Cracked tooth syndrome

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Abstract

Cracked tooth syndrome (CTS) is both a transient and progressive condition. There are numerous factors that may predispose a tooth to varying degrees of a crack. Incompletely fractured teeth are capable of causing great discomfort to the patient and it is also a source of concern for the dental practitioner. Diagnosis of CTS can be difficult. The patient reports with pain, and often the dentist relies on a periapical radiograph to determine the origin of the pain. Because CTS is a vital pulp condition, the periapical radiograph is of limited value as a diagnostic test. As a result, lack of treatment, or inappropriate treatment, will not resolve the symptoms, and the condition can result in the eventual loss of the affected tooth. This article will present the epidemiology, classification, etiology, signs and symptoms, the accurate diagnosis modalities and treatment options, along with prognosis and future prospects for this clinical condition through the undertaking of a comprehensive literature review of contemporarily available data.

Introduction

Cameron coined the term cracked tooth syndrome (CTS) to define the condition as “an incomplete fracture of a vital posterior tooth that involves the dentin and occasionally extends to the pulp.”[1][2]

In recent times, the definition has been modified as follows: “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.”[3]

The incidence of cracks in teeth seems to have increased since the last three decades. This is probably because of better health care facilities, people live longer and their teeth last longer too, thus making them more susceptible to cracking, from normal wear and tear. Stress and stress-related habits such as bruxism and clenching have also become more prevalent, thereby contributing to the increased incidence of cracks. Finally, because dentists are becoming increasingly aware of the existence of cracks, more cracks are being diagnosed than before.[4]

Other terms often used interchangeably with CTS include: “incomplete fracture of posterior teeth”,[5] “green-stick fracture”, “split tooth syndrome.”[6]

Through a comprehensive literature review, this article aims to provide an overview of the epidemiology, classification, etiology, signs and symptoms, diagnosis, treatment and prognosis, as well as future prospects of cracked teeth which may be a diagnostic challenge in clinical practice.

Materials and Methods

Search criteria

Inclusion criteria

• The search was limited to review articles and case studies involving human subjects
• Restrictions were not placed regarding the study design and the language usage
• A minimum follow-up duration of 1 year was selected
• All original research articles, review articles, case reports, case series, and pilot studies were included.

Exclusion criteria

• Publications that did not meet the above inclusion criteria are excluded
• Studies conducted on animals.

Search strategy

A literature review was performed in Pubmed Central, MEDLINE, the Cochrane Library, and the EBSCO host. The articles identified included those published up to November,
2013 with the following Medical Subject Headings (MeSH) terms and/or key words in various combinations: Cracked tooth, vertical root fracture, tooth fracture, split tooth, cuspal fracture odontalgia, bite tests, and splinting. About 272 articles were found, out of which many were excluded based on the exclusion criteria mentioned above and 60 of the articles were used for this review.

Discussion

Epidemiology
The presence of a cracked tooth occurs primarily in adulthood. Contradictory data were reported regarding the correlation between a patient’s age and the occurrence of CTS. Fitzpatrick[7] observed that incomplete fractures primarily occurred in people between the ages of 30-39; these findings indicate that more and more young patients are affected by CTS.[8] Luebke[9] found mandibularolars especially the distolingual cusp to be the most susceptible to cracking. The maxillary molars and premolars have a similar incidence of fracture, with the mandibular premolars being the least susceptible because the stresses during mastication is minimal on these teeth.[10] Cracks not only appear in restored teeth but also may occur in intact ones.

Classification of tooth fractures-(By American Association of Endodontics)[11]
They can be classified into five broad categories-each differing in location and severity. In order of increasing severity, the categories are: (1) Craze line, (2) fractured cusp, (3) cracked tooth, (4) split tooth, and (5) vertical root fracture.[11]

• Craze lines: They involve enamel only and are usually asymptomatic. In posterior teeth, craze lines are usually evident crossing marginal ridges and/or extending along buccal and lingual surfaces. Long vertical craze lines are often found in anterior teeth.[12]
• Fractured cusp: According to the American Association of Endodontists, the fractured cusp results from a lack of cusp support due to a weakened marginal ridge. It is the easiest to identify and treat with the best prognosis
• Cracked tooth: The depth of this crack is variable, it occurs in a mesiodistal direction. The most challenging form of incomplete tooth fracture is a cracked tooth, which may be difficult to diagnose and is a source of frustration for both the dentist and the patient
• Split tooth: A split tooth extends from one proximal surface to the other; fracture is complete and extends across the tooth.[1] A split tooth can never be saved intact, and the position as well as extent of the crack will determine whether any portion of the tooth can be salvaged; in most cases, the whole tooth must be extracted[1]
• Vertical root fracture-Vertical root fractures are cracks that begin in the root of the tooth and extend occlusally.

The diagnosis can be difficult to establish because the fracture can mimic other conditions such as sinusitis, atypical facial pain, etc. Treatment is usually extraction of the tooth.[13]

Etiology
The etiology of CTS is multifactorial. Guersten et al.,[14] stated that “excessive forces applied to a healthy tooth or physiologic forces applied to a weakened tooth can cause an incomplete fracture of enamel or dentine.” Lynch et al.,[15] have subdivided the causes of cracks into four major categories: Restorative procedures, occlusal factors, developmental conditions, and miscellaneous factors.

Restorative procedures
• Pin-retained restorations (self-threaded or friction lock pins)[16]
• Tightly fitting cast restorations[17] (excessive hydraulic pressure while luting)
• Non-incremental placement of composite restorations
• Torque on abutment in long span bridges
• Excessive removal of tooth tissue during cavity preparation which significantly lowers tooth rigidity.[17] A cavity of width more than one-fourth of the intercuspal distance is at an increased risk of fracture[18]
• Ratcliff et al.,[19] found that a tooth with an intra-coronal restoration is at a risk of fracture 29 times greater than that of an unrestored tooth. Differences in the coefficients of thermal expansion between that of the tooth tissue and restorative material may also have the potential to induce fracture.[20]

Even endodontically treated teeth are at an increased risk of fracture, the reason being the loss of hard tooth substance during preparation of the access cavity.[19]

Sometimes due to high forces applied during lateral compaction of gutta percha or cementation of a post, vertical cracks may appear.[21]

It has been found that 26-72% of endodontically treated posterior teeth restored with mesio-occlusal, disto-occlusal, or mesio-occlusodistal amalgam restorations cracked over a 20-year period.[22]

• Occlusal factors: It has been stated that CTS most commonly occurs because of using excessive force to bite suddenly on a hard object.[23] Fracture may also be caused by trauma from occlusion. A great amount of force is applied during parafunctional habits such as nocturnal bruxism, the reason for this being the suppression of cortical inhibitors during sleep.[23]
• Developmental conditions: Various morphologic factors maybe the possible cause for cracked teeth, like deep occlusal grooves, pronounced vertical radicular
grooves, or a bifurcation. Thus, maxillary premolars are significantly more susceptible to fracture than mandibular premolars. Additionally, an extensive pulp space, a “steep cusp/deep groove” inter-relationship between the maxillary and mandibular premolars, and the resulting wedging effect of the prominent facial cusps of mandibular premolars, contribute to the increased susceptibility to fracture of maxillary premolars.\(^{[24,25]}\)

- Miscellaneous factors—Miscellaneous factors include wasting diseases like abrasion, erosion or attrition, acidogentic extensive loss of enamel and dentin, and bulimia or anorexia nervosa, may also increase the risk of a fracture.\(^{[14]}\)

In recent years, the lingual barbell or tongue piercing has been identified as a frequent cause for cracks on teeth.\(^{[26]}\)

With age, dental tissues become more brittle and less elastic, thus even forces which were otherwise within normal physiologic limits may exceed the elastic limits of an aged dentition, making it more susceptible to fracture.\(^{[27]}\)

Signs and symptoms

The most classic symptom of CTS is a history of sharp pain when biting or while consumption of hot/cold beverages.\(^{[28]}\) This pain on biting increases as the applied occlusal force is raised.\(^{[27]}\) The pain usually occurs on release of pressure when fibrous foods are eaten, hence it is known as “rebond pain.”\(^{[29]}\) The alternative stretching and compressing of the odontoblastic processes located in the crack has been thought to be the cause for this short, sharp pain.\(^{[24]}\)

This pain has also been accounted to the sudden movement of fluid present in dentinal tubules which occurs when the fractured portions of the tooth move independently of one another, which results in the activation of myelinated A-type fibers within the dental pulp. Hypersensitivity to cold may also occur as a result of the seepage of noxious irritants through the crack, which results in the subsequent release of neuropeptides causing a concomitant lowering in the pain threshold of unmyelinated C-type fibres within the dental pulp.\(^{[29]}\)

Very often fractures are not diagnosed in time because of which they may enter the pulp chamber, causing pulpal inflammation and necrosis. Fractures extending to the root generally cause periodontal inflammation. Thus, a localized periodontal breakdown adjacent to a restored tooth frequently indicates a fracture.\(^{[5]}\)

Diagnosis

Diagnosing CTS has proved to be difficult even for the most experienced dental practitioners, the reason being that associated symptoms are usually very variable and sometimes even bizarre.\(^{[28]}\)

Successful treatment and favorable prognosis would depend on an accurate and early diagnosis.

A detailed history is imperative along with a thorough assessment of all symptoms, though these vary with the depth and orientation of the crack.

If the crack is directly visible, diagnosis can be fairly simple.\(^{[5]}\) This is possible in cases where there is exogenic staining from food or beverages. But more often than not, common mesiodistal cracks are not visible because most of these teeth present with an overlying occlusal or proximal restoration. Hence removal of these restorations may prove to be useful.\(^{[28]}\) With larger restorations, cracks tend to be more superficial and thereby produce fewer symptoms, whereas with smaller restorations cracks tend to be deeper and closer to the pulp.\(^{[31]}\) Initial cracks may not be visible because they are too small to be detected by the naked eye.\(^{[32]}\)

Many authors have suggested the use of stains like gentian violet or methylene blue to stain the fracture line and make it visible.\(^{[28]}\) But this technique still has its disadvantages—first, that staining may take many days to become effective, hence requiring an interim restoration,\(^{[5]}\) which may further compromise the structural integrity of the tooth. Furthermore, after the use of these dyes, placing a definitive aesthetic restoration may prove to be difficult.\(^{[28]}\)

Magnifying loupes and transillumination using a fiber-optic device have been considered instrumental in the diagnosis of a cracked tooth.\(^{[16]}\)

One of the classic symptoms of CTS, which most dental operators consider to be an important indicator, is cold sensitivity and sharp pain on biting hard or tough food which ceases on the release of pressure.

This “relief pain” can be replicated by bite tests.\(^{[13]}\) To accurately diagnose an incomplete fracture by the use of any of the following—orange wood sticks, cotton-wool rolls, rubber abrasive wheels such as a Burlew wheel or the head of a number 10 round bur in a handle of a cellophane tape.

In order to localize the cusp affected by CTS, a wood stick can be rested on each individual cusp of the suspected tooth and the patient asked to bite. According to Kruger, pain produced by release of pressure confirms a case of CTS.\(^{[33]}\)

The use of commercially available diagnostic tools like Fractfinder (Denbur, Oak Brook, IL, USA) and Tooth Slooth II (Professional Results Inc., Laguna Niguel, California, USA) have found to be more sensitive and accurate in the identification of the affected/involved cusp when compared with the more conventional tools.\(^{[1]}\)

Most cracks propagate in a mesiodistal direction, because of which radiographs are barely of any use.\(^{[15]}\) However in the
rare cases where the fracture occurs bucco-lingually they are valuable in the diagnosis.\textsuperscript{[34]}

But Cone Bean Computed Tomography (CBCT) may prove to be useful in many cases.

**Treatment**

**Immediate therapy**

To avoid irreversible damage, it is imperative that a cracked tooth be treated as soon as possible.

Occlusal adjustment of affected teeth must be done immediately to reduce the stress on the tooth and prevent further damage to the tooth.

If the tooth in question presented with a preexisting restoration, it should be removed. This may cause the affected cusp to "splinter off" and the further treatment protocol can then be decided.\textsuperscript{[35]}

In case there is no splintering, immediate immobilization should be employed, using an “immediate extra-coronal circumferential splint.” A copper ring or a stainless steel orthodontic band can be used for this purpose.\textsuperscript{[5]}

The use of full coverage acrylic provisional crowns has been advocated for “immediate splinting.”\textsuperscript{[36]}

Another available option is the use of bonded composite resin to splint the teeth, which is known as a “direct composite splint” (DCS).\textsuperscript{[37]}

**Definitive therapy**

In case of non splintering teeth, intra coronal restorations, without cuspal coverage may also be used. Dental amalgam, composite resin and glass-ionomer cements are most commonly used. The strength of the tooth can be restored by using these materials.\textsuperscript{[38]}

Amalgam overlays have been found to increase the fracture energies of cracked teeth to levels equivalent to that of intact teeth.\textsuperscript{[39]} Hence direct restorations with cuspal coverage have been advocated as a primary mode of treatment.\textsuperscript{[31]}

In cases where aesthetics is not a matter of great concern, cast metal inlays with cuspal coverage or partial crowns with circumferential external splinting are applied or else, adhesive ceramic restorations can also be used.

Full coverage crowns are the most appropriate form of restoration for cases where the crack extends from the occlusal incline to the cervical third of the clinical crown.\textsuperscript{[36]}

It has been reported by a number of authors that the loss of vitality following the application of full coverage single unit crowns is in the range of 15-19%. Loss of pulpal vitality is an obvious problem following the preparation of teeth to receive a full coverage crown. In CTS, reversible pulpitis would already be a pre-existing condition so the problem appears to be further compounded [Figure 1].\textsuperscript{[15,40,41]}

![Treatment options](image)

**Figure 1:** Treatment options
Prognosis

In case of a cracked tooth, the patient should be fully informed that the prognosis is questionable at best. A number of factors would need to be considered before evaluating the prognosis of a cracked tooth.

The location and extent of the crack is probably the most important of these factors. Prognosis is considered excellent for cracks that are limited to dentine and not involving the dental pulp, or for those fractures which are limited to a single marginal ridge which do not extend more than 2-3 mm below the periodontal attachment. The prognosis becomes poor in cases involving both marginal ridges, or reaching up to the pulp. Prognosis is defined to be hopeless in cases which present with complete mesio-distal fractures, or where gingivoplasty or an alveoplasty does not expose the fractured segment.

Anatomy of the tooth and roots, the previous operative/ restorative history of the tooth and the functional forces acting on the tooth (during both functional and parafunctional activity), are other factors affecting the prognosis. The loss of pulp vitality has also been found to have adverse effects on the prognosis of the tooth. Finally, the technique used and skill and experience of the operator can also affect the long term prognosis of such teeth.

Future prospects

In recent years the ability of Swept Source Optical Coherence Tomography (SS-OCT) to detect cracks has been evaluated and it has been found that, it can clearly discriminate cracks, which appear as highlighted lines due to the scattering of light. But further clinical studies would be required before this technique could be used extensively.

The DCS has also been found to have the potential, in theory, to be used as both an immediate and intermediate restorative option. It is a biologically conservative, aesthetic, easy to apply and inexpensive treatment modality. But before this treatment option can be applied in every-day dental practice, considerable further clinical research is needed.

Conclusion

The CTS presents both a challenge and an opportunity for the dentist. The diagnosis of this condition can be difficult, but every attempt must be made to do it with expediency. Though a number of definitive restorative techniques have been described for the treatment of posterior teeth affected by CTS, there is very limited clinical evidence available in the dental literature to substantiate the use of any of them. Three principal factors determine the prognosis of a tooth affected by CTS: The extent and location of the fracture, the point in time when restorative intervention is initiated and thirdly by the type of restoration applied to splint the fracture. It is our foremost duty to provide a solution to the problem the patient comes to us with. No matter what the prognosis of the particular tooth, all available treatment options must be known to the dentist and explained well to the patient to help him decide on and initiate the proper treatment plan.

References

Shetty, et al.: Cracked teeth


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Source of Support: Nil Conflict of Interest: No conflict of interest.

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