Republic of Iraq
Ministry of Higher Education
Ministry of Higher Education
and Scientific Research

(Cracked Tooth Syndrome)

A Project Submitted to

The College of Dentistry, University of Baghdad, Department of Restorative & Esthetic Dentistry
in Partial Fulfillment for the Bachelor of Dental Surgery

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March **2023**

Certification of the Supervisor

I certify that this project entitled "**Cracked tooth syndrome**"

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B.D.S.,M.Sc.

Date

Dedication

I would like to dedicate this project to my family, especially my parents Dad & Mom , who have supported me during these five years as I pursued my dream to become a dentist.

MOM , your patience and self-less nature were always comforting during my times of stress, and every day I strive to be more like you. I hope one day I can repay you for all the opportunities you've allowed me

to experience.

thanks for being the role model that every daughter wants and deserves. Your hard work has inspired me to be the best person I could be.

My dear sisters (Aya, Haneen , Maryam) who have encouraged me to finish this project, and especially dear (HANEEN) who was always willing to help me with many things even things that I felt were a bit easy, and my nephews Mohaymen & Mohamed who helped me with solving many problems I faced during finishing this year ,my best friend and love (Ahmed) thank you for being beside me to pass this hard year.

and lastly, to my supervisor Dr, Marwah Ismael for her advice and being available all time .

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Abbreviations	Meaning
CTS	**Cracked tooth syndrome**
HNRT	**Head and Neck Radiotherapy**
DEJ	**Dentin-enamel junction**
VRF	**Vertical root fractures**
FOTI	**Fiber-optic transillumination**
CBCT	**cone-beam computed tomography**
SS-OCT	**Swept-Source Optical Coherence Tomography**
ICG-NIRF	**Indocyanine green-assisted near-infrared fluorescence**
DCS	**Direct Composite Splint**
MOD	**Mesial-occlusal-distal**
CAD/CA	**Computer-aided design/computer-aided manufacturing**

Introduction

Cracked tooth syndrome (CTS)" was firstly defined in 1964 as a critical posterior tooth incomplete fracture that includes the dentin extending to the pulp. This definition was later modified by Ellis (Ellis S, 2001) as "a fracture plane of unknown depth and direction passing through the tooth structure that, if not already involved, may progress to communicate with the pulp and/or periodontal ligament The term 'incomplete fracture of posterior teeth' is often used interchangeably with that of cracked tooth syndrome,while the terms 'green-stick fracture' or split tooth syndrome' have also been used synonymously.

Patients suffering from cracked tooth syndrome (CTS) classically present with a history of sharp pain when biting, or when consuming cold food/beverages.It has been suggested that the symptom of pain on biting increases as the applied occlusal force is raised. A detailed assessment of the symptoms may reveal a history of discomfort that may have been present for several months previously
Other symptoms may include pain on release of pressure when fibrous foods are eaten, 'rebound pain' (Stanley H R 1968)..
Pain may also be elicited by the consumption of sugar containing substances and also by the act of tooth grinding or during the undertaking of excursive mandibular movement (Griffin J.2006) .
While some patients are able to specify the precise tooth from which the symptoms may be arising, the latter is not a consistent feature. The absence of heat induced sensitivity may also be a feature.
Where the fracture line may eventually propagate into the pulp chamber ('complete fracture'), symptoms of irreversible pulpitis or apical periodontitis may ensue, while

fractures which progress further towards the root may be associated with areas of localised periodontal breakdown or at worst culminate in vertical tooth fracture The physiological basis of pain on chewing has been hypothesised by Brannstrom et al (1972).
to be accounted for by the sudden movement of fluid present in dentinal tubules which occurs when the fractured portions of the tooth move independently of one another. It is thought that the latter results in the activation of myelinated A-type fibres within the dental pulp, thereby accounting for the acute nature of the pain. It has also been suggested that the perception of hypersensitivity to cold may occur as a result of the seepage of noxious irritants through the crack. (Sapra A,2020) in the subsequent release of neuropeptides which cause a concomitant lowering in the pain threshold of unmyleinated C-type fibres within the dental pulp (Davis R, Overton J. 2000).
An alternative hypothesis has been proposed, whereby it has been postu- lated that the symptoms are caused by the alternating stretching and compressing of the odontoblast processes located within the crack (Poyser N J, Porter R W J, Briggs P F A, 2005).

The Aim Of study :

This review aimed to provide details relating to the background of cracked tooth syndrome including the epidemiology, patho-physiology, aetiology and diagnosis of the syndrome, together with a consideration of factors which may influence the prognostic outcome of teeth affected
by incomplete, symptomatic fractures.The review also discuss the management of cracked teeth, and also provide a detailed account of the application of both direct and indirect restorations and restorative techniques used respectively in the management of teeth affected by this complex syndrome.

CHAPTER ONE

REVIEW OF LITERATURE

1. Epidemiology of Cracked Tooth Syndrome

CTS is a condition which generally affects adult patients, typically in the age range of 30 to 60 years. While the results of an early epidemiological survey by (Cameron C , 1964) seemed to suggest that the condition was much more prevalent among female , it has since been shown by more recent studies that both sexes seem to be equally affected (Roh BD, 2006). Tooth fractures are a potential major cause of tooth loss in the industrialized world. The availability of incidence data on the condition of cracked tooth syndrome is largely lacking (Geursten et al, 1999) .

An incidence rate of 9.7% among 8,175 patients referred to a private endodontic practice over a period of six years. It would be logical to assume that as more patients are retaining their teeth into older age incomplete fractures of posterior teeth are more likely to be observed to be occurring at even higher frequency in the future in teeth which have carious lesions or contain dental restorations (Krell et al, 2007). 35% of

the cases presenting with CTS were sound and caries free. Mandibular molar teeth appear to be the most commonly involved teeth by this condition, followed by maxillary premolar and maxillary molar teeth – while mandibular premolar teeth seem to be least affected. since lower first molar teeth are usually the first permanent teeth to erupt into the dental arch, they are most likely to be affected by the condition of dental caries, followed by the need of subsequent restorative intervention.These teeth are therefore more likely to be rendered with large, deep restorations, making them more vulnerable to the process of subsequent fracture (Hiatt WH, 1973).

2. Etiology Cracked Tooth Syndrome

A comprehensive understanding of the etiology of CTS is an important prerequisite for its prevention, diagnosis, and management. The predisposing factors for CTS are factors that increase the force acting on the teeth or those that weaken the resistance of the teeth to the chewing force (Talim S, 1974) (Table 1). The etiology of CTS is diverse and is related to noniatrogenic and iatrogenic factors that dictate the intervention required. While the former includes developmental and functional status as well as pathological processes, the latter involves the odontiatrogenic factors.

Table: 1 Etiological factors of cracked tooth syndrome.

Etiological factors		
Noniatrogenic factors	Aging	Increasing levels of dental fatigue
		Weakened dental hard tissues
		Lost dentin elasticity
		Increasing number of restored teeth
	Oral habit	Thermal cycling eating habits
		Long-term unilateral chewing
		Sleep bruxism
		Precocious occlusion
	Dental structure	The structural defect in the tooth
		Cusp inclination
Odontiatrogenic factors	HNRT	Affects the tooth structure
		Synergistic effects of clustering of oral symptoms
	Root canal therapy	The contact between the instrument and canalwall
		Use of higher concentration of sodiumhypochlorite
		Excessive widening of the root canal
	Restorative Procedure	Stress concentration
		Excessive removal of tooth tissue
	Material performance	Metallic materials
		Difference in the thermal expansion coefficient
		Material deformation
	Stress	function

2.1. Noniatrogenic Factors

1. **Aging** : is one of the most important factors in the etiology of CTS is aging. Some studies have shown that CTS mainly occurs in individuals >40 years of age. As ageincreases, the degree of fatigue of the teeth increases, hard tissues become fragile and the elasticity of the dentin is also lost. Therefore, when the force imposed on the teeth exceeds the limit of dentin elasticity, the teeth crack (Zhang S, 2021).

2. **Oral Habit** : Bad oral habits**,** such as thermal cycling eating habits long-term unilateral chewing, sleep bruxism, and precocious occlusion, promote CTS. The normal bite force in humans ranges between 3 and 30 kg; hence, when teeth are subjected to forces beyond this range, such as chewing hard objects, the probabilityof the tooth structure getting damaged increases (Qiao F, 2017).'

3. **Dental Structure** : The structural defect in the tooth: deep occlusal and large vertical radicular grooves or bifurcations and even extensive pulp spaces are all tooth structures that can cause CTS. Local areas of the teeth appear structurally weak due to incomplete fusion of the calcified areas during the developmental stages. These local areas may also lead to CTS (Zhang S, 2021).

4. **Cusp inclination** : the tooth anatomy can partly explain the risk indicators for CTS the tip tilt being one of the key parameters. Related studies have shown that the horizontal component of the bite exerts force at the bottom of the fovea and the tooth neck.

   The tensile stress of the area, thus, increases with the increase in the cusp inclinations. Thus, the high and steep cusp inclinations of the teeth can promote the formation of tooth cracks (Xie N, 2017).

2.2. Odontiatrogenic Factors

1. **Head and Neck Radiotherapy (HNRT)** : HNRT impacts the tooth structure. On one hand, it directly affects the tooth structure, changing the protein composition that forms the cleavage plane of the tooth as well as affecting the production of porous enamel at the dental cervix (Madrid C et al. 2017). Conversely, HNRT leadsto synergistic effects of clustering of oral symptoms. For example, a decrease in saliva flow will cause the tooth enamel to become brittle in a dry environment; that is, the fracture toughness will decrease, the organic matter in the dentin-enamel junction (DEJ) will get reduced due to dehydration, and the anchorage between the dentin and enamel gets reduced. The altered characteristics of the DEJ would also change the distribution of mechanical stress (Thiagarajan G et al. 2017).

Fig: 1 Clinical image of enamel crack lines (arrows) in patients affected by HNRT.

2. **Root Canal Therapy**: The incidence of cracks and dentin defects is higher after root canal preparations (De-Deus G et al. 2015) during this process; the dentinis stressed due to the contact between the instrument and the canal wall, which may lead to the occurrence of CTS. When root canal therapy is performed in a dry environment, even for a short period of time, it may have a harmful effect on the dentin, and the probability of the occurrence of CTS increases. The placement of the intracanal post, use of higher concentration of sodium hypochlorite, and obturation techniques may also contribute to the occurrence of vertical root fractures (VRFs) (Fuss Z, 2001).

3. **Restorative Procedures**: Restorative procedures can reduce the structural strength of teeth as well as increase the risk of cracked teeth by almost 29 times. Intracoronal restorations can further lead to the occurrence of cracked teeth by

promoting a sharp inner line angle and the old caries design, which weaken the structural strength of teeth and cause stress concentration (Reeh E, 1989).

Many restoration procedures, such as the placement of “friction locks” or “self-threaded dentin pins,” may cause stress on the residual tooth structure and eventually result in cracks. Large amalgam restorations of the mandibular molars are often accompanied by tooth cracks (Chen Y, 2021).

4. **Material Performance:** Compared to nonmetallic materials, metallic materials are more likely to cause CTS. There is a difference in the thermal expansion coefficient between the tooth and the restoration material, and this may also cause CTS (Bearn D, 1994).

fig: 2 shown the metallic material cause CTS

5. **The restoration material deforms** under the action of an external force or the influence of the oral environment, thereby causing abnormal bite force distribution which easily leads to CTS. Therefore, the properties of the material being used are of great significance in preventing the occurrence of cracked teeth. Stress Function Guersten found that the excessive force exerted on healthy teeth or the weakened

physiological forces of teeth can cause incomplete fracture of the enamel or dentin. Moreover, the stress exerted on the teeth during the extraction process can have an impact on the formation of cracks, and tooth slices are also a cause of dentin crack formation (Reeh E, 1989).

3. Classifications of Cracked Tooth Syndrome

The American Association of Endodontists, in a document titled “Cracking the Cracked Tooth Code” identified five types of cracks in teeth.

1. Craze lines

Are found in the majority of adult teeth and only involve enamel. In posterior teeth, craze lines are usually evident crossing marginal ridges and/or extendingalong buccal and lingual surfaces. Long vertical craze lines are often found in anterior teeth. Fractured cusps usually result frominsufficient cusp support when the marginal ridge is weakened by an intra-coronal restoration. The crack often extends in mesio-distal and buccolingual directions commonly involving one or both marginal ridges as well as a buccal or lingual groove and terminates in the cervical region either parallel to the gingival margin or slightly subgingival.

2. A cracked tooth

is indicative of a crack extending from the occlusal surface of the tooth apically without separation of the two segments. The crack is generally located centrally in a mesio-distal direction and may involve one or both marginal ridges.

3. Split tooth

is indicative of a crack extending through both marginal ridges usually in a mesio-distal direction splitting the tooth completely into two separate segments The crack is generally located centrally in the tooth and this entity is the result of crack propagation of a cracked tooth

4. Vertical root fracture :

Commence in the root generally in a bucco-lingual direction. The crack is generally complete though may be incomplete and involve only one surface. The crack may involve either the entire root or only a portion of the root (Kahler W, 2008).

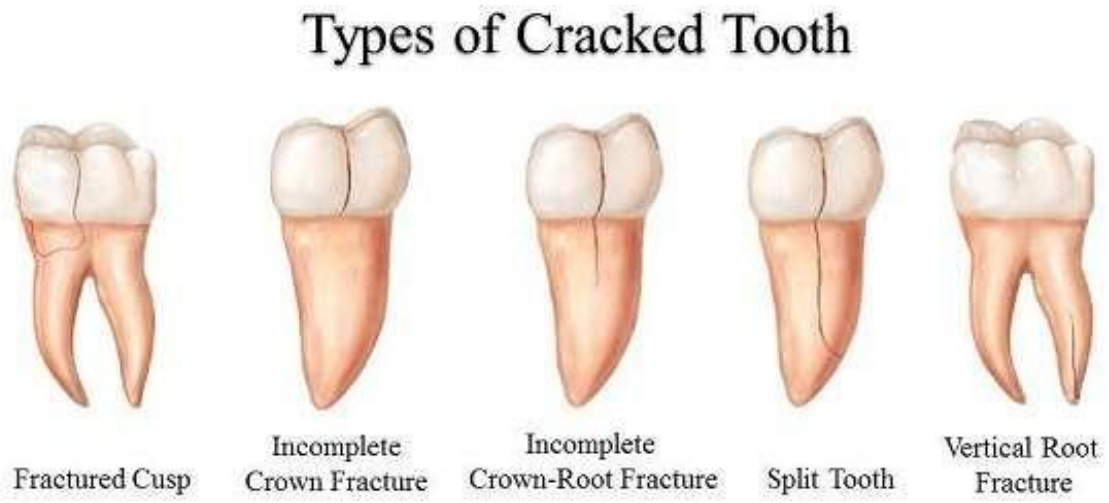

Fig: 3 Types of Cracked Tooth Syndrome

4. Diagnosis of Cracked Tooth Syndrome:

During earlier stages of CTS, when the symptoms and signs are frequently blurred, it is generally difficult for dentists to diagnose cracked teeth. Dentists must arrive at a clear diagnosis as much as possible. Currently, there are multiple

techniques that include clinical examination, auxiliary iconography examination, and a few new types of technologies toward the diagnosis of CTS.

1. Clinical Examination

When the patient has clinical symptoms, the dentist can use a combination of the percussion, point load, and cold stimulation test to find the sick tooth or use a special plastic bite block (for example, Tooth Slooth, Professional Results Inc.; Figure 4) for the bite test However, some researchers believe that applying pressure to teeth with suspicious symptoms may result in further propagation of cracks and, due to the associated risk, do not recommended point load and bite tests (Ehrmann E, 1990).

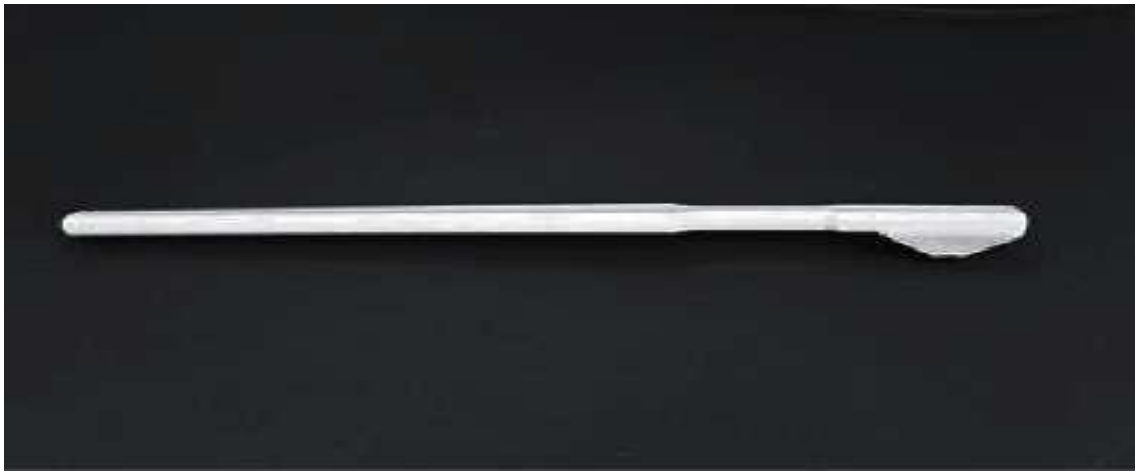

Fig: 4 Tooth Slooth tool for the bite test.

Methylene blue dye staining assists the visual detection of coronal cracks. This is due to the aggregation tendency of the dye. However, the use of the dye may hide cracks or lead to subtle color changes in the deeper layers of the enamel. Furthermore, the original restoration materials need to be removed before applying the dye which takes 2–5 days (Mathew S, 2012).

Fiber-optic transillumination (FOTI) is a cross illumination of an optical fiber probe placed at different points on the surface of the crown or root. Because the refractive index of the crack differs from that of the peripheral tissue, there is a back reflection of the light reaching the crack resulting in the fracture line being distinctly displayed. FOTI not only assists clinicians in enhancing the rate of clinical diagnosis but also serves as an appropriate machinery for adjuvant therapy, such as lighting the root canal orifice during root canal therapy (Strassler H, 2014). An operating microscope is commonly used equipment for the assisted diagnosis of CTS. Dentists usually diagnose cracks by observing the peripheral crack lines of the fractured surface. However, the observed crack lines do not represent their size and shape (Mamoun J, 2015).

Fig: 5 transillumination of cracked cusp showing mesial midline and lingual fractures. the transmission of the light beam has been ‘stopped’ mesiolingually by the presence of the fracture.

3.1. Radiography

While the traditional periapical X-rays (PR) can only provide a definitive diagnosis when the deviation of the root fracture is obvious cone-beam computed tomography (CBCT) can detect subtle loss of the periapical bone during VRFs. However, the resolution of CBCT being only approximately 80 μm, it is not suitable for the clinical diagnosis of cracked teeth and detecting early VRFs (Brady E, 2014).

In an in *vitro* study, Yuan et al (2020) demonstrated that compared to the conventional approach, scanning using CBCT can be enhanced using meglumine diatrizoate as a contrast agent as it can objectively and effectively show hidden cracks. Therefore, some researchers consider this an auxiliary method in the imaging of the tooth periapex.

3.3. New Technology

3.3.1. Swept-Source Optical Coherence Tomography (SS-OCT): SS-OCT is a promising technique for the detection and analysis of incipient enamel caries and early CTS. SS-OCT is a variant of the fast Fourier transform algorithm, which emits different wavelengths of light using a laser source with variable wavelengths (at the near-infrared wavelength of 1300 nm, the enamel and cracks have high transparency and high contrast, respectively). A study by Lee et al, (2016) showed that the diagnostic accuracy of SS-OCT is better than that of micro-CT, FOTI, and visual inspection.

Although SS-OCT has the advantage of enhancing the resolution, the specificity of SS-OCT in detecting full-thickness cracks is weak because the enhanced image of deep enamel cracks often overlaps with the enamel plexus. SS-OCT has a confined

penetration depth in the coronal part within 3 mm that can be irradiated by laser. Hence, its main application is restricted, and it is suitable only for early diagnosis (Imai K, 2012).

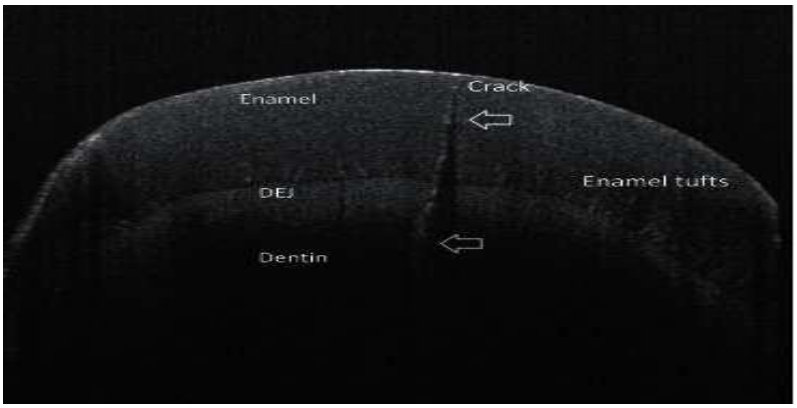

Fig: 6 SS-OCT image of the dentin crack. The crack extended beyond the DEJ and displayed as a bright white line.

Near-Infrared Imaging : Recently (Li et al, 2020) confirmed the practicability of using indocyanine green-assisted near-infrared fluorescence (ICG-NIRF) imaging to detect enamel-dentin and enamel cracks in vitro. ICG-NIRF imagingcan detect more cracks than using only the second region of near-infrared light, which detects the cracks and their depths not detected by CT and X-ray. But, it cannot distinguish crack types and obtain accurate crack depth information.

3.4. Other Techniques

3.4.1. Ultrasonic System : Detection of CTS using the ultrasonic system has a promising future because it has the ability to penetrate hard tissue (in theory, penetrating some radiopaque restorations) and lacks the hazards associated with ionizing radiation. (Culjat et al,2005) successfully applied an integral ultrasonic

system to detect known cracks in simulated teeth.

3.4.2. Infrared Thermography: The application of infrared thermography technologycan assist detecting small cracks (4–35.5 μm), when other diagnostic techniquesfail. Because the smaller cracks will be vibrated by ultrasonic power (the amplitudeand detection angle should be 0.89 W and within 45°, respectively), local friction that occurs under the effect of vibration consequently generates heat (Bernardes R, 2009).

3.4.3. Near-Infrared 810 nm Diode Laser: A near-infrared 810 nm diode laser can beused as a new technology to assist in the management of symptomatic CTS. When the laser energy is irradiated on teeth with suspicious symptoms, most patients experience sharp pain, and only few of them get dull pain. This may be because when the laser beam enters the depth of the crack, the energy that is applied to the pulp causes an analogous irritation (Sapra A, 2020).

In clinical diagnosis, the commonly used diagnostic methods and new technologies need to pay attention to problems arising in the earlier process. Table 2 provides a summary of the available technologies.

Table: 2 four common techniques in detecting cracked teeth.

Features	Transillumination	Intraoral X-ray	CBCT	SS-OCT
Distinguish the type of crack	✕	✕	✕	○
Show root fractures	✕	○	○	✕
Determine the crack depth	✕	✕	○	○
Produce radiation	✕	○	○	✕

4. Management Cracked Tooth Syndrome

4.1. Immediate Management

4.1.1. Occlusal Adjustment : From the perspective of many authors, once dentists diagnose CTS (especially when cracks are on mandibular lingual cusps), occlusion is adjusted to minimize the loading on the CTS tooth, thereby alleviating the symptoms and delaying the cracking process. After occlusal adjustment, the restoration should be placed on the affected cusp to avoid any further fractures in the

tooth (Agar J, 1988).

4.1.2. Copper Rings and Stainless Steel Bands: Copper rings and stainless steel bands can be used for the diagnosis and immediate management of early CTS cases, whose cracks are observed extending beneath the gingival margin or in which one or more surfaces of the tooth are missing (Lee J, 2021).

As they act like a splint, the incorrect diagnosis of CTS is avoided. If the pain does not subside following the use of them, it indicates that the diagnosis may be incorrect or further endodontic treatment may be required. In cases where symptoms resolve with the use of a tight stainless steel band, a full crown may be used to replace the previously placed restoration. Following splint fixation, occlusal tests must be repeated to confirm the diagnosis. Stainless steel bands are preferable to copper ones because their contoured shape results in low gingival irritation. The drawbacks of stainless steel bands include the requirements of prefabricated belts and their large inventory. However, this can be solved by quickly processing the bands using forming pliers and spot welding (Ehrmann E, 1968).

4.1.3. Direct Composite Splint (DCS): The DCS was developed based on the concept of “Dahl” (Dahl B, 1975). Except in cases with limited eruptive potential, this occlusal contact was reconstituted after a period of time by a combinatorial procedure of alveolar segment intrusion and extrusion.

The DCS does not require any prior tooth preparation and has the advantage of easy removal, and though it is marginally invasive, it can be used for short-term management. It can be applied quickly and easily because its application does not

require details of anatomical contours, and materials and equipment for its fabrication are readily available (Figure 6). However, adherence to careful inclusion criteria, selection of a suitable composite resin, the application method, and the use of proper bonding systems need to be considered (Banerji S, 2014).

Fig: **7** A DCS restoration utilized as a diagnostic aid: (a) upper view of the restoration; (b) lower view of the restoration.

4.1.4. Temporary Crown: A crack is fixed after the placement of the full-coverage crown. The occlusal forces are diverted and dispersed over the entire prepared tooth surface, thus minimizing the pressure on the cracked area. The crown is held in place by friction, and surface cementation prevents the movement of cracks during mastication. However, the fabrication of a temporary crown for the interim management of an incomplete fracture of a posterior tooth is time consuming and intrusive, and it is extremely cumbersome to remove the posterior tooth. Additionally, as tooth preparation and temporary crown fabrication take some time,

it may delay the fixation of the fracture, resulting in its continued expansion. Due to continued bleeding, the risk of endodontic complications increases (Opdam N, 2003).

4.2. Direct Restoration

Clinically, patients rarely visit a doctor with a dental crack as a complaint because patients with slight dental cracks generally have no discomfort, despite the appearance of an asymptomatic fracture line on the tooth enamel. Moreover, patients' oral health awareness being weak, the chances of early detection and direct repair are minimal. Generally, direct repairs are usually performed by dentists when patients visit them for undergoing treatment for dental caries and other oral diseases (Okiyama S, 2003).

Fig: 8 Direct composite restoration in an intact cracked 46 with reversible pulpitis (a) preoperative long-cone periapical radiograph (b) crack line visible (arrows) after investigation with bur (c) composite restoration completed (d) periapical radiograph at 6 months follow-up; the tooth has remained vital and asymptomatic.

Bonding restorations can effectively restore the strength of teeth weakened by cavity preparation, and Staninec and Holt demonstrated that amalgam can be cemented to the etched enamel and dentin with an adhesive liner. However, when some studies evaluated the efficacy of direct composite intracoronal resin restorations (including amalgam restorations) for the management of painful and cracked posterior teeth over a 7-year follow-up period, they found that bonded silver amalgam restorations were less favorable than resin-covered restorations that received direct bonding. This may be because, in the coronal approach, the adhesive interface between the tooth and the restoration gets progressively damaged under

periodic functional loads (Banerji S, 2017).

Compared with unrepaired teeth, amalgam restorations show a significant increase in fracture resistance. Composite resin restorations are more resistant to fracture than amalgam restorations, and the strength of premolars restored with composite resin restorations has been reported to be approximately twice that of the unrepaired premolars (Joynt R, 1987 and Reel D, 1989).

Age is also a factor in the selection and use of repair materials (Arola D, 2004). Composite and amalgam restorations also differ in the incidence of cusp fractures among patients depending on their age. Although there was no significant difference in the incidence of apical fractures between amalgam and composite restorations in younger patients (18–54 years), in older patients (55–96 years), the incidence with composite restorations was higher than that with amalgam restorations. With increasing age, the basic metabolic rate of the tooth tissue (especially dentin) decreases and is accompanied by continuous tissue dehydration and loss. Due to this, the brittleness increases, and thus, it is prone to fracture. Gradually, oral cracks form and expand to the surroundings. However, regardless of the material used, temporary restorations do not maintain the same resistance to chewing pressure as against the restorations performed with stronger dental material (Lubisich E,2010).

4.3. Indirect Restoration

4.3.1. Inlay Restorations: Practitioners acknowledge that inlay restorations undermine the residual tooth structure when preparing the tooth, resulting in tooth fractures occurring on unprotected surfaces. Furthermore, traditional inlay restorations use a “wedge retention” concept, which can create periodic occlusal pressure on the tooth before bonding and during use. Therefore, conventional inlays

are ineffective in the management of CTS cases (Shillingburg H, 1997).

The effects of inlays with adhesive materials are quite different. An in vitro experiment demonstrated that indirect resin-bonded composite inlays, as well as bonded mesial-occlusal-distal (MOD) ceramic inlays, have the ability to improve the fracture strength of prepared teeth to a level similar to that of healthy teeth (Taha D,2017).

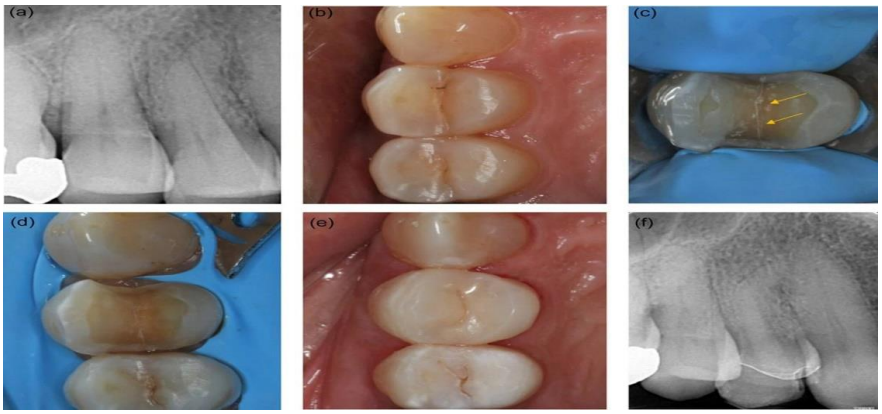

Fig: 9 Indirect composite onlay restoration in an intact cracked 14 with reversible pulpitis (a and b) preoperative long-cone periapical radiograph and occlusal view (c) crack line revealed (arrows) after investigation with bur (d) onlay preparation (e) postoperative occlusal view with bonded indirect composite onlay (f) periapical radiograph at 6 months follow-up; the tooth has remained vital and asymptomatic.

Compared to ceramic inlays, resin composite inlays experience greater wear in the early stages at the bonding site, but there is no difference between the two in terms of long-term usage. This may be due to the different locations of stress distribution on the affected teeth covered with the two different material restorations. The stresses on ceramic inlays are mainly distributed on the ceramic structure. However, resin composite inlays release shrinkage stresses at the interface of the

tooth structure thereby promoting the creation and extension of cracks in the enamel. Therefore, ceramic inlays can be more efficient in restoring CTS than resin composite inlays (Yu P et al, 2019).

The advancement of computer-aided design/computer-aided manufacturing (CAD/CAM) technology is worth mentioning. A study showed that CAD/CAM-fabricated resin inlays improved accelerated fatigue resistance and reduced the propensity for cracking in large MOD restorations compared to direct resin restorations (Batalha-Silva S, 2012).

4.3.2. Only Restorations : referred to gold onlays as the most conservative restoration approach. In this study, gold onlays were cemented with resin-modified glass ionomer luting cement (Figure 9). Annual examinations over the next six years showed a solid, defect-free onlay with no symptomatic recurrence. A clinical review also concluded that the survival rate of type III gold alloy (Firmilay, Jelenko, San Diego, CA, USA) restorations bonded with Panavia Ex cement (Kuraray Co., Japan) at 60 months was 89%, which is satisfactory. Microscopic mechanical cementation methods, such as using composite materials and resin-modified glass ionomers, are emerging, permitting alloy restorative preparation methods to evolve toward simpler.

Fig: 10 Restoration of a fractured right mandibular second molar using a gold onlay. (a) A cracked tooth prepared for restoration via onlay bonded with resin; (b) 22

months after restoration via bonded type III gold alloy inlays with Panavia Ex cement**.**

4.3.3. Full coverage Crown : can be the first choice of treatment, both with and without the symptoms of CTS (Christensen G, 2007). Gutherie and DiFiore claimed that full- coverage crowns best meet the target of treating CTS. Especially after root canal therapy, the survival rate of cracked teeth restored with a full crown is significantly higher than that restored with others, and the incidence of complications is reduced (Nguyen Thi W,2021). With the usage of acrylic resin crowns for the treatment of CTS, the failure rate was 11%.

5.Prevention :

Prevention plays an important role in halting the occurrence and development of CTS caused by medical, environmental, or genetic factors.

Individuals should maintain good oral hygiene by adopting good cleaning practices, developing healthy chewing habits, and following a proper diet (such as avoiding clenching, extensive grinding, abrasion, bruxism, eating betel nut, and hard food). Additionally, increasing the frequency of oral examinations can also be effective in preventing CTS, which is especially important for the elderly.

When patients are treated for caries or other periapical diseases, medical workers should avoid secondary damage or secondary crack generation to the affected tooth and surrounding teeth as much as possible. Dental appliances such as hard acrylic and soft splints can prevent CTS by dividing the force throughout the masticatory system and decreasing the frequency, but not the intensity of bruxism.

Appliances should be worn continuously because once the appliance is

removed, the muscle activity may return to previous levels (Green J, 2016). When symptoms of CTS occur, occlusal adjustments or bonded restorations can be performed to prevent further extension of the cracked tooth (Agar J, 1988).

CHAPTER TWO

Conclusion

CTS is a common, multiple, clinically significant tooth fracture caused by a variety of factors.

From the common clinical diagnosis methods to the newer techniques represented by SS-OCT, the diagnostic accuracy of CTS has been advancing continuously. In clinical practice, the choice of management options by dentists is not uniform, and the majority of doctors recommend full crown treatment. To summarize, with the development of clinical techniques, it is believed that the occurrence of CTS will become more predictable, diagnosable, and amenable to management CTS .

References

(A)

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