

## Criteria For Management of Cracked Tooth Syndrome: A Review

Roma M<sup>1</sup>, Shreya Hegde<sup>1\*</sup>, Puttur Laxmish Mallya<sup>2</sup>, Chitra<sup>2</sup>

1. Department of Conservative dentistry and Endodontics, Manipal College of Dental Sciences, Mangalore, Affiliated to Manipal Academy of Higher Education, Manipal.

2. Department of Conservative dentistry and Endodontics Manipal College of Dental Sciences, Mangalore, Affiliated to Manipal Academy of Higher Education, Manipal.

### Abstract

A cracked tooth is a confusing and difficult clinical entity in the dentistry. This clinical scenario poses a diagnostic challenge to the clinician. The cracks in the teeth may propagate coronally or from radicular portion of the teeth. Cracked teeth can occur both in healthy and endodontically treated teeth. Cracked tooth syndrome requires appropriate diagnosis and treatment planning as the signs and symptoms can be vague and misleading. Initial diagnosis of cracked teeth have proven to give a successful prognosis and the treatment can be kept as conservative as possible. This article highlights a detailed overview of etiology, signs, symptoms, classification and diagnosis and treatment modality of cracked teeth.

Review (J Int Dent Med Res 2020; 13(3): 1198-1203)

**Keywords:** Cracks, Cracked tooth, Craze line, Fractured cusp.

**Received date:** 16 March 2020

**Accept date:** 11 May 2020

### Introduction

Craze line or incomplete fractures of the teeth which appear asymptomatic can become symptomatic. The clinical signs may be bizarre ranging from sensitivity to varying degrees of pain. The localization of this condition is vague and annoying. The cracks may develop in enamel and underlying dentin in the initial cases but in severe cases, it may affect the pulp and the periodontal supporting structures. The range of pain may vary from slight sensitivity to severe gnawing pain which cannot be tolerated.

Cracked tooth or split tooth is described as complete or incomplete tooth fracture that involves dentin and in some instances affects the pulp (1- 4). Cracked tooth was first noticed as an incomplete cuspal fracture of a posterior tooth and was termed as "cuspal fracture odontolagia" by Gibbs in 1954 (5). The terminology cracked

tooth syndrome was first coined by Cameron in 1964 (2). In this scenario, the symptoms were not clear but the teeth exhibited a painful response to pulp sensibility tests, and the tooth was rendered necrotic, whilst the pulp and periodontium were healthy (2,6).

Ellis in his literature exhibited the incomplete fracture of the teeth as a fracture line of varying direction extending through tooth structure to an unknown depth and may advance to connect with the pulp and/or periodontal ligament (6-9).

Teeth affected with cracks may present themselves in vertical or horizontal fracture involving crown and root (10). The causative factors for the cracks is generally the combination of occlusal load and the treatment procedures (11). Crown and Crown root fractures are considered as incomplete fractures in the crown aspect of the posterior teeth extending in a mesiodistal direction involving the marginal ridge.

The crack initiates in the coronal aspect of the tooth and may end at the cementoenamel junction or extend into the radicular portion of the tooth (2, 10, 12, 13). Vertical root fractures are complete straight-line fractures extending from the root to the periodontium (14). The various etiological factors are mentioned in table 1.

**\*Corresponding author:**

Dr Shreya Hegde,  
Associate Professor,  
Department of Conservative Dentistry and Endodontics,  
Manipal College of Dental Sciences, Mangalore (Affiliated to  
MANIPAL ACADEMY OF HIGHER EDUCATION, Manipal)  
Light House Hill Road, Mangalore, Karnataka,  
India – 575001  
E-mail: drshreyahegde16@gmail.com

Etiology of Cracked tooth syndrome – Classification, factors associated and examples

			
<b>Operative Procedures</b> <ul style="list-style-type: none"> <li>Inadequate cavity design --- wide cavities, insufficient cuspal coverage</li> <li>Concentration of Stress --- post placement, too much condensation force</li> </ul>	<b>Occlusal disharmony</b> <ul style="list-style-type: none"> <li>Accident due to masticatory forces --- Sudden biting on piece on bone</li> <li>Excessive horizontal forces --- eccentric contacts</li> <li>Parafunctional habits --- Bruxism</li> </ul>	<b>Developmental</b> <ul style="list-style-type: none"> <li>Incomplete calcification of teeth- presence of cracked teeth in developmental anomalies like amelogenesis imperfecta</li> </ul>	<b>Miscellaneous</b> <ul style="list-style-type: none"> <li>Thermal cycling --- Enamel cracks or craze lines</li> <li>Dental instruments --- Cracking and crazing due to high speed handpiece</li> </ul>

**Table 1.** Etiology of cracked teeth.

Cracked teeth vary from craze lines to greenstick fractures to severe form of vertical root fractures. This condition usually presents in people aged between 30 years to 50 years (12,15,16). No gender variation has been reviewed for this condition (17). The incidence of cracked tooth syndrome is great with mandibular second molars, followed by mandibular first molars and maxillary premolars (1, 18).

There are two definitive patterns in cracked teeth (2). In the first type, the crack is centrally placed and in the second type, the crack is peripherally placed resulting fracture of the cusp. In case of split tooth, when the force is applied to the crown, the tooth fragments get separated resulting in excruciating pain. The separated fragments in the dentin result in fluid movement within the dentinal tubules triggering the stimulation of odontoblasts in the pulp resulting in excitation of pulpal nociceptors (1, 4, 19).

### Classification

Several classifications have been proposed by various authors based on site of the crack, type of the placement of the crack and the direction of the crack. American Association of Endodontists had laid down a classification of the cracks in a paper titled, “cracking the cracked tooth code” where the origin of the crack and its prognosis for the treatment was assessed (20). [table.2]

### Craze Lines

Craze lines are initial and evident cracks which are confined to the enamel. In posteriors, the craze lines usually intersects the marginal ridge and extend buccally or lingually. Vertical and the longest craze lines are usually seen in anterior teeth. The craze lines are well detected

under transillumination. If the light doesn't pass through, it is diagnosed as crack. If the light passes through and lightens the entire crown, it is termed as craze line (21). [fig. 1]

### American Association of Endodontists Classification of Cracked teeth

Classification	Origin	Directions	Symptoms	Pulp status	Prognosis
Craze line	Crown	Variable	Asymptomatic	Vital	Excellent
Fractured cusp	Crown	Buccolingual/Medio distal	Mild sensitivity	Vital	Good
Cracked tooth	Crown and root	Mediodistal often central	Acute pain on biting occasionally sharp pain	Variable	Questionable depends on depth and extent of crack
Split tooth	Crown and root	Mesiodistal	Marked pain on chewing	Often root filled	Poor
Vertical root fracture	roots	Faciolingual	Vague mimicking periodontal disease	Mainly root filled	Poor

**Table 2.** AAE classification of cracked teeth.

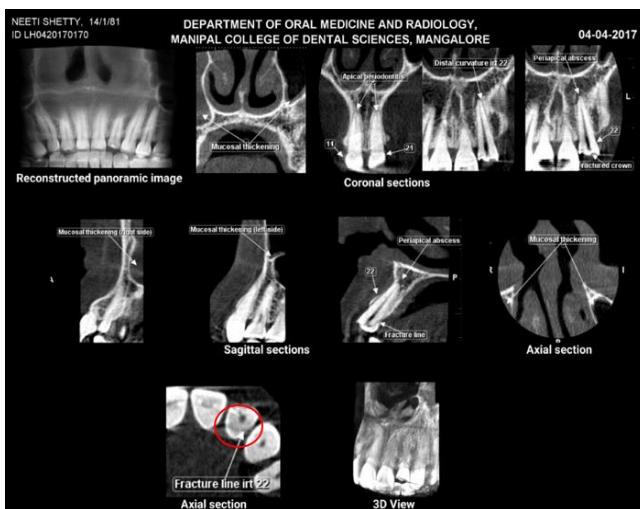


**Figure 1.** Craze lines.

### Fractured Cusp

Fractured cusp is a clinical entity where there is a separated cuspal fragment from the remaining part of the teeth. The fracture can be complete or incomplete. These fracture lines usually start at the occlusal and extend towards cervically. These fractures commonly occur in the buccal cusp of maxillary premolars and the mesiobuccal and distobuccal cusp of maxillary molars (22). In a study by Bader et al. it was found that lingual cusps break more commonly than buccal cusps in mandibular molars (23).

Fractured cusps are usually seen in teeth with large restorations with inadequate cuspal enamel. The patients with fractured cusp usually complain of severe pain on mastication, and more distinctly on the release of biting force. They also complain of sensitivity to cold. This condition can be confirmed by a bite test using a tooth slooth and surgical loupes and microscopes can be used for identification. The pulpal response is usually vital. Radiographically no periapical changes. [fig. 2]



**Figure 2.** CBCT of fractured cusp with pulpal symptoms.

### Cracked tooth

A cracked tooth is a characteristic crack extending from the occlusal surface of the tooth run downwards apically without the separation of the fragments. According to the studies by Roh and Lee (24) and Seo et al. (25), the cracks run more commonly mesiodistally than buccolingually.

Cracked teeth are usually identifiable by staining using methylene blue dye(26) and transillumination using fibre-optic (27). Bite test using tooth slooth is considered as the dependable test for diagnosis (21). Bite test becomes positive when the lesion involves periapical area resulting in apical periodontitis. Pain elicited on the release of the biting force is considered as the pathognomonic sign for a cracked tooth. This condition is usually associated with deep narrow pockets. A cracked tooth can be further confirmed using CBCT and surgical microscope. [fig. 3]



**Figure 3.** Cracked teeth in a mesiodistal direction.

### Split tooth

A split tooth is symptomatic crack running through both the marginal ridges in a mesiodistal direction and splitting the tooth into two fragments. This type of crack is placed centrally and the prognosis of the tooth is rendered poor. This condition occurs in endodontically treated teeth. The fragments are mobile and easily diagnosable. Split tooth is accompanied with pain on biting, periodontal pockets, horizontal bone loss and may be associated with periodontal abscess.

### Vertical root fractures (VRF)

Vertical root fractures, according to the American Association of Endodontists (AAE) are described as complete or incomplete fractures originating from the root and extending buccolingually. [Fig 4] It may occur in root canal treated tooth or vital teeth (20). In a study by Tang et al., it has been proven that vertical root fractures are more in endodontically treated teeth (28). Vertical root fractures can occur during any procedure of root canal treatment or even during the post space preparation. Vertical root fractures can be associated with teeth with endo-perio relation having a deep periodontal pocket and J shaped or halo radiolucency. CBCT is an excellent diagnostic tool for the diagnosis of vertical root fractures (29,30).



**Figure 4.** Vertical Root Fracture.

### Diagnosis Aids for the Cracked Teeth

#### Operating Microscopes

Surgical microscopes with high resolution (X6–X8 magnification or higher) helps in more accurate diagnosis than loupes (21).

### Transillumination

According to AAE, transillumination with fibre optic light source is one of the accurate aid in the diagnosis of a fracture (31). In this, the tooth is air-dried and the fibre optic light is placed directly on to the tooth. The principle behind transillumination is that the light passes through the substrate and reaches the gap, following with which the light gets reflected. Dark and light areas are formed which are separated by fracture line. The major drawback of transillumination is that it highlights all the minor cracks and may be misleading for the diagnosis.

### Optical Coherence Tomography

OCT is a high resolution computing imaging technique which uses echo time delay of the backscattered light (32). It provides microscopic visualization of details and cellular structures. The basic disadvantage of OCT is backscattering and therefore it is not recommended.

### Scanning electron microscopy

SEM or scanning electron microscopy is one of the commonest methods to detect cracks in extracted teeth. SEM uses high-energy electrons to detect the crystalline structure, morphological entity and the composition of the test specimen (32).

SEM is highly technique sensitive but can detect the 3D morphology of the specimen (33). This technique can visualize the cracks of less than 1nm (34).

### Micro-computed tomography

This imaging system produces images at micrometer levels. It visualizes the 3D morphology of the object without destroying it. The x-ray beam used in micro-CT is of higher range and can penetrate through the thickest layers of the specimen. This imaging system has better clarity than conventional CT. The disadvantage of this system is that it requires more exposure time. Studies have been conducted to analyze the crack morphology using BaSO<sub>4</sub> stain (35, 36).

### Transmission electron microscopy

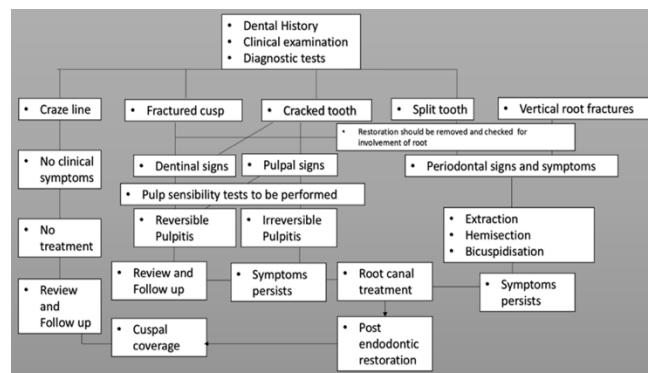
Transmission electron microscopy (TEM) is a high magnification imaging system which uses higher energy electrons than SEM and produces images of high-resolution quality. The study sample is illuminated with high electron beam in a vacuum and the electrons transmitted through the sample are detected on a phosphorescent screen or through a camera (37).

Studies have been performed by Kubo et al. to check for the dentinal microcracks with TEM (38).

### Management Of Cracked Teeth

Initial diagnosis of this clinical scenario is very important for the treatment and its success of the cracked teeth to prevent the progression of crack into the pulp and periodontal tissues (39). A decision flowchart for the treatment options have been laid down in Table 3. Initial cracks are easy to detect, hence can be managed conservatively. Minor cracks in the teeth can be restored with restoration or with crown. Severe cracks which involve pulp require endodontic treatment and then restored with a crown (41). Teeth with deep cracks cannot be treated and hence extracted.

Clark and Caughman laid down a classification for the prognosis of the cracked teeth (40). The prognosis was categorized as excellent, good, poor and hopeless.



**Table 3.** Decision flowchart for the management of cracked teeth

1. Excellent: (a) fractured cusp restricted to dentin that arises from facio-pulpal or linguo-pulpal line angle of a cusp to the CEJ or slightly below. (b) Fracture of the cusp in a horizontal direction which does not involve the pulp.
2. Good: A vertical fracture present in the coronal aspect running mesiodistally involving the dentin and not the pulp.
3. Poor: A vertical fracture present in the coronal aspect running mesiodistally involving the dentin and the pulp (confined to the crown).
4. Hopeless: A vertical fracture present in the coronal aspect running mesiodistally involving the pulp and root.

## Conclusions

It is mandate for every practitioner to have comprehensive information and knowledge about cracked tooth syndrome and its existence. One should be able to diagnose with the chief complaint and a good case history. Careful clinical examination and the diagnostic tests will help in arriving at the diagnosis. Treatment modalities will vary depending on the severity, extent and the location of the crack. Proper analysis for the management varies according to the clinical need like occlusal contouring to the rehabilitation of cuspal fracture with composite restoration to prosthetic rehabilitation. In the most severe cases, extraction will be planned.

### List of Abbreviations

1. AAE : American Association of Endodontists
2. CBCT : Cone beam computed tomography
3. VRF : Vertical Root Fractures
4. OCT: Optical Coherence Tomography
5. SEM : Scanning electron microscopy
6. micro-CT : Micro-computed tomography
7. TEM : Transmission electron microscopy

### Declaration of Interest

The authors declare that they have no conflicts of interests.

### References

1. Christopher D. Lynch, Robert J. McConnell. The Cracked Tooth Syndrome. *J Can Dent Assoc* 2002; 68(8):470-5.
2. Cameron CE. Cracked-tooth syndrome. *J Am Dent Assoc* 1964;68(March):405-11.
3. Ehrmann EH, Tyas MT. Cracked tooth syndrome: diagnosis, treatment and correlation between symptoms and post-extraction findings. *Aust Dent J* 1990; 35(2):105-12.
4. Rosen H. Cracked tooth syndrome. *J Prosthet Dent* 1982; 47(1): 36-43.
5. Gibbs JW. Cuspal fracture odontalgia. *Dent Dig* 1954;60:158-60.
6. Hasan S, Singh K, Salati N. Cracked tooth syndrome: Overview of literature. *Int J App Basic Med Res* 2015;5:164-8.
7. Brannstrom M. The hydrodynamic theory of dentinal pain: Sensation in preparations, caries, and the dentinal crack syndrome. *J Endod* 1986;12:453-7.
8. Kahler B, Moule A, Stenzel D. Bacterial contamination of cracks in symptomatic vital teeth. *Aust Endod J* 2000;26:115-8.
9. Ellis SGS. Incomplete tooth fracture-proposal for a new definition. *Br Dent J* 2001;190:424-428.
10. William Kahler. The cracked tooth conundrum: Terminology, classification, diagnosis, and management. *Am J Dent* 2008;21:275-282.
11. Bender IB, Freedland JB. Adult root fracture. *J Am Dent Assoc* 1983;107: 413-419.
12. Hiatt WH. Incomplete crown-root fracture in pulpal-periodontal disease. *J Periodontol* 1973;44:369-379.
13. Goel VK, Khera SC, Gurusami S, Chen RCS. Effect of cavity depth on stresses in a restored tooth. *J Prosthet Dent* 1992;67:174-183.
14. Pitts DL, Natkin E. Diagnosis and treatment of vertical root fractures. *J Endod* 1983;9 338-346.
15. Snyder DE. The cracked-tooth syndrome and fractured posterior cusp. *Oral Surg Oral Med Oral Pathol* 1976; 41(6):698-704.
16. Ellis SG, Macfarlane TV, McCord JF. Influence of patient age on the nature of tooth fracture. *J Prosthet Dent* 1999; 82(2):226-30.
17. Türp JC, Gobetti JP. The cracked tooth syndrome: an elusive diagnosis. *J Am Dent Assoc* 1996; 127(10):1502-7.
18. Ehrmann EH, Tyas MT. Cracked tooth syndrome: diagnosis, treatment and correlation between symptoms and post-extraction findings. *Aust Dent J* 1990; 35(2):105-12.
19. Stanley HR. The cracked tooth syndrome. *J Am Acad Gold Foil Oper* 1968; 11(2):36-47.
20. American Association of Endodontists. Endodontics: Colleagues for Excellence-Cracking the cracked tooth code. Chicago, IL: Fall/Winter 1997.
21. Alsolaihim AN, Alsolaihim AA, Alowais LO. In vivo and in vitro diagnosis of cracked teeth: A review. *J Int Oral Health* 2019;11:329-33.
22. Tang W, Wu Y, Smiles RJ. Identifying and reducing risks of potential fractures in Endodontically treated teeth. *J Endod* 2010;36:609-17.
23. Bader JD, Martin JA, Shugars DA. Incidence rates for complete cuspal fractures. *Community dent Oral Epidemiol* 2001;29:3346-53.
24. Roh BD1, Lee YE. Analysis of 154 cases of teeth with cracks. *Dent Traumatol* 2006;22:118-23.
25. Seo DG, Yi Ya, Shin SJ, Park JW. Analysis of fractures associated with Cracked Teeth. *J Endod* 2012;38:288-92.
26. Mathew S, Thangavel B, Mathew CA, Kailasam S, Kumaravadivel K, Das A. Diagnosis of cracked tooth syndrome. *J Pharm Bioallied Sci* 2012;4:S242-4.
27. Clark DJ, Sheets CG, Paquette JM. Definitive diagnosis of early enamel and dentin cracks based on microscopic evaluation. *J Esthet Restor Dent* 2003;15: 391-401.
28. Tang L, Zhou XD, Wang Y, Zhang L, Zheng QH, Huang DM. Detection of vertical root fracture using cone-beam computed tomography: report of two cases. *Dent Traumatol* 2011;27:484-8.
29. Dhwani A, Gupta S, Mittal R. Vertical root fractures: An update review. *J Res Dent* 2014;2:107-13.
30. Nikbin A, Dalili Kajan Z, Taramsari M, Khosravifard N. Effect of object position in the field of view and application of a metal artifact reduction algorithm on the detection of vertical root fractures on cone-beam computed tomography scans: An in vitro study. *Imaging Sci Dent* 2018;48:245-254.
31. American Association of Endodontists. Transillumination: the 31"Light Detector". Chicago, IL: AAE; 2008. p. 1-2.
32. Fujimoto JG, Pitris C, Boppart SA, Brezinski ME. Optical coherence tomography: an emerging technology for biomedical imaging and optical biopsy. *Neoplasia* 2000;2:9-25.
33. Yamada MK, Uo M, Ohkawa S, Akasaka T, Watari F. Noncontact surface morphology analysis of CO<sub>2</sub> laser-irradiated teeth by scanning electron microscope and confocal laser scanning microscope. *Mater T* 2004;45:1033-40.
34. Dumbrty I, Linkeviciene L, Linkevicius T, Malinauskas M. Enamel microcracks in terms of orthodontic treatment: A novel method for their detection and evaluation. *Dent Mater J* 2017;36:438-46.
35. Landrigan MD, Flatley JC, Turnbull TL, Kruzic JJ, Ferracane JL, Hilton TJ, Roeder RK. Detection of dentinal cracks using contrast-enhanced microcomputed tomography. *J Mech Behav Biomed Mater* 2010;3:223-7.
36. Jamleh A, Komabayashi T, Ebihara A, Nassar M, Watanabe S, Yoshioka T, et al. Root surface strain during canal shaping and its influence on apical microcrack development: a preliminary investigation. *Int Endod J* 2015;48:1103-11.
37. Marco A. Versiani, Bettina Basrani, Manoel D. Sousa-Neto (Ed) *The Root Canal Anatomy in Permanent Dentition*. Springer, 2018.

38. Kubo M, Miura J, Sakata T, Nishi R, Takeshige F. Structural modifications of dentinal microcracks with human ageing. *Microscopy (Oxf)* 2013;62:555-61.
39. Agar JR, Weller RN. Occlusal adjustment for initial treatment and prevention of cracked-tooth syndrome. *J Prosthet Dent* 1988;60:145-147.
40. Clark LL, Caughman WF. Restorative treatment for the cracked tooth. *Oper Dent* 1984;9:136-142.
41. Fitia Prabantari Angela, Anggraini Margono. Diagnosis and Management of Maxillary Left Second Molar with Cracked Tooth Syndrome: A Case Report. *Journal of International Dental and Medical Research* 2017; 10 (1):169-175.