognosis:** Patients with cracked teeth have to be informed that the prognosis is questionable in order to prepare the patients for a potential failure since these fractures have a tendency to grow with time. The long term prognosis of cracked tooth is good when no crack is visible or the crack does not extend to the chamber floor and the tooth is rendered pain free by banding or placement of a temporary crown. In spite of a successful treatment, some cracks will continue to propagate resulting in a split tooth that requires extraction. Placement of cuspal reinforced restoration is certainly beneficial in many cases but does not guarantee success.

## CONCLUSION

The patient with cracked tooth syndrome may present with varied signs and symptoms making the diagnosis challenging to a practitioner. A detailed dental history and a thorough clinical examination aids in the diagnosis of this condition. The most ideal technique for detection of this condition would be using transillumination under magnification. The earlier the condition is diagnosed, the easier it would be to treat and better would be the prognosis. This condition can be managed by either immobilization of the tooth, subtractive occlusal adjustment, reduction of the fractured crown or by providing intracoronal and onlay restorations. Recently,

an ultra conservative technique of management has been proposed which uses supra occlusal restoration to disocclude the teeth.

Once occlusion is equilibrated, the supra occlusal restoration is replaced with a full coverage crown. Further studies have to be carried out to check the long term outcomes of this technique as well as to compare this technique with other alternative techniques in order to conclude any one as a superior technique. The prognosis of this condition depends on the severity and extent of the crack. More the subgingival extent of the crack, poorer the prognosis. The decision to save the cracked tooth by the practitioner comes from a thorough knowledge of this condition, proper diagnosis and skillful management.

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**Conflicts of Interest:** Nil

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