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Review

Etiology, Classification, and Clinical Features of Cracked Tooth Syndrome

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Abstract

Cracked tooth or incomplete tooth fracture involves a fracture plane whose depth and direction is not known and extends through tooth structure with current presence or future probability of pulpal and periodontal communication. These cracks, whether symptomatic or asymptomatic, predispose the tooth to pulpal disease. Originally, tooth fractures or cracks were related to the inlay restorations with soft gold which needed to be physically malleated to the cavity for adaption to the tooth surface. Currently, the etiology of cracked tooth syndrome is multifactorial with two primary risk factors implicates in the development of cracks: natural tooth features and iatrogenic factors. A number of classification schemes have been proposed including classification of fractured teeth on the basis of the type of crack, degree and direction of fracture and location of crack. A classic clinical finding of cracked tooth syndrome (CTS) is a history of sharp, localized pain on biting or chewing that stops once the pressure is withdrawn, or while taking hot or cold drinks. Rebound pain a characteristic feature of CTS and particularly happens when a fibrous food is chewed. Moreover, special consideration is required to address vertical root fractures as their presentation may vary widely clinically. Such patients, oftentimes, report a history of discomfort and chronically inflamed gingiva in relation to the affected tooth. Every dental practitioner should have the knowledge of the risk factors, clinical features and different presentations of CTS in the clinic. A differential diagnosis of CTS must be considered when pain or discomfort on chewing or biting is present.

Keywords: cracked tooth syndrome, fractured tooth, rebound pain, bite test

Introduction

The term "cracked tooth syndrome" was first introduced by Cameron to address teeth symptomatology of cracked or fractured teeth. He defined cracked tooth syndrome (CTS) as partial fracturing of vital posterior tooth with definite dentinal involvement and probable pulpal involvement (1). According to Ellis, incomplete tooth fracture involves a fracture plane whose depth and direction is not known and extends through tooth structure with current presence or future probability of pulpal and periodontal communication (2). These cracks, whether symptomatic or asymptomatic, predispose the tooth to pulpal disease. Most epidemiological studies reported that the incidence of CTS was strongly associated with the presence of intracoronal restorations, and the prevalence was highest among lower molars (3). Cracked tooth primarily are seen in adult patients (4). Studies have found that 80% of cracked teeth occur from fourth decade of life onwards (5). Few studies have shown a female predominance in CTS cases (6). It is believed that one in 23 adults annually is affected by a fractured posterior tooth (7). One study (8) that observed the overall incidence of complete tooth fracture noted that its rates were 5.0 teeth pert 100 adults annually, and 4.4 teeth per 100 adults annually for posterior teeth with roughly 15% of incidences leading to pulpal compromise or extraction. 3.1 and 1.3 teeth per 100 adults were the reported incident rates of molar and bicuspid fractures, respectively among all cases of posterior teeth fractures.

Methodology

This study is based on a comprehensive literature search conducted on April 18, 2022, in the Medline and Cochrane databases, utilizing the medical topic headings (MeSH) and a combination of all available related terms, according to the database. To prevent missing any possible research, a manual search for publications was conducted through Google Scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed the information about etiology, classification, and clinical features of cracked tooth syndrome. There were no restrictions on date, language, participant age, or type of publication.

Discussion

Cracks are formed in two classical ways (6). Firstly, the crack may be positioned in the tooth center and follows the path of the dentinal tubules while propagating towards the pulp chamber. Alternatively, the fracture line may be located peripherally predisposing the cusps to fracture. Application of pressure on the coronal portion of the fractured tooth separates the tooth sections along the line of fracture. This dentinal separation causes its fluid to move, leading to the stimulation of pulpal odontoblasts in addition to traction and rupture of odontoblastic processes present in the tubular dentin (9). These pathways trigger the nociceptors in the pulp. Further, entry of saliva through the crack might raise the dentinal sensitivity (10). In case of pulpal extension of fracture line, its tissues are directly stimulated.

Etiology

Originally, tooth fractures or cracks were related to the inlay restorations with soft gold which needed to be physically malleated to the cavity for adaption to the tooth surface (11). Currently, the etiology of CTS is multifactorial with two primary risk factors implicates in the development of cracks: natural tooth features and iatrogenic factors. According to Lynch and colleagues (12), the causal factors can be classified into four groups: restorative, occlusal, developmental, and miscellaneous factors.

Firstly, among the restorative factors are pin-retained restorations such as threads and lock pins (13), tightly fitted cast restorations due to extreme luting agent pressure (14), non-incremental application of composite, abutment torque in case of long span bridges, and overpreparation of cavity (15). Studies have shown that cavity width of more than a quarter of the intercuspal distance is at 29 times higher fracture risk compared to an unprepared tooth. Occlusal contact between extensive Class I and II intracoronal cast metal or composite restorations and the opposing tooth predispose the remaining tooth structure on the restored tooth to pressure form lateral masticatory movement, especially while chewing (2). Formation and growth of these cracks often is a result of these cyclic forces (2). Further, thermal expansion coefficient variation between the tooth tissue and restorative agent may also increase fracture susceptibility (16). Expansion from poor quality amalgam on contamination with moisture is also causes fracture formation (17). Endodontic therapy also reduces hard tooth tissue during access cavity preparation and increases the risk of CTS (17). Additionally, lateral compaction with gutta percha or post cementation also exert pressure, and thereby predisposing the tooth to vertical cracks (18). The fracture rates over a period of 20 years in endodontically treated posterior teeth with different proximo-occlusal amalgam restorations were observed to be between 26% to 72% (19).

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Secondly, it is believed that the most frequent cause for CTS is application of excessive occlusal force while biting down a hard substance (14). Similarly, trauma from occlusion and related excursive interferences, excessive forces on the teeth in individuals with parafunctional habits like bruxism and clenching, facial or oral injuries are other causes of CTS (20). A cumulative effect of such occlusive interferences and restorative materials' thermal expansion and contraction, also called thermal cycling, have been linked to coronal cracks (21). These occlusal forces are especially implicated in CTS of unrestored, carious teeth (17).

Thirdly, developmental conditions like degree of lingual incline of lingual cusps of lower molars, an extensive pulpal area, steep cusp/fossa in case of upper premolars, bifurcation deep occlusal grooves, and severe vertical radicular grooves (22). Upper bicuspids are substantially more prone to CTS than lower bicuspids (23). Cuspal fractures are mainly linked to the wedging effect arising from the cusp and fossa relationship (3). Apart from the anatomical factors, developmental weaknesses in the coalescence of calcification zones have been suspected of contributing to CTS in teeth without other CTS risk factors (3). Therefore, not all teeth involved in CTS are extensively restored.

Miscellaneous factors such as enamel and dentin wasting conditions like abrasion, erosion and attrition are other risk factors for CTS (23). More recently, lingual piercings such as barbells have observed to cause tooth fracture (24). Another factor commonly associated with increased CTS risk is age (25). Dentinal resistance to fatigue crack growth declines with age related dehydration of the tissue.

Classification

A number of classification schemes have been proposed including classification of CTS on the basis of the type of crack, degree and direction of fracture and location of crack. The most commonly used scheme is by the American Association of Endodontists (AAE) (26). They segregated the cracks into five classes. However, it is vital to note that, clinically, it is not always possible to distinguish one kind form the other. Firstly, the most benign form of CTS involves a craze line. These are usually asymptomatic cracks visible to the naked eye, and seemingly restricted to the enamel, although confirmation of the restriction of crack to enamel is not always possible. They are observed in most of the adult teeth. In posterior teeth, craze lines can be found to extend across marginal ridges as well as buccolingual surfaces. Anterior teeth usually demonstrate long craze lines that extend vertically. Fractured cusps initiate in the coronal portion of the tooth, extending to dentin, and terminating in the cervical portion. They are commonly found in the cusps of extensively restored teeth due to unsupported enamel and weakened marginal ridge. Cracked tooth is one of the most challenging types of tooth fracture to diagnose and treat. It involves a crack of variable depth that incompletely separates the fractured segments. it runs in a mesiodistal direction and may include one or both marginal ridges. A split tooth is a complete tooth fracture and is the result of crack propagation in a cracked tooth (1). Usually located centrally, the crack involves both marginal ridges usually in a mesio-distal direction splitting the tooth completely into two separate segments. The position and degree of fracture will determine whether any portion of the tooth can be retained as the entire split tooth can never be saved in this case. Usually, the tooth needs to be completely removed via extracted (27). Vertical root fractures are generally complete cracks that commence in the root of the tooth and extend occlusally in a bucco-lingual direction. The fracture may involve either the entire root or only a segment. The diagnosis may be difficult to make as the crack can mimic other problems like sinusitis and atypical facial pain. Treatment generally involves tooth extraction (28).

Another classification by Silvestri and Singh characterized tooth cracks into two major types: complete and incomplete fractures (29). The complete fracture was then categorized based on the crack direction into obliquely and vertically directed types. The complete oblique fracture is understood to occur frequently as a result diminished cuspal support from an extensive restoration. The compromised cusp then is totally sheared off by masticatory forces or parafunctional movements. Vertically propagating complete cracks are clinically seen as two separately moving coronal and radicular tooth sections in relation to one another. Incomplete tooth fractures were also classified into two kinds: oblique and vertical. An oblique fracture commences generally in the cuspal enamel on the occlusal surface, extends into dentin in an oblique fashion below the cusps, and ends gingivally in enamel or cementum. Total shearing of tooth sections in not observed in this case. Vertical incomplete cracks initate in enamel and run into the dentinal tissue, occasionally extending into the radicular portion. The crack may propagate in a mesiodistal fashion over one or both marginal ridges or on buccal and lingual surfaces between the cusps with no complete splitting of sections.

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A more elaborate classification scheme was proposed by Talim and Gohil that segregated tooth fractures into four classes (30). Class I includes fractures extending only within enamel. Subtypes include horizontal/oblique and vertical cracks which maybe further be classified as complete or incomplete vertical fracture. Class II includes fractures propagate through enamel and dentin without pulpal involvement. These are further classified as horizontal/oblique and vertical. Vertical cracks are again classified into complete or incomplete fractures. Class III fractures that run through enamel and dentin with pulpal involvement. They are categorized into horizontal/oblique and vertical fractures, the latter of which may be complete or incomplete. Class IV fractures are radicular fractures. These are further classified as vertical or oblique fractures, and horizontal fractures. Subtypes of the former type include fracture with pulpal involvement and fractures not involving pulp. Horizontal radicular fractures are further classified based on the location into apical, middle or cervical third root fractures.

Clinical features

Primarily based on clinical symptoms, CTS is challenging to diagnose. Symptomatology may vary based on the location and extent of the incomplete fracture (1). A classic clinical finding of CTS is a history of sharp, localized pain on biting or chewing that stops once the pressure is withdrawn, or while taking hot or cold drinks (31). Often history reveals CTS incidences while eating or putting other hard items such as pens and pipes between teeth (17). The diagnosis is straightforward in cases where the crack is visible (32). These cracks may be accompanied with exogenic food stains. However, in most cases, mesiodistal cracks on tooth surfaces underlie restorations, and in such cases these cracks can be sighted only once the restorations are removed (31). Superficial cracks are more commonly reported with larger restoration. These cracks tend to produce lesser symptoms. In contrast, restorations of smaller sizes tend to develop deeper fracture lines and more severe symptoms (33). In many cases, the patient is unable to perceive which tooth is affected due to the lack of pulpal proprioceptive fibres. A positive result is elicited on vitality investigation (6). Usually, the tooth displays no tenderness when percussing axially (34). Pain is perceivable on pressure application on the specific cusp (17). Bite tests employ this feature of CTS to detect fractures. Pain proportionally increases with increase in occlusal pressure and vice versa, although some patients report a sharp, fleeting painful sensation after pressure withdrawal (1). This is a characteristic feature of CTS and is called rebound pain, and particularly happens when a fibrous food is chewed. This rebounding sensation is thought to arise due to the snapping back of cracked dental segments when the pressure on dentinal nerves is relieved after biting. Bite test findings are used to conclude diagnosis in CTS patients (5). With respect to past dental history, there is often presence of large intracoronal restorations (35). A CTS patient may also demonstrate sensitivity to sweet substances (3). If the crack extents in the pulp, pulpitis may ensue (36). Asymptomatic chronic pulpal inflammation may exist as a consequence of microleakage of microbial toxins (36). CTS patients may also have a past treatment history involving elaborate or multiple occlusal adjustments, and retreatments that have been unsuccessful in providing relief. Oftentimes, the pain commences after a dental treatment involving cementing of an intracoronal cast metal restoration and is misdiagnosed as “high point” (5). Repeated failure of cementation might suggest the presence of occult cracks (6).

Special consideration is required to address vertical root fractures as their presentation may vary widely clinically (37). Such patients, oftentimes, report a history of discomfort and chronically inflamed gingiva in relation to the affected tooth. If swollen, the gingival lesion usually has a broad base, and any visible sinus tract is observed near the attached gingiva rather than the root apex. Two or more sinus tracts may often be present (28). There are also reports of foul taste and painful biting (28). Vertical root fractures commonly present with periodontal pockets neighboring the cracked tooth (38).

Conclusion

Every dental practitioner should have the knowledge of the risk factors, clinical features and different presentations of CTS in the clinic. A differential diagnosis of CTS must be considered when pain or discomfort on chewing or biting is present. Etiological consideration forms the foundation of CTS treatment. The main aim of therapy in CTS is the elimination of symptoms and mobility of the fracture segments. Even when CTS arises due to bruxism, clenching and other parafunctional behaviors, these habits must be addressed as well.

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Data availability

Data that support the findings of this study are embedded within the manuscript.

Authors' contribution

All authors contributed equally to the drafting, writing, sourcing, article screening and final proofreading of the manuscript.

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