Original Article

Comprehensive Review on the Management of Cracked Tooth

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Abstract

Aim: To do a comprehensive review in a systematic fashion and provide a decision analysis tree for the management of cracked teeth.

Background: Tooth fractures are commonly encountered in day to day dental practice. The consequences of these fractures can range from a minor to severe from a stage where no treatment is needed to a stage leading to root canal therapy or even tooth loss. One form of these fractures include cracked tooth syndrome. It often presents a difficulty in diagnosis to the dentist and many times it's a painful and a frustrating event to the patient. Cracked tooth syndrome is a term applied to a presumptive diagnosis of an incomplete tooth fracture which typically presents with the symptoms of pain on biting and responds to temperatures especially to cold stimuli. Routine clinical examinations in patients with asymptomatic teeth, often uncover these fracture lines. Unfortunately, by the time these incomplete tooth fractures become symptomatic, the tooth may already be destined to root canal therapy or extraction. Hence appropriate knowledge is needed for dentists in the prevention, diagnosis and treatment of the cracked teeth.

Methodology & Result: Literature search was carried out on cracked teeth.

Keywords: Cracked teeth, Root canal therapy, Extraction, Pulpitis, Trans-illumination

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Introduction

A cracked tooth is a condition that occurs in a tooth where there exists a partial or a complete fracture along the stress plane that commonly occurs in that tooth (Ellis, 2001). A tooth stress plane is a result from the occlusal force that is commonly imposed on a tooth during mastication. So, any instance of higher energy is always concentrated along these stress planes. These higher energies result in the disruption of some chemical bonds within the natural tooth while travelling along the stress planes. A clinically significant fracture may develop on the long run of several masticatory loads along these stress planes (Mamoun and Napoletano, 2015). As the fracture proportionately expands, due to proportionate stress being put on the remaining un-fractured area of the stress plane, the rate of fracture theoretically accelerates. Occlusal forces now become capable of causing teeth to flex. If these stress planes are in continuous contact with the periodontal ligament or pulp chamber they lead to the fluid movement within the odontogenic process, leading to sensitivity (Rosen, 1982). Eventually these stress planes cause the complete fracture of the teeth resulting in the separation of the tooth piece along the stress plane. Sometimes a single sudden traumatic hit results in a complete fracture along these stress planes (Majorana *et al.*, 2002). The endodontic and periodontal prognosis of the fractured teeth depend on what aspects of the tooth are intersected by the existing fracture or would be intersected if the tress plane is fractured completely (Mamoun and Napoletano, 2015). A tooth fracture plane or a stress plane, may be completely supra or subgingival and may or may not intersect with the pulp chamber, a furcation or a sub-gingival aspect of the root surface or a tooth root, making the prognosis poor (Bruyne, De Bruyne and De Moor, 2005). Various types of furcation fractures, cuspal fractures, root fractures, craze lines, gingival interface fractures may be defined on what structures the fracture planes intersect. A partial fracture is considered as catastrophic, if the complete fracture of these stress planes would result to non- restorability of the tooth with a crown or an endodontic procedure or a post endodontic restoration. A partial fracture is considered as non-catastrophic, when the complete fracture of the stress plane is still restorable with a crown or post endodontic restoration (Mamoun and Napoletano, 2015). Various terminologies have been proposed to describe these cracked teeth, but there is no clear cut universal agreement among the dentists concerning the exact correct descriptive systems (Nguyen and Palmer, 2009). The major reason for this being the inconsistency in symptoms and the random shapes of these fracture lines that appear clinically (Cameron, 1976). Cameron claimed the phenomena of these cracked teeth can be defined as a cracked tooth syndrome (Cameron, 1976),(Nguyen and Palmer, 2009). A cracked tooth is not a disease, but instead it's a factor that can facilitate the biomechanical, pulpal and periodontal problems (Chakravarthy *et al.*, 2012). The

symptoms of these cracked teeth are inconsistent (Türp and Gobetti, 1996)**,**(Bailey and Whitworth, 2020)**,**(Lubisich, Hilton and Ferracane, 2010)**,**(Nguyen and Palmer, 2009)**,**(Garg and Garg, 2018). These two realities contradict the scientific rationale for cracked teeth as a syndrome (Nguyen and Palmer, 2009)**.** Some authors define cracked tooth syndrome as an incomplete fracture involving the dentin and occasionally extends into the pulp but this definition excludes the complete fractures of the teeth and also the fractures of the non-vital teeth and doesn't specify the symptoms of a cracked teeth making the term syndrome irrelevant (Bailey and Whitworth, 2020). Some authors claim these fractures as horizontal, oblique or vertical (Khasnis *et al.*, 2014)**,**(Ubassy, 1993). However it is very unambiguous to differentiate between different crack types, based on the directions of these fracture planes because these fracture planes are mostly irregular. Some authors claim that fracture that involves only the enamel is called a non-structural craze, which doesn't require any treatment (Nguyen and Palmer, 2009)**,**(Lubisich, Hilton and Ferracane, 2010)(Andreasen *et al.*, 2011). If the structural crack in the dentin becomes complete, it would result in a chunk of the tooth structure fracturing off the tooth (Robertson, 1997). Since outcomes for the teeth with incomplete fractures can be so consequential, results are a significant problem to both dentists and patients (Lubisich, Hilton and Ferracane, 2010). The stress planes resulting in the incomplete or complete cracked tooth are mainly the furcation stress planes, cuspal stress planes, gingival interface stress planes and root fractures. Fracture stress planes are such that when a complete fracture of the stress planes occur, results in a separation or disconnection of one root from another. Complete disconnection of a root occurs when these stress planes fracture the tooth structure inferior to the pulp chamber floor, which helps to connect the two roots. Observation of a furcation fracture in an asymptomatic tooth is possibly an indication that the tooth is necrotic (Robertson, 1997). Cuspal stress planes occur approximately apical to one cusp or apical to two or more connected cusps. These stress planes may intersect with the pulp chamber wall or roof but not the floor. The lateral aspect of these stress planes may intersect with the external buccal or lingual tooth surface and possibly a root that is located subgingivally (Robertson, 1997).Our team has extensive knowledge and research experience that has translate into high quality publications (Sathivel *et al.*, 2008; Panda *et al.*, 2014; Govindaraju, Neelakantan and Gutmann, 2017; Johnson *et al.*, 2020; Saraswathi *et al.*, 2020) (Kumar *et al.*, 2006; Devi and Gnanavel, 2014; Varghese *et al.*, 2015; Sivamurthy and Sundari, 2016; Chen *et al.*, 2019). Gingival interface stress plane occurs along the cross section of the tooth structure that is located approximately at the interface between the supra and subgingival tooth structure (Robertson, 1997). Root fracture is a fracture of a stress plane, contained within a single root, such that complete fracture of the stress plane results in the disconnection of one root from the other (Robertson, 1997)**.**

Classification of tooth fractures by Talim and Gohil (Talim and Gohil, 1974)

Class I. Fracture involving enamel
- a. Horizontal or oblique
- b. Vertical
1. Complete
2. Incomplete

Class II. Fracture involving enamel and dentin without involving pulp
- a. Horizontal or oblique
- b. Vertical
1. Complete
2. Incomplete

Class III. Fracture of enamel and dentin involving the pulp
- a. Horizontal
- b. Vertical
1. Complete
2. Incomplete

Class IV. Fracture of the roots
- a. Vertical or oblique
1. Involving the pulp
2. Not involving the pulp
- b. Horizontal
1. Cervical third
2. Middle third

3. Apical third

These cracked teeth are mostly associated with the intracoronal restorations and most prevalent in mandibular molars. The highest prevalence rates are seen in patients over 40 years of age (Cameron, 1976)**,**(Eakle *et al.*, 1986)**,**(Roh and Lee, 2006). Some studies state women are being more affected than men, but some others say almost equal in distribution. The best way to prevent these cracks is to understand the factors that predispose a tooth to crack. The main predisposing factors for the cracks are natural and iatrogenic causes. Natural inclination of the lingual cusps of the mandibular molars, steep fossa or cusp of maxillary premolars, bruxism, clenching, extensive attrition and abrasion. The iatrogenic causes include the usage of rotary instruments, cavity preparation, and width and depth of the cavity (Robertson, 1997)**.** Age is also a contributing factor. It has been shown that as the age of the tooth increases, fatigue resistance of a human dentin decreases as a consequence of dehydration (Bailey and Whitworth, 2020).

Diagnosis

Cracked tooth syndrome is described in literature as a difficult diagnostic and treatment problem. The diagnosis is purely symptomatic with localised pain on chewing or biting with unexplained sensitivity to cold and pain during release of pressure (Garg and Garg, 2018). Several other tests are also performed by a clinician to diagnose a cracked tooth syndrome. The most commonly used ones being the vision enhancers, symptom reproducers and radiographs (Ailor and Edward Ailor, 2000). Fiber optic transillumination and use of light magnification aids like optic loupes or surgical microscope, will aid in the visualization of crack (Ellis, McCord and Burke, 1999)**.** The tooth should be clean on diagnosing and the light source is being placed directly on the restoration. The crack that penetrates into the dentin will cause the disruption of light transmission. Some others state that removal of the restorations and staining the tooth**,** will further aid in visualisation of the crack (Ailor and Edward Ailor, 2000)**.** The patient's symptoms can be reproduced by percussion, biting and thermal tests. To perform a bite test, a burlew wheel, a small rubber disc or a plastic stick is placed over each of the occlusal cusp pain is asked to bite on the tooth slot and observed for the pain on the release of pressure which is indicative of a cracked tooth (Ailor and Edward Ailor, 2000). Radiographs can evaluate the pulpal and periodontal health but they can rarely diagnose a crack (Ailor and Edward Ailor, 2000). Ultrasound can be used as a device in diagnosing the cracked teeth and it can be an important diagnostic aid in future. Although all these diagnostic tests have been reported in literature, none have been tested on the patient in controlled clinical trials. Thus still cracked tooth syndrome remains a difficult condition to diagnose and a source of frustration to both dentist and patient.

Treatment

Conventional treatment approaches reported in the literature include some form of the protective cuspal coverage restorations. The specific protocol is suggested in the treatment of cracked teeth. Remove any of the existing restoration, evaluate the health of the pulp and remaining coronal tooth structure and restore with a full crown if indicated. Any tooth with irreversible pulpitis or pulpal necrosis, RCT has to be performed prior to the crown placement (Nguyen and Palmer, 2009)**.** Cast gold partial or complete coverage or porcelain fused to metal full coverage and all porcelain can be used. Some authors suggest the removal of the restoration, placement of sedative filling orthodontic band stabilisation for a few weeks and once the symptoms resolve, a restorative build up or a full coverage restoration can be placed (Chakravarthy *et al.*, 2012). Some advocate occlusal adjustments in addition to a full coverage restoration. The teeth can also be restored with the composite or amalgam restorations with mechanical retention (Mamoun and Napoletano, 2015)**.** Extraction is the treatment option where the crack is deep into the bone which is complete and involves the furcation leading to the pieces to be mobile (Robertson, 1997).

Conclusion

The periodontal and biomechanical prognosis of the cracked tooth depends on what aspects of the tooth structures are involved or intersected by a partial or a complete fracture. It is in the hands of the dentist to decide the situation of these expanding cracks and to go ahead with an appropriate treatment plan specifically to the patient's condition and needs and provide a hermetic sealing of the cracked teeth which is an important feature for the long term prognosis. So, it is hoped that in near future, correlation of these diagnostic aids with an effective assessment of treatment plan, prevention and management of these cracked teeth will be done successfully and maintain the periodontal and biomechanical stability of the tooth in function.

Limitations

The present review was concentrating on analysing the studies and doing a comprehensive review on the present topic. But ideally, a systematic review would yield better high evidence data rather. So, another drawback would be having

heterogeneity as we had to collect all the article types to do a comprehensive treatment plan for a specific clinical condition.

Future Scope

The future studies have to concentrate more on analysing the cracks in patients both prospectively and retrospectively with well designed trails. Increased sample size estimations, would rather yield the precise data for formulating the appropriate plan of action.

Our team has extensive knowledge and research experience that has translate into high quality publications (Ezhilarasan, 2020; Narendran *et al.*, 2020; Reddy *et al.*, 2020; Singh, Rohit Singh and Ezhilarasan, 2020; Teja and Ramesh, 2020; Bhavikatti *et al.*, 2021; Chakraborty *et al.*, 2021; Karobari *et al.*, 2021; Muthukrishnan, 2021a, 2021b; PradeepKumar *et al.*, 2021; Sawant *et al.*, 2021)(Priyadharsini *et al.*, 2018; Romera *et al.*, 2018; Priyadharsini, 2019; Gudipaneni *et al.*, 2020; Kanniah *et al.*, 2020; Maheswari, Nivedhitha and Ramani, 2020; Raj R, D and S, 2020; Chaturvedula *et al.*, 2021).

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Conflict of Interest: NIL

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Ethical Clearance: Not applicable

Table 1: Characteristics of Included Studies

S.no	Author & Year	Study Design	Study Purpose	Study Outcomes
1	Thomas J Hilton; 2018	Study	How the various traits, external tooth, cracked tooth characteristics corresponds to the type of symptoms that the teeth with visible cracks demonstrate, when pain during biting, pain due to cold stimuli or unpremeditated pain.	With symptomatic cracked teeth, pain to cold was the most commonly noted pain other than pain on biting, or spontaneous pain.
2	C. I. (Kip) Homewood; 2008	clinical study	It reports on CTS in general practices (divided into the two gender categories; male and female), and the various types of treatments which can be given.	Out of the 62 teeth with CTS, 90% (56 teeth) presented with the symptoms of tenderness when biting, cold, heat, etc. The most common treatment which was given was overlaying the cracked tooth cusp with amalgam or resin composite after the cusp reduction of 2mm was followed through.

3	Christopher I.Udoye; 2009	clinical study	It highlights the facts of profuse treatments, and factors which play an important role such as, age (18-30, 31-40, 41-50, 51+), gender (male, female), the specific tooth (first premolar, second premolar, first molar, second molar, third molar).	Patients with unexplained pain in a vital, amalgam-restored tooth, without a previous history of accident may have a cracked or fractured tooth. As a successful endodontic treatment, fibre posts was used to increase the resistance to fracture and it was shown to improve the prognostication in cases of fracture.
4	ZiYang Hu; 2021	Study	diagnosis of CTS through sodium iodide (Nal), dimethyl sulfoxide (DMSO) as contrast agent in CBCT scan compared to a micro-CT.	It was concluded that the 18 teeth were cracked artificially by soaking them cyclically in liquid nitrogen and hot water. There were 63 crack lines in all 18 teeth. Both the micro-CT as the contrast agent was equivalent to CBCT with NaI +DMSO when in comparison to the number of fracture lines and the depth of the cracked lines.
5	Yen-TungChen; 2021	Study	To assess the correlation of multiple factors on the diagnosis of cracked teeth which had already undergone endodontic treatment at an early stage.	After the study population, 3680 patients, received endodontic treatment, their follow up records of at least 1 year were assessed by the certain type of treatment plan which was giving to the individual. Full-coverage should be considered as one of the most important treatment plan for cracked tooth syndrome.
6	Roy George; 2021	clinical studies	Evaluating the treatment outcomes of patients who have received treatments over the age of 18 with at least 1 year of occlusal function.	When compared to different treatment plans, it was evident that there was a moderately high survival rate of endodontically treated CTS teeth.
7	Jacob OZUNA; 2021	retrospective study	To asses the characteristics and the distribution of cracked tooth syndrome among the Southern Nevada population.	An overall 893 patients were taken into account who presented with CTS where 41% of the population had documented symptoms. The results were filtered though various categories, such as factors including age, gender, race, and particular the particular tooth. It was evident that 45-54 age range had the highest number of teeth with cracks, overall 49% of the data comprised of males, Caucasians (58.9%) and African Americans (21.1%) represented a majority of the population with CTS, and first and second molars had the highest effect for fractures (59.8%).
8	Wan-Chuen Liao; 2021	clinical study	To compile on the clinical characteristics, different treatment plans, demographics, and cracked teeth survival at a time frame of 6 months, 1 year and 2 year postop.	It was concluded that most of the CTS cases occurred in patients over 40 years. CTS was seen more often in molars (79.22%), non-terminal tooth in arch (62.34%), nonendodontically-treated teeth (94.81%). The symptoms were all compared as pain to percussion (63.64%), positive mobility (76.62%), biting (73.03%). Absence of the following above, increased/ associated with higher survival rates of cracked teeth.
9	Dariela Isabel Gonzalez-Guajardo; 2021	systematic review	To examine the CTS, as its etiology, prevalence, pulp involvement and treatment aspect.	As stated there were many causes which lead to CTS and cracks, one main being cracks caused by malocclusion, restorations, etc. It will always be a challenge for dentists to diagnose CTS in patients and for the treatment plan.

10	Domenico Ricucci; 2015	Clinical Study	Purpose was to assess the	The cracks which were present on the tooth surfaces were colonized with bacterial biofilms. There were various factors in which the pulp tissue responds according to the location, direction, and to the extent of the crack.

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