# Etiology, Prevalence, and Classification of Cracked Tooth Syndrome (CTS), Literature Review

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**Abstract**

**Background**: Dentists all around the world struggle with diagnosing cracked tooth syndrome. For most cases, detection of CTS is the main problem since the crack can be hidden under fillings or on the enamel surface which is too small to be detected with the naked eye or can be part of a root that sometimes is not visually evident. Nowadays, using dental magnifications (Dental Loupes, Dental Operating Microscope (DOM)) in everyday practice makes it possible to discover lots of dental anatomical structures and make the treatment outcome more predictable than ever. The above-mentioned devices are also used for detecting tooth cracks, but they are not the only tools that can be used to diagnose CTS.

**Aim**: This article aims to explore cracked tooth syndrome, describe existing classification- compare contrast discuss challenges with diagnosis, and bring dental professionals' attention to this phenomenon. Due to outdated and limited existing literature about CTS, this article attempts to fill in the informational gap, while creating an incentive for dentists and scholars to further explore this topic.

**Methods**: to analyze CTS in-depth descriptive qualitative research method, specifically an existing literature review was applied. Collected information includes scholars' research from: PubMed, ResearchGate, Springer, Wiley, Elsevier, JoE, FDI World Dental Federation, European Journal of Prosthodontics and Restorative Dentistry, NCBI National Library of Medicine, The Journal of Prosthetic Dentistry (JPD), JADA.

**Results**:The results of the research show that a lack of knowledge about CTS, its etiology, and prevalence remains a challenge. Absence of the evidence-based scientific research in Georgia limits professionals to be vigilant about the CTS and provide the relevant treatment plan for it. Additionally, the article identifies the recent classification of CTS, and it underscores the importance of further studies to be done about CTS.

**Conclusions**: CTS classification helps us differentiate cases and create tailored approaches based on the individual needs of the patient. To make a correct diagnosis it is crucial to be aware of the classification which will lead to a correct treatment plan in the future. The prevalence among the different demographics of patients is not studied well enough and there is a lack of recent statistical data regarding its incidence. **TCM-GMJ June 2025; 10 (1): P46-P49)**

**Keywords:** CTS, Prevalence, Etiology, Classification, craze line, incomplete fracture, cracked tooth

## Introduction

The term "Cracked tooth syndrome" (CTS) includes all types of linear damage on the tooth surface. For dentists, it is still challenging to differentiate crack types from each other and most of the time they mistakenly diagnose them. In addition, cracks might have different directions, and it is not predetermined how deep or which direction the damage has spread [1].

Etiology:

In 2022, the World Dental Federation (FDI) published an article about the prevalence of cracked teeth cases that "especially increased during the COVID-19 pandemic due to its stressful nature, affecting people's oral health and overall well-being." Also, it may be caused by stress or trauma-related symptoms such as teeth grinding and chewing or biting on hard objects [2].

Cracks are the result of trauma or tension on the tooth structure. Most of the cracks on the crown part are horizontal and are caused by trauma whereas vertical incomplete fractures are more caused by tension or iatrogenic manipulations [3].

The symptoms of CTS vary from each other. Usually, there is more than one symptom is presented; however, the most frequent symptom that was stated by patients was sensitivity to cold [4]. Pain on biting and spontaneous pain were less common.

As it is extremely hard to diagnose cracked teeth it is harder to state the exact etiology of this phenomenon, however, there are many hypotheses regarding occlusal forces impacting tooth

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structures.

Many scholars have mentioned the link between the different types of restorative materials could impact developing tooth cracks in time. Most of the cases CTSs were associated with amalgam restorations or substantial amounts of composite material that was introduced into the cavity in large portions.

A study by Hiatt has shown that most affected teeth are mandibular molars due to the cusp-fossa correlation between the upper molars. Mostly there are 2 main reasons for this unpleasant outcome:

a. The chronic structural fatigue due to the cuspal-fissure connection because these areas have shown the lack of calcification in fissures of lower molars.
b. Exerted force affects the fulcrum area more due to the lever principle and has a higher incidence of cracks in the second molars compared to the first.

Silverstri mentions iatrogenic factors during the MOD preparation of the tooth cavities.

Other additional factors include bad habits that use excessive masticatory forces.

Classification:

The American Association of Endodontists (AAE) and the World Dental Federation (FDI) have created a classification of CTS to diagnose different types of cracks.

According to the classification of AAE, the cracks can be divided into 5 locations and described by their origin, direction, symptoms, pulp status, and prognosis (Table 1; Fig. 1), whereas FDI classification (Fig. 2) has six subdivisions, which is more detailed and gives dentists precise condition of hard tissues, pulp, and periodontium status during CTS [5].

However, FDI has made 2 more additional types of clinical cases of the CTS: 1. The crack that extends from enamel to dentin layer- "Crack of Dentine". 2. The crack that extends from the enamel to the pulp- "Crack Expending to Pulp".

To summarize these two classifications, both have their advantages and disadvantages. The AAE mentions "vertical root fracture" which is not included in the FDI classification whereas the FDI has more detailed information about the pulp and periodontium status.

The cracks that are in a vertical direction oriented mesiodistally may develop into a split tooth in the future. Vertical cracks are more likely to develop on non-functional surfaces or cusps of teeth while horizontal and oblique cracks were more common on incisal edges or functional cusps of teeth [7].

Prevalence:

C. E. Cameron was the first scholar who use the term "cracked tooth syndrome (CTS)" in 1964 and defined it as a critical posterior tooth incomplete fracture that includes the dentin extending to the pulp [8].

Back in 1976, He published an early epidemiological survey where he stated the prevalence of CTS was high among female dental patients [9].

Since then, much research has been done over the years, and new findings are not sex-related, thus there are no differences in incidence between males and females.

A study conducted in 2010 by S. Banerji et al. revealed that CTS affects adult dental patients, typically in the age range of 30 to 60 years [10].

In another study that was published by WH Hiatt in 1973 under the name "Incomplete crown-root fractures in pulpal periodontal disease," he specified that "Cracked Tooth Syndrome appears to typically affect adult patients that are past their third decade, often affecting teeth that have previously received the restorative intervention, although not exclusively." [11]

Iit has since been shown by more recent studies that both sexes seem to be equally affected- in 2006 the scholar Byoung-Duck Roh et al. Analyzed 154 cases of teeth with cracks. He announced the prevalence of CTS that "were observed most frequently in the teeth with no restorations (60.4%) and with class I restorations (29.2%). The most prevalent age was in those over 40 years of age (31.2% in their 40s, 26.6% in their 50s) and the prevalence was similar in men (53.9%) and women (46.1%). Cracked teeth were found more frequently in the maxillary molars (33.8% in the first molar, 23.4% in the second molar) than in the mandibular molars (20.1% in the first molar, 16.2% in the second molar). 96.1% of the cracked teeth responded to the bite test, and 81.1% of the cracked teeth were observed in the mesiodistal direction. The prevalence of cracked teeth was highest in intact teeth with no restoration, in maxillary molars, and in those over 40 years of age. When examining an intact maxillary posterior tooth that is sensitive to a bite and thermal change, a crack in the mesiodistal direction needs to be considered one of the causes." [12] The cracks are mostly found in posterior mandibular and maxillary molars, and craze lines- in anterior teeth [13].

Abou Rass published the most fractured teeth- the second lower molars, then the first lower molars, upper premolars, and upper second molars [14].

It is considered that the lowest number of fractures with 0.2% is the lower first premolar probably because of having a single big cusp on the buccal side.

The following characteristics need to be taken into consideration:

1) Heavily developed masticatory musculature
2) Wear facets in molars and premolars
3) Big cusps accompanied by deep grooves and fossae
4) Stained grooves and fossae.

In 2012, Deog-Gyu Seo et al. published an analysis of factors associated with cracked teeth. He studied one hundred-seven (n=107) teeth with longitudinal fractures from 103 patients. The result showed that "eighty-seven teeth were diagnosed with a cracked tooth (81.3%), 14 were diagnosed with vertical root fracture (VRF, 13.1%), 4 had a split tooth (3.7%), and 2 had a fractured cusp (1.9%); 82.2% showed a sensitive reaction on the bite test…VRF was associated with endodontic treatment." He also concludes that the best diagnostic test can be a bite test for reproducing the symptoms, however, it would be better to do a combination diagnosis with other diagnostic methods. [15]

Cracks can be found in restored as well as unrestored teeth [16]. Inlay (class I) restorations are more prone to crack development [17], but in 2021 J Lee et al. mentioned that intact teeth also might develop different sizes of cracks [18], which is mostly caused by the aging process and are found typically in patients over 40 years old due to an accumulation of fatigue stresses.

C. J. Yeh was the first scholar who mention the term "fatigue root fracture" in 1997 [19]. The root fractures were examined in non-endodontically treated teeth, and he stated that the reasons for cracks could be the result of excessive, repetitive, and heavy masticatory stress applied to a tooth.

Borelli et al. reported an unusual vertical and horizontal tooth fracture in 1999 [20]. This phenomenon has been reported less frequently in Caucasians and more often in Asians [21].

In 2023 Shue-Fen Yang et al. published a cross-sectional study about the incidence of chronic fatigue in non-endodontically treated teeth and they concluded that "the incidence of chronic fatigue root fracture is 0.76%. Both VRF and HRF occur mainly in aged males, in posterior

teeth with attrition, and in teeth without restoration. Tooth position, cross-section root morphology, and terminal tooth are contributing factors related to chronic fatigue root fracture." [22]

Pathogenesis of CTS is very interesting: "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 causes the release of neuropeptides, and a concomitant lowering in the pain threshold of unmyelinated C-type fibers within the dental pulp." [23]

In 2023 Domenico Ricucci et al. discussed the histopathologic and histobacteriologic Aspects of cracked teeth [24]. He concluded that "the cracks in all teeth were colonized by bacterial biofilms. Dentinal tubules were invaded by bacteria, especially when the crack extended perpendicularly into the dentin. Severe accumulations of inflammatory cells were present in the pulp zone subjacent to tubules involved with the crack. In many cases, the crack extended to the pulp, leading to reactions with intensities ranging from acute inflammation to total pulpal necrosis. Symptoms occurred in most cases in which the pulp was affected. In some cases, polymorphonuclear neutrophils were seen migrating from the pulp into the crack space and facing the bacterial biofilm located therein. Severe pulp reactions were also observed when the crack extended to the pulp chamber floor."

## Methods

Literature review was used as the main research method. The main goal of the study is to collect existing information and prepare for other types of research on this topic in the future. Also, to gain an understanding of the existing research around the topic and debate relevant to a particular matter or area of study, and to present that knowledge in the form of a written article.

## Results and discussion

The present article gives the reader an idea of the severity of the issue. Knowledge of the classification allows us to conduct a differential diagnosis with similar conditions or diseases and avoid making a wrong diagnosis. The prevalence of this syndrome varies across races and time periods, with age and other environmental factors causing gaps in the final data set, giving us only a rough idea of in which group of teeth we might expect to see the CTS.

## Conclusion

CTSs are multifactorial in origin and these factors lead to VRFs. The complexity of CTS is its diagnosis. The symptoms and clinical characteristics vary - making diagnosing and creating the right treatment plan is challenging for dentists. The difficulty is not only in diagnosis but also in choosing the right treatment plan, the outcome of the treatment, and maintenance of it. The prevalence of cracked teeth is not studied well enough and needs to be observed by creating more clinical research.

Table 1. American Association of Endodontists classification of CTS:

| Classification | Origin | Direction | Symptoms | Pulp Status | Prognosis |
|---|---|---|---|---|---|
| Craze line | Crown | Variable | None | Vital | Excellent |
| Fractured cusp | Crown | Mesiodistal and/or buccal-lingual | Mild and general, only to bite and cold | Usually, vital | Good |
| Cracked tooth | Crown with/without root | Mesiodistal often Central | Acute pain on biting Occasionally sharp pain to cold | Variable | Questionable: dependent on depth and extent of the crack |
| Split tooth | Crown with root | Mesiodistal | Marked pain on chewing | Often root canal treatment is needed | Poor unless crack terminates just subgingivally |
| Vertical root fracture | Roots | Buccal-lingual | Vague pain similar to periodontal disease | Mainly root-canal treatment needed | Poor: root resection indicated in multi-rooted teeth |

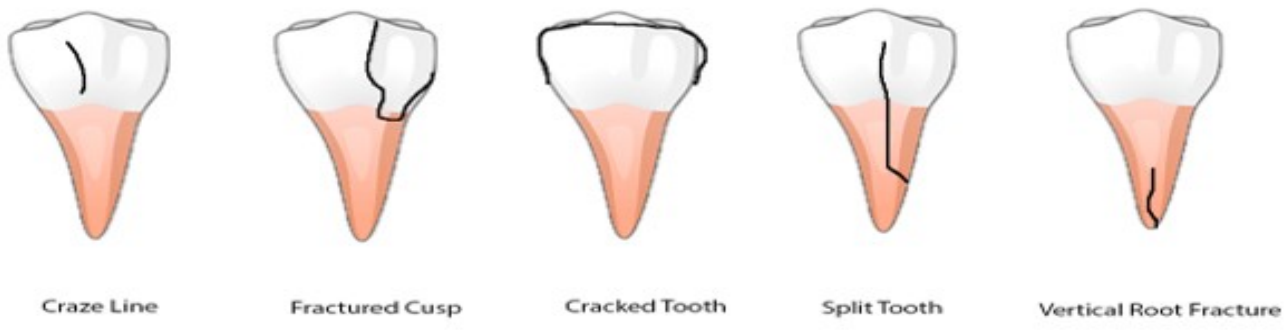


Fig. 1

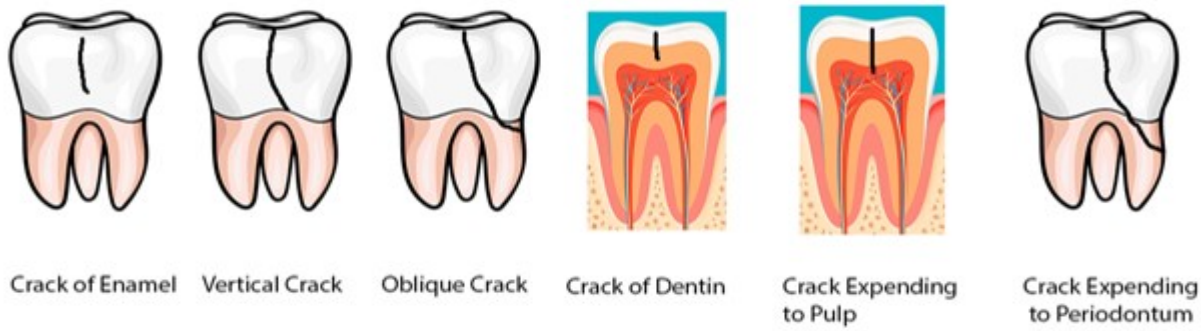


Fig. 2

## Referencs


1. Mamoun JS, Napoletano D. Cracked tooth diagnosis and treatment: An alternative paradigm. European journal of dentistry. 2015 Apr;9(02):293-303.
2. https://www.fdiworlddental.org/sites/default/files/2022-07/FDI%20Cracked%20Tooth%20Syndrome.pdf
3. Castellucci A. Endodontics: 2 Volume Set. Edizioni LSWR; 2022 Dec 13.
4. Hilton TJ, Funkhouser E, Ferracane JL, Gordan VV, Huff KD, Barna J, Mungia R, Marker T, Gilbert GH, National Dental PBRN Collaborative Group. Associations of types of pain with crack-level, tooth-level and patient-level characteristics in posterior teeth with visible cracks: Findings from the National Dental Practice-Based Research Network. Journal of dentistry. 2018 Mar 1;70:67-73.
5. Korkut B, Bayraktar ET, Tağtekin D, Çolak H, Özcan M. Cracked Tooth Syndrome and Strategies for Restoring. Current Oral Health Reports. 2023 Dec;10(4):212-22.
6. Rivera E, Walton R. Detection and Treatment of Various Longitudinal Tooth Fractures Endodontics. Cracking the Cracked Tooth Code. Colleagues for Excellence Summer. 2008.
7. Segarra MS, Shimada Y, Sadr A, Sumi Y, Tagami J. Three-dimensional analysis of enamel crack behavior using optical coherence tomography. Journal of dental research. 2017 Mar;96(3):308-14.
8. Cameron CE. Cracked-tooth syndrome. The Journal of the American Dental Association. 1964 Mar 1;68(3):405-11.
9. Cameron CE. The cracked tooth syndrome: additional findings. Journal of the American Dental Association (1939). 1976 Nov 1;93(5):971-5.
10. Banerji S, Mehta SB, Millar BJ. Cracked tooth syndrome. Part 1: aetiology and diagnosis. British dental journal. 2010 May 22;208(10):459-63.
11. Hiatt WH. Incomplete crown-root fracture in pulpal-periodontal disease. Journal of periodontology. 1973 Jun;44(6):369-79.
12. Roh BD, Lee YE. Analysis of 154 cases of teeth with cracks. Dental traumatology. 2006 Jun;22(3):118-23.
13. Yap RC, Alghanem M, Martin N. A narrative review of cracks in teeth: Aetiology, microstructure and diagnostic challenges. Journal of Dentistry. 2023 Nov 1;138:104683.
14. Abou-Rass M. Crack Lines: The Precursors of Tooth Fractures--Their Diagnosis and Treatment. Quintessence international. 1983 Apr 1;14(4).
15. Seo DG, Yi YA, Shin SJ, Park JW. Analysis of factors associated with cracked teeth. Journal of endodontics. 2012 Mar 1;38(3):288-92.
16. Liao WC, Tsai YL, Chen KL, Blicher B, Chang SH, Yeung SY, Chang MC, Jeng JH. Cracked teeth: Distribution and survival at 6 months, 1 year and 2 years after treatment. Journal of the Formosan Medical Association. 2022 Jan 1;121(1):247-57.
17. Kahler W. The cracked tooth conundrum: terminology, classification, diagnosis, and management. American journal of dentistry. 2008 Oct 1;21 (5):275.
18. Lee J, Kim S, Kim E, Kim KH, Kim ST, Jeong Choi Y. Survival and prognostic factors of managing cracked teeth with reversible pulpitis: A 1-to 4-year prospective cohort study. International Endodontic Journal. 2021 Oct;54(10):1727-37.
19. Yeh CJ. Fatigue root fracture: a spontaneous root fracture in non-endodontically treated teeth. British dental journal. 1997 Apr;182(7):261-6.
20. Borelli P, Alibrandi P. Unusual horizontal and vertical root fractures of maxillary molars: an 11-year follow-up. Journal of Endodontics. 1999 Feb 1;25(2):136-9.
21. Tsai YL, Liao WC, Wang CY, Chang MC, Chang SH, Chang SF, Chang CW, Huang YD, Chan CP, Jeng JH. Horizontal root fractures in posterior teeth without dental trauma: tooth/root distribution and clinical characteristics. International endodontic journal. 2017 Sep;50(9):830-5.
22. Yang SF, Chen YW, Tsai CL, Cheng HC, Wu SL, Tamse A, Ho YC. Incidence and contributing factors of non-root canal treated teeth with chronic fatigue root fracture: A cross-sectional study. Journal of the Formosan Medical Association. 2023 Dec 1;122(12):1338-44.
23. Hasan S, Singh K, Salati N. Cracked tooth syndrome: overview of literature. International Journal of Applied and Basic Medical Research. 2015 Sep 1;5(3):164-8.
24. Ricucci D, Siqueira Jr JF, Loghin S, Berman LH. The cracked tooth: histopathologic and histobacteriologic aspects. Journal of endodontics. 2015 Mar 1;41(3):343-52.