

CRACKED TOOTH SYNDROME

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Abstract: Cracked tooth syndrome is defined as an incomplete fracture of the dentine in a vital posterior tooth that involves the dentine and occasionally extends into the pulp. CTS is the third leading cause of tooth loss in adult patients. Mandibular molars are most commonly affected teeth. The aim of this paper is to indicate the frequency and significance of cracked tooth syndrome. To investigate the etiological factors and the mechanism of occurrence, as well as to present the clinical picture and the specificity of the diagnostic protocol. Of course, guidelines should be given to make the right decision for therapeutic procedure, because especially in patients with CTS, the individual approach is of great importance.

For the preparation of this paper, a search was made of papers from the last 10 years from a relevant database from MEDLINE® / PubMed®, Science Direct®.

Given the difficult diagnosis of CTS, it is necessary to distinguish some terms. The American Association of Endodontists (AAA) has divided longitudinal tooth fractures into 5 classes: infracture, crown fracture, cracked tooth, split tooth, and vertical root fracture.

The diagnosis of CTS is often problematic and has been known to challenge even the most experienced dental operators, accountable largely by the fact that the associated symptoms tend to be very variable. Complications of CTS are involvement of the pulp and/or periodontal ligament, cusp fracture or loss of tooth vitality. In order to diagnose CTS, dentist should elicit thorough dental history, do the clinical examination and use clinical tests such as visual dyeing, vitality tests, dental radiograph imaging and endodontic microscope.

Conclusion: Early detection avoids a number of complications and ultimately can prevent tooth loss. The inability to visualize the crack during the clinical examination reduces the probability of making a correct diagnosis. In order to carry out the best possible treatment, it is necessary to take into account all the factors from the occurrence of the syndrome, the condition and the prognosis of the tooth.

Therapy varies according to the position and extent of the fracture.

Key words: *Cracked tooth syndrome, CTS, Cusp fracture.*

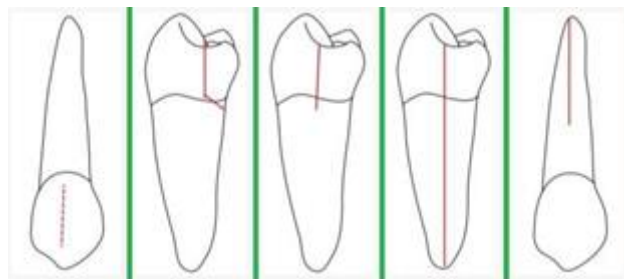
Introduction: Cracked tooth syndrome is an incomplete fracture of a vital tooth in the transcanine sector. The first definition was given by Cameron, who defines it as a fractured line with an unknown depth that starts on the tooth surface, from the enamel, and the dentin, and can lead to contact with the pulp or the periodontal ligament. Most often affected by this type of fracture are the mandibular molars. [1] The clinical signs and symptoms are changeable, and most often this is the main reason for an unsuccessful diagnosis.

The symptoms are usually progressive. Since the crack appears on the surface, and then extends towards the pulp, the first symptom is pain when biting, followed by sensitivity to thermal sensations, and spontaneous pain.[2,3] If not diagnosed in time, complications can occur, such as gum swelling or a complete fracture of the tooth.

Unlike the complete teeth fractures that are described in detail in the literature, the cracks and the incomplete fractures had not received much attention. [2-4]Thomas described them as "fissural fractures" and stated that if they are deep, the fractures could allow bacteria to invade the pulp. In 1962, Sutton described a "greenstick fracture of the tooth crown." [5,6]This fracture is considered as a stage before the fracture and a fracture of the tooth itself - the tooth is cracked, but the two parts are not completely separated. It is most often caused by trauma to the lateral forces of the teeth that are weakened by restorations or caries. [22]

Due to the fact that CTS is difficult to be diagnosed, it is necessary to distinguish some terms. The AAE (American Association of Endodontists) divided the longitudinal tooth fractures into 5 classes (Figure 1) - infraction, tuber fracture, cracked tooth, split tooth, and vertical root fracture.[13]

The infraction affects only the enamel as a result of occlusal forces, and it is asymptomatic. A crown fracture also involves separation of the part of the crown. A cracked tooth is an incomplete fracture that begins on the crown, and is most often placed mesiodistally. A split tooth is a complete fracture that begins on the crown, often extends and subgingivally affects both marginal ridges. A vertical fracture is a complete or incomplete fracture at any level usually directed buccolingually. [5]



Picture 2. 5 classes of longitudinal teeth fractures. From left to right – infraction, tuber fracture, cracked tooth, split tooth, and vertical root fracture[5]

The purpose of this paper is to indicate the frequency and the significance of the cracked tooth syndrome, to investigate the etiological factors and the mechanism of occurring, as well as to present the clinical picture and the specificity of the diagnostic protocol. Of course, guidelines should be given in order to bring a right decision for a therapeutic procedure, since especially the patients with CTS need an individual approach.

Material and method: For the writing of this paper, a search of papers from the last 10 years was made from a relevant database of MEDLINE®/PubMed®, and ScienceDirect®.

Etiology: CTS is a complex condition whose etiology is multifactorial. Some of the causes are previous restorative treatments, occlusal factors, developmental anomalies, trauma, and aging with associated changes in the tooth tissue. [17]

Some of the harmful habits that can contribute to the development of CTS are tooth clenching, gnashing, and chewing hard objects, since it is considered that the effect of the excessive forces on a healthy tooth, and the effect of forces with physiological intensity on a weakened tooth can equally be one of the causes for incomplete fracture of enamel or dentin.[3] The usage of composite cements for cementing "inlays", "onlays" or crowns with an inadequately prepared surface where excessive pressure is applied to the dental structures, can also lead to cracks or fractures. [1]

Although parapulpal pins are used as a therapeutic option for teeth restoration with a large loss of the tooth substance, it is important to note that they can lead to a fracture or CTS. [7]

The application of amalgam alloys with poor quality and the excessive pressure during amalgam condensation are also some of the factors that can lead to CTS. The difference in the coefficient of thermal expansion between the tooth and the restorative material can also lead to the appearance of this syndrome.[8,9] Most of the teeth with CTS have restorations that do not significantly cause weakening of the tooth structure, but it is considered that the occlusal stress is a more dominant factor compared to the amount of the remaining tooth substance.[27-30]

The endodontic treatment of teeth is also one of the risk factors, whereas besides that a larger amount of the tooth substance is removed, there may be additional retention during the filling that further contributes to the occurrence of CTS.[11,16] The use of Sodium Hypochlorite that causes chemical and mechanical changes in the dentin in proportion to the concentration leads to a weakening of the dentin collagen, which consequently leads to a decrease in the elasticity of the dentin. Therefore, the application of the rotary instruments in the channel without a controlled force may cause a crack in the dentin. [25,26]

Also, one of the most common causes is considered to be the masticatory trauma of a bite of solid foods/objects and the bruxism that can be much stronger than those contractions provoked consciously. [9,10] This leads to the action of force of extremely strong intensity on a small area. Also, the erosion, abrasion and the caries, cause a physical stress especially in older people, where they have been acting continuously for a long time.[29]

Among the developmental anomalies are those structural anomalies that lead to weakening of the tooth structure. There are studies that present cases where the tongue piercing is the cause of CTS. It often appears at adolescents, and the frequency is up to 70%.[32] The excessive removal of the tooth substance during the preparation of the cavity, especially of the mesio-occlusal or disto-occlusal cavity with which the marginal ridges are removed, increases the risk of a fracture.[18-20]

Clinical picture

CTS is a condition that is difficult to be diagnosed with a clinical examination since it is often not possible to visualize the fractured line. [3]

CTS is characterized by a specific pain that occurs after occlusal pressure subsides. This is the so-called rebound pain or recurrent pain that occurs after chewing fibrous food. The pain occurs especially after consuming cold drinks. The absence of pain is characteristic after warm stimulus. The

pain also occurs after protrusion, retrusion and lateral movements where the occlusal surfaces pass over each other.[8-10] Also, an acute pain may occur after eating solid food, which eventually spreads to the entire ipsilateral side of the face. However, sometimes the pain could be mild or even spontaneous. The patients can most often localize the pain, which to some extent facilitates the diagnosis from other odontalgias.[14] If the patient does not localize the pain, the percussion usually localizes it, whereas the intensity of the pain is proportional to the strength of the force. The patients often complain that the pain persists for several months. After force application, there is no separation of the tooth segment.[15,18]

CTS can be accompanied by reversible pulpitis that occurs as a result of hypersensitivity of the tooth itself, and if bacteria penetrate from the fractured line, it can lead to deterioration and development of irreversible inflammation.[21]

If a fractured line eventually reaches the pulp chamber, symptoms of irreversible pulpitis or apical periodontitis follow, and if the line progresses toward the root, they are usually accompanied by localized periodontal damage.[28] The most common symptoms that patients report are sensitivity to cold, sweet, or sometimes warm or a combination. The explanation lays in the hydrodynamic theory of pain, that is based on the fluid movement in the dentinal tubules and the activation of the delta fibers that are responsible for short-term sharp pain.[23-25]

About 70-80% of the nerve endings in the pulp are non-myelinated C-fibers that are responsible for mild pain that is difficult to localize and is usually a result of hot stimulus. These fibers are usually activated when the pulp is affected, so if patients with CTS develop a mild pain from hot stimulus, an urgent treatment is needed, that comprises of tooth immobilization by placing an orthodontic wire on both sides of the fractured line. Also, it is recommended to apply zinc oxide eugenol for a proper edge closure in order to fill the crack and eventually preserve the vitality of the tooth.[17]

Diagnosis: The diagnosis of CTS is relatively difficult to confirm since the pain that occurs is similar to many other conditions of sinusitis, temporomandibular joint disorder, headache, or earache. The early diagnosis is especially important for a proper therapy and prevention of progression in form of fracture, pulp or periodontal tissue affection.[19]

In order to place a diagnosis, a comprehensive dental history is required, along with clinical examination, visual tests, vitality tests, radiography, and the use of a microscope.

The inability to see a crack during a clinical examination reduces the likelihood of placing an accurate diagnosis.[26] However, the existing of some factors during the clinical examination, such as abrasive facets on the occlusal surfaces, the presence of localized periodontal defects that usually occur when the fractured line is localized sublingually, could significantly facilitate the diagnosis.[36,37] Many authors recommend the removal of existing restorations and pigmentations for easier visualization of the fractured line. The rubber dam makes the visualization easier and also highlights it and acts contrastive compared to the color of the rubber itself. Also, in the clinical examination we include tactile examination, translumination and Bite- test. [30-33]

The X-ray diagnostics is certainly an indispensable part of placing a diagnosis, especially for excluding other pathological conditions or a fracture in the buccolingual direction, because the fractures in the mesiodistal direction are parallel to the film and cannot be recognized. [35]Bitewing images are certainly superior to the retroalveolar ones. The usage of a microscope facilitates the

visualization of small cracks, and also allows precise positioning of the crack explorer during the tactile detection. With the combination of a microscope and translumination, the depth of the fracture line can be seen.[12]

The acute periodontitis, reversible pulpitis, dentinal hypersensitivity, postoperative sensitivity, occlusal parafunctional trauma, and trigeminal neuralgia should be considered differentially diagnostic.[34]

Therapy: The basis of a good CTS therapy is the detection of the etiological factor that led to the cracking. There is no unified treatment protocol, but it has been established that the primary goal is to immobilize the cracked tooth segment that is under pressure.[36] This is achieved by removing the affected tuber and restoring the defect or placing a restoration on the both sides of the crack that will prevent movement of the tooth segment. The purpose of this approach is not only to alleviate the symptoms but also to prevent the flexion of the affected tuber, a propagation of the crack and the entering of microorganisms into the pulp.[40] Some clinicians recommend removing the affected tuber which is later restored by occlusal balancing, and according to some authors, that tuber should be removed from contact. Others do not recommend contact removal.[39] CTS treatment can be immediate, with indirect or direct restorations, with or without tubal replacement. Some clinicians recommend crowns on CTS-affected teeth because the fractured line almost always extends to the cervical third of the crown. Placing a crown allows arrangement of the occlusal forces to the treated tooth in order to reduce the possibility for propagation of the fractured line, it serves as a splint and excludes the possibility of tooth fragments movement.[32,34] During the preparation of the teeth, it is necessary to reduce the functional pressure that is transferred to the fractured parts of the tooth. A modification of teeth preparation with CTS includes additional reduction of the affected tubers, avoiding of replacing grooves to the fractured line or with it, usage of low viscous cements and apical placement of the edge of the preparation. The prognosis of CTS teeth depends mainly on 3 factors: the location and the length of the fracture line, the time of initiation of the intervention, and the type of restoration that serves as the fracture splint.[23,24] Direct adhesive restorations without compensating the tuber are acceptable in teeth where the filling would not be greater than half the buccal-lingual width. Teeth with CTS should be restored immediately with direct adhesive restoration, and indirect restorations should be applied after the symptoms have subsided.[28]

Whole crowns and onlays are the gold standard for many clinicians. However, the large loss of the tooth tissue and the high risk of loss of vitality are the disadvantages when making crowns for CTS therapy.[38,39] While the indirect restorations require preparation of temporary restorations, they take longer to be made and are more expensive.[31] The purpose of the restoration is to extend the life of the tooth, therefore, the direct restorations by replenishing the tubers are best for treating complete fractures of the lateral teeth. They are economically acceptable, and efficient for taking care of such defects and if they are made of composite, they are aesthetically acceptable restorations.[38]

The earlier the crack is repaired the more likely it is to avoid reversible damage. The therapy depends on the position and angulation of the fractured line, as well as the involvement of the tooth structure.[33,34]

Conclusion: CTS is the third leading cause of lateral tooth loss in adult patients. Therefore, it is very important to raise the awareness of students and clinicians about this syndrome. Most epidemiological data indicate that the most commonly affected teeth are the mandibular molars.

Taking into consideration the multifactorial etiology of CTS, it can be said that the removal of the marginal ridge during the preparation and the action of occlusal forces have the biggest role. An early detection can detect numerous complications and ultimately tooth loss. In order to carry out the best possible treatment, it is necessary to take into consideration all the factors from the occurrence of the syndrome itself, the condition and the prognosis of the tooth. The fractures that involve only the dentin and extend horizontally without affecting the pulp and those not less than 2 mm below the epithelial attachment of the gums are considered favorable for treatment. The prognosis is poor in teeth where the fracture involves both marginal ridges, affects the pulp, and goes deep subgingivally.

USED LITERATURE

- [1] Geurtsen W, Schwarze T, Gunay H . Diagnosis, therapy and prevention of the Cracked tooth syndrome. *Quintessence Int* 2003; 34: 409–417.
- [2] Udoye, C. I., & Jafarzadeh, H. Cracked Tooth Syndrome: Characteristics and Distribution among Adults in a Nigerian Teaching Hospital. *Journal of Endodontics* 2009; 35(3), 334–336.
- [3] Mathew S, Thangavel B, Mathew C, Kailasam S, Kumaravadivel K, & Das A. Diagnosis of Cracked tooth syndrome. *Journal of Pharmacy and Bioallied Sciences* 2012; 4(6), 242.
- [4] Ellis S. G. S, Macfarlane T. V, McCord J. F, Ellis S. G. S, Macfarlane T. V, & McCord J. F. Influence of patient age on the nature of tooth fracture. *J Prosthet Dent* 1999; 82(2), 226–230.
- [5] Seo, D.-G., Yi, Y.-A., Shin, S.-J., & Park, J.-W. Analysis of Factors Associated with Cracked Teeth. *Journal of Endodontics* 2012; 38(3), 288–292.
- [6] Rivera EM, Williamson A. Diagnosis and treatment planning: Cracked tooth. *Tex Dent J* 2003 Mar;120(3):278-83.
- [7] Cameron, C. E. Cracked-tooth syndrome. *The Journal of the American Dental Association* 1964; 68(3), 405–411.
- [8] Yang Y, Chen G, Hua F, Yu Q, Yang W. Biting pain reproduced by the Tooth Sloth: an aid for early diagnosis of Cracked tooth. *Quintessence Int* 2019;50(1)82-87.
- [9] Ritchey B, Mendenhall R, Orban B. Pulpitis resulting from incomplete tooth fracture. *Oral Med Oral Surg Oral Pathol* 1957; 10:665-70.
- [10] Berman LH, Kuttler S. Fracture necrosis: diagnosis, prognosis assessment, and treatment recommendations. *J Endod* 2010;36:442–6.
- [11] Roh B D, Lee Y E . Analysis of 154 causes of teeth with cracks. *Dent Traumatol* 2006; 22: 118–123.
- [12] Geurtsen W. The Cracked tooth syndrome: clinical features and case reports. *Int J Periodontics Restorative Dent* 1992; 12: 395–405.
- [13] Ehrmann EH, Tyas MJ. Cracked tooth syndrome: diagnosis, treatment and correlation between symptoms and post-extraction findings. *Aust Dent J* 1990;35:105–12.

- [14] Blum JY, Machtou P, Micallef JP. Analysis of forces developed during obturations. Wedging effect: Part I. *J Endod* 1998 Apr;24(4):217-22.
- [15] Hiatt WH. Incomplete crown-root fractures in pulpal periodontal disease. *J Periodontol* 1973; 44: 369-379.
- [16] Fuss Z, Lustig J, Katz A, Tamse A. An evaluation of endodontically treated vertical root fractured teeth: impact of operative procedures. *J Endod* 2000; 27: 46-48.
- [17] Rosen H. Cracked tooth syndrome. *J Prosthet Dent* 1982;47:36-43.
- [18] Arnold M. Bruxism and the occlusion. *Dent Clin North Am* 1981;25:395-407
- [19] Nguyen, V., & Palmer, G. A Review of the Diagnosis and Management of the Cracked Tooth. *Dental Update* 2009; 36(6), 338-349.
- [20] Bader JD, Martin JA, Shugars DA. Preliminary estimates of the incidence and consequences of tooth fracture. *J Am Dent Assoc* 1995; 126: 1650-1654.
- [21] Geurtsen W, Garcia-Godov F. Bonded restorations for the prevention and treatment of the Cracked tooth syndrome. *Am J Dent* 1999; 11: 266-270.
- [22] Bales DJ. Pain and the Cracked tooth. *J Indiana Dent Assoc* 1975;54:15-8.
- [23] Skinner, E. W, and Phillips, R. W. *The science of dental materials*, ed. 5. Philadelphia, W . B. Saunders Co 1960.
- [24] Ratcliff S, Becker IM, Quinn L. Type and incidence of cracks in posterior teeth. *J Prosthet Dent* 2001;86:168-72.
- [25] Lynch C, McConnel R. The Cracked tooth syndrome. *Jour Can Dent Assoc* 2002; 68: 470-475.
- [26] Turp C, Gobetti J . The Cracked tooth syndrome: an elusive diagnosis. *J Am Dent Assoc* 1996; 127: 1502-1507.
- [27] Goel V, Khera S, Gurusami S, Chen R. Effect of cavity depth on stresses in a restored tooth. *J Prosthet Dent* 1992; 67: 174-183.
- [28] Plasmans P J, Breugers N H, Mulder J. Long term survival of extensive amalgam restorations. *J Dent Res* 1998; 77: 453-460.
- [29] Van Nieuwenhuysen J P, D'Hoore W, Carvahlo J, Quist V. Long term evaluation of extensive restorations in permanent teeth. *J Dent* 2003; 131: 395-405.
- [30] Staninec M, Holt M. Bonding of amalgam to tooth structure: tensile adhesion and microleakage tests. *J Prosthet Dent* 1988; 59: 397-402.
- [31] Ueno Y. A clinical evaluation of adhesive amalgam lining with 4 META/MMA TBB adhesive resin without anaesthesia. *J Jpn Soc Adhes Dent* 1989; 73: 181-189
- [32] Omura I, Yamauchi J, Harada I, Wada T. Adhesive and mechanical properties of a new dental adhesive. *J Dent Res* 1984; 62: 233.

- [33] Bearn D, Saunders E, Saunders W. The bonded amalgam restoration – a review of the literature and report of its use in the treatment of four cases of Cracked tooth syndrome. *Quintessence Int* 1994; 25: 321-326.
- [34] Eakle W S, Staininec M, Lacy A M. Effect of bonded amalgam on the fracture of teeth. *J Prosthet Dent* 1992; 68: 257-260.
- [35] Oliveira J P, Cochran M A, Moore B K. Influence of bonded amalgam restorations on the fracture strength of teeth. *Oper Dent* 1996; 21: 110-115.
- [36] Geurtsen W, Orth M, Gartner A. Fracture resistance of human maxillary molars with MOD amalgam or composite fillings. *Dtsch Zahnarztl Z* 1989; 44: 108-110.
- [37] Ausiello P, DeGee A S, Rengo S et al. Fracture resistance of endodontically treated premolars adhesively restored. *Am J Dent* 1997; 10: 237-241.
- [38] Weiczowski G, Joynt R B, Klockowski R et al. Effects of incremental versus bulk fill technique on resistance to cuspal fractures of teeth restored with posterior composites. *J Prosthet Dent* 1988; 60: 283-288.
- [39] Van Dijken J W V. Direct resin composite inlays/ onlays: an 11 year follow up. *J Dent* 2000; 28: 299-300.
- [40] Stavridakis M M, Kakaboura A I, Ardu S, Krejci I. Marginal and internal adaptation of bulk filled class I and cuspal coverage direct resin composite restorations. *Oper Dent* 2007; 32: 515-523.