Recent Advances in the Diagnosis of Enamel Cracks: An Update

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Abstract

Pain around the teeth or jaws following a dental procedure is called tooth pain.In clinical practice, cracked tooth syndrome is a major diagnostic challenge. Due to a lack of awareness of this ailment and its unique clinical symptoms, accurate diagnosis and appropriate therapy are difficult.An extensive review of the literature on the causes, classification, symptoms, diagnosis, and most recent developments of cracked tooth syndrome is given in this article. This article highlights recent developments in the diagnosis of enamel cracks. The lack of awareness of this condition and its peculiar clinical features makes accurate diagnosis and treatment tough. Early recognition has been associated with improved prognosis and successful restorative intervention.

Keywords: Craze line, Cracked Tooth Syndrome, Prevalence of cracked tooth, Risk factors of cracked tooth, Tooth fractured

Introduction

Dental tissues respond biologically to stresses and strains imposed during mastication. The strains on these teeth may cause microcracks in the dentine and enamel. These microcracks might spread and produce symptoms in other important teeth, potentially resulting in tooth fracture. In 1964, Cameron coined the term “cracked tooth syndrome” (CTS). An incomplete dentine fracture involving the dentine and occasionally extending into the pulp of a critical posterior tooth is called a cracked tooth.[1]

One or two marginal ridges are implicated in tooth cracks that extend from the crown to the apex and gradually propagate into the dentin (Figure:1).[2]Depending on the crack's extension depth and subsequent bacterial infections, cracked teeth can cause several clinical symptoms.Unexplained pain when exposed to a cold stimulus and acute pain when chewing or releasing the occasion are the most typical symptoms.[3]A periodontal pocket that is narrow and deep can indicate that the crack is subgingival.

Given that the symptoms associated with CTS can occasionally be erratic and strange, diagnosing the condition can be challenging and has been known to confound even the most skilled dentists.[4]If the cracked tooth is not adequately treated, the cracks will eventually expand and result in pulpitis or a total fracture of the tooth.Finding microcracks in the early stages of the disease was the main goal of the cracked tooth diagnosis. Visual inspection, periodontal probing, bite diagnosis, pulp vitality test,

staining, transillumination, computed tomography (CT), and so forth were the most common clinical diagnosis methods. Surface crack detection methods such as optical coherence tomography (OCT) have recently attracted attention.When it comes to identifying longitudinal tooth cracks, micro-CT and cone beam computed tomography (CBCT) seem to be more useful than conventional clinical dental imaging methods.[5]The purpose of this article is to give a broad overview of CTS diagnosis.

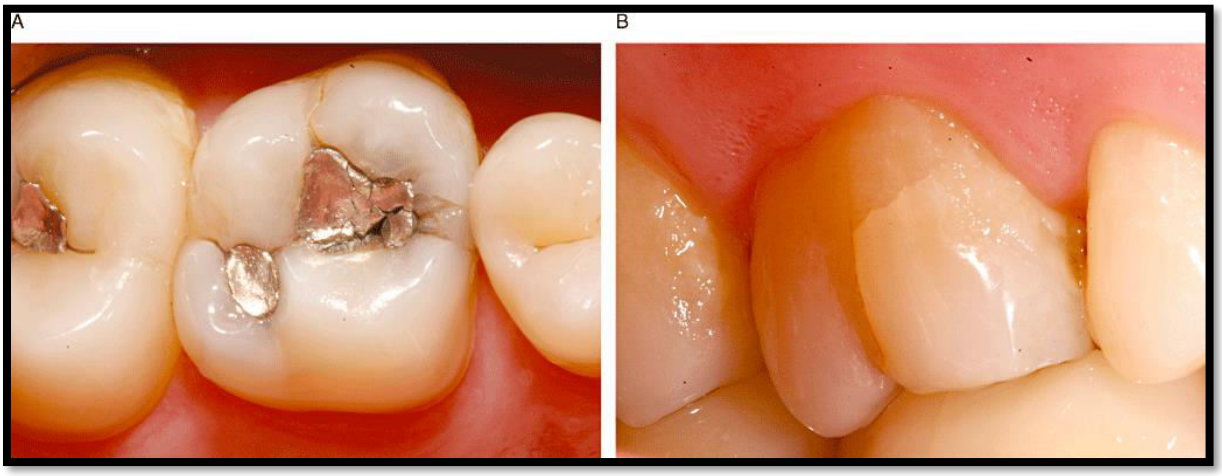

Figure 1: A: In his occlusion view of tooth fracture, vertical fracture extend from a faulty amalgam restoration over the mesial marginal ridge and down the mid-facial surface.
B: On the facial aspect of the same tooth, an incomplete tooth fracture extending vertically from the occlusal surface approximately 2/3rd the distance to the cementoenamel junction before proceeding in a mesial direction could be observed.

Epidemiology

A 34–74% incidence rate has been observed for cracked tooth syndrome, even though the exact cause is unknown[6]It is most common in people between the age of 30-50, with a female predisposition.[1]The mandibular molar is the most usually affected tooth, followed by the maxillary premolar, maxillary molars, and mandibular premolar.Because mandibular first molars are the first permanent teeth to erupt into the dental arch, they are more susceptible to dental caries and subsequent restorative treatment. They are therefore more likely to fracture. Another possible contributing factor is the "wedging effect" that the prominent mesio-palatal cusp of the maxillary first molar teeth has on the lower first molar teeth.

Clinical Features

Clinical signs and symptoms of cracked tooth syndrome vary depending on the location and extent of the incomplete fracture.[7]It's feasible to elicit a history of months of discomfort and acute pain while biting or consuming cold food/beverages.“Rebound

pain" or pain that occurs when pressure is released after eating fibrous foods, is a frequent thing.The act of tooth grinding or during excursive mandibular movements can cause pain, as can the consumption of sugar-containing substances.Patients may or may not be able to find the problem tooth (there are no proprioceptive fibers in the pulp chamber). The absence of heat-induced sensitivity may also be a feature. Microleakage of bacterial byproducts and toxins can cause chronic pulpitis without causing clinical symptoms. Pulpal and periodontal symptoms may develop from cracks with pulpal involvement.[8]The physiological basis of chewing pain was proposed by Brannstrom and Astrom.The sudden movement of fluid in thedentinal tubules occurs when the fractured portions of the tooth move independently. Acute pain is caused by the activation of myelinated-A-type fibers within the dental pulp. The seepage of toxic irritants through the crack may cause hypersensitivity to cold. Unmyelinated C type Fibres in the tooth pulp have a lower pain threshold as a result of the release of neuropeptides brought on by the toxic irritant leakage. According to another author, the symptoms are caused by the odontoblast processes within the crack alternately stretching and compressing.[9]

Difference between a Cracked Tooth and a Fractured Cusp or a Split Tooth

To differentiate a cracked tooth from a cusp or slit tooth, use wedging to check for movement of the segments. A cracked tooth is demonstrated by no movement with wedging pressures. Under light pressure, a fractured cusp may break off, leaving patients with no further mobility. A split tooth will display mobility under wedging stresses, and the mobile segment will extend deep beyond the cementoenamel junction. Postoperative sensitivity associated with microleakage from freshly installed composite resin restoration, fractured restorations, ad areas of hyperocclusion from freshly installedcomposite resin restorations, fractured restorations, and areas of hyperocclusion from dental restoration, bruxism pain, orofacial pain, or atypical facial pain can all be mistaken as a cracked tooth.[10]

Diagnosis

Dentists have had difficulty diagnosing CTS, and it is a cause of discomfort for both the dentist and the patient. It may be difficult to distinguish the discomfort or pain from other conditions such as sinusitis, temporomandibular joint disorders, migraine, ear pain, or atypical orofacial pain. As a consequence, diagnosis might take a long time and be clinically challenging. Because restorative therapy can stop fracture propagation, microleakage, pulpal or periodontal tissue involvement, and catastrophic cusp collapse, early identification is essential.[3]

The ease at which a fracture can be diagnosed varies depending on its location and extent. Mandibular first and second molars as well as maxillary premolars are the teeth that are most frequently affected by dental disease. An extensive intracoronal repair is

usually present on the tooth. Pain can arise after dental procedures, such as the cementation of an inlay, and is often misdiagnosed as interferences or high spots on the new restoration. Presence of underlying cracks could be indicated by the regular debonding of cemented intracoronal restorations such as inlays.

Dental History

Certain distinct clues can be obtained when eliciting the patient's history.There may be a history of extensive dental treatment, such as recurrent occlusal adjustments or restorative replacement, which has failed to alleviate the symptoms.The patient will describe how biting on a particular tooth results in pain, which is more common with foods that have small, discrete, harder particles, such as bread with hard seeds or muesli.[11]Besides the pain during biting, the patient will be sensitive to temperature changes, particularly cold. Patients who have had a previous episode of CTS are often able to self-diagnose their condition. Sweets might cause sensitivity in some people. It's also important to note that in some cases, the patient may be asymptomatic for an extended period. Without a definite diagnosis, many dentists would have evaluated them.Patients who already have a damaged tooth are more likely to develop more cracked teeth. Crushing or grinding your teeth, as well as eating ice, pens, hard sweets, or other similar objects, can all lead to fractured teeth.

Cracked tooth syndrome includes three phases:

- **Craze Lines:** Tiny and harmless cracks that occur in the outer enamel of the tooth.
- **Cracks:** It occurs when craze lines penetrate the body of the tooth (dentin).
- **Fractures:** A fracture occurs when cracks expand deep into the root of the tooth.

Etiology

Table 1: Etiological factors of cracked tooth syndrome[12]

Non-iatrogenic factors	Aging	Dental fatigue is becoming more prevalent.
		The hard tissues of the teeth are weakened.
		Dentin elasticity has been lost.
		An increasing number of teeth are being restored.
	Oral habit	Eating habits with thermal cycling
		Unilateral chewing for a long time
		Bruxism during sleep
	Dental structure	The tooth has a structural defect.
		Inclination of cusp
		Affected tooth structure

Odontiatrogenic factors	HNRT	Aggregation of oral symptoms exerts synergistic effects.
	Root canal therapy	The instrument's contact with the canal wall
		Sodium hypochlorite at a greater concentrationExcessive widening of the root canal
	Restorative procedures	Stress concentration
		Tooth tissue removal that is excessive
	Material performance	Materials made of metals
		Thermal expansion coefficient differences
		Deformation of the material
	Stress function	
Iatrogenic factors	Others factors	Teeth with large fillings
		Application of too much pressure on one tooth
		Biting down too hard
		Teeth that have undergone root canal treatment
		Clenching or grinding of the teeth
		Physical injury to the teeth
		Sudden temperature change
		Oral piercings

Classification/Definitions of Tooth Fracture

Gibbs described incompletely fragmented teeth in 1954, and Ritchey and colleagues described them in 1957.Five forms of cracks in teeth have been discovered by the American Association of Endodontists (AAE).[13]Although knowing all the forms of cracks is essential for a physician to use as a diagnostic tool, clinically differentiating between the different kinds of cracks can be challenging. A craze line is the first and most mild fracture. Craze lines are enamel-only fractures that are visible. However, establishing that a visible fracture is limited to enamel is not always possible. Fractured cusps start at the crown of the tooth, extend into the dentin, and end in the cervical area. They're generally connected with large restorations that leave the cuspal enamel unsupported. The AAE defines a cracked tooth as one that extends apically from the tooth's occlusal surface without dividing two parts. Asplit tooth has a break that runs through both marginal ridges, usually in a mesiodistal direction, totally dividing the tooth into two halves. Vertical root fractures begin in the root and are habitually complete, though they might be partial. All classification methods have the difficulty of failing to relate the descriptions to clinical outcomes or treatment recommendations.

Tooth fracture was divided into two types by Silvestri and Singh (1978): completely fractured teeth and incompletely fractured teeth.Complete fractures were then separated

into obliquely directed and vertically directed complete fractures. The authors suggest that a complete restoration that compromises a cusp is the most common cause of the full oblique fracture. The undermined cusp is completely sheared off under the stresses of mastication or parafunctional habits. Clinically, a vertically oriented complete fracture is seen as two independently mobile tooth and root segments about one another. There were two types of incomplete tooth fractures: oblique and vertical. Oblique and vertical fractures are the source of an oblique crack. An oblique crack begins on the tooth's occlusal surface, affects one or more cusps, travels obliquely into the dentin beneath the cusps, and terminates gingivally in the cementum or enamel.Tooth segments are not completely crushed. Vertical incomplete fractures start in the enamel and progress through the dentin and, in some circumstances, the root. With no complete separation of segments, the crack may extend in a mesiodistal direction over one or both marginal ridges, or buccolingually between the cusps.

Talim and Gohil (1974) developed a more comprehensive classification approach:[14]

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

Early Methods of Diagnosing Enamel Crack

Dentists find it extremely difficult to diagnose cracked teeth in the initial stages of CTS when symptoms and signs are frequently confused. Dentists must provide as precise a diagnosis as possible.[1]Auxiliary iconography examination, clinical examination, and a few novel technologies are currently available for the diagnosis of CTS.

Clinical Examination

The presence of facets on the occlusal surfaces of teeth—which indicates teeth in eccentric contact and at risk of damaging lateral forces—the existence of localized periodontal defects—found where racks extend subgingivally—and the induction of symptoms in response to sweet or thermal stimuli are additional indicators that can be seen during an examination. Many authors advise removing old restorations and stains to help identify the crack once the tooth has been discovered. By keeping the area clear of saliva, isolating the teeth, emphasizing the fracture with a contrasting background, and minimizing peripheral distractions, the use of a rubber dam increases the likelihood of finding these fissures.

Visual Inspection

Even though it is helpful to visually inspect the tooth, cracks are frequently invisible without the use of magnifying loupes. Rarely, it can be recognized. It isn't always evident, though. Many authors advise removing old restorations and stains once the tooth has been discovered in order to help visualize the crack.[15,16]

Tactile Examination

Use a sharp explorer tip to make surface scratches on the tooth. There's a chance the tip will get trapped in a crack.

Exploratory Excavation

Sometimes exploratory excavation is required to reach a visual diagnosis. Excavation should always be done with the patient's permission because it is not guaranteed that a fracture will be discovered beneath any removed restoration. Fracture lines may become visible if old repairs are removed.

Percussion Test

They rarely react well to percussion, even when it is applied apically.

Periodontal probing

Periodontal probing can assist in differentiating between a cracked and a split tooth when the fracture line extends below the gingiva, resulting in a localized periodontal defect. To

find evidence of an isolated periodontal pocket, carefully probe any suspicious cracks. Conversely, isolated deep probing often reveals the existence of a split tooth, a sign of bad prognosis.

Dye Test

Methylene blue or gentian violet stains can be used to draw attention to fracture lines (Figure: 2)[17]Visual detection of coronalcracks is facilitated through the use of methylene blue dye staining. This results from the dye's propensity to aggregate. However, using the dye may hide cracks or cause slight color changes in the enamel's deeper layers.[15]In furthermore, the original restorative elements must be removed before the dye can be applied, which takes 2-5 days.[18]Another problem is that a permanent aesthetic restoration is not feasible.

Figure 2: Visual detection of coronal fissures is facilitated by the use of methylene blue dye staining

Transillumination

When attempting to locate a crack, transillumination can help identify both full and incomplete vertical root fractures, such as those seen in CTS. Ideally, the light source should be positioned directly on the tooth and the tooth should be cleaned before transillumination (Figure: 3).A break that penetrates the dentin of the tooth will disrupt light transmission in these circumstances.[19]Transillumination is arguably the most widely used method for traditional crack diagnosis. There are two drawbacks to using transillumination without magnification. To begin with, transillumination accentuates all flaws to the extent that craze lines seem to be nothing more than structural fissures. Second, slight color shifts are made invisible. A crack can be more easily seen with the use of magnification and fiber-optic light transillumination.[20]Dentists usually diagnose cracks by looking at the cracked surface's peripheral crack lines. The observed crack lines, on the other hand, do not accurately represent the size and shape of the cracks.

The magnification used to determine the spectrum of enamel fractures is approximately 14-18 times, according to experienced clinicians, with 16 times being the ideal magnification for evaluating enamel cracks.[19]Structural and minor cracks can be properly distinguished or detected using the FOTI equipment and the dental operating microscope. They're well enough and effective diagnostic tools for CTS and dental caries, and they're widely used in clinical practice.

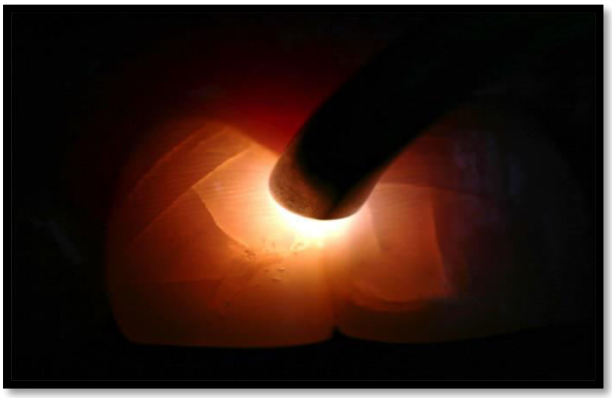

Figure 3: Transillumination showing enamel crack

Bite Tests

The symptoms of a partial posterior tooth fracture can be mimicked with the use of symptom mimickers. Orangewood sticks, cotton wool rolls, rubber abrasive wheels such as Berlew wheels, or the head of a number 10 round bur in a handle made of cellophane tape can all be used for bite testing.[21] The patient is instructed to bite on each cusp independently when utilizing orange wood sticks to identify cracks. This aids in the shattered cusp's isolation.

Cotton rollers can be used to find cracks. It is recommended that the patient bite down on cotton rolls and then abruptly release pressure. The diagnosis is validated by the presence of discomfort upon abrupt pressure release. Anesthetic carpules with rubber plungers hanging on a floss strand can be used similarly to cotton rolls; two examples of such products are Tooth Slooth II (Professional Results Inc., Laguna Niguel, CA, USA) and Fractfinder (Denbur, Oak Brook, IL, USA)[12]Ehrman et al[8] have advocated for the use of this technology since it is more sensitive than using wood sticks. This helps in the correct identification of the cusp in concern. The Fractfinder or Tooth Slooth (Figure 4) can be used on each cusp while the patient chews, allowing selective pressure to be applied to one cusp. If there is discomfort when biting or pressure is removed after biting, it could mean that the cusp is cracked. Most vitality tests yield positive results. However due to the presence being made public. Most vitality tests yield positive results. However, the impacted teeth may exhibit hypersensitivity to cold stimuli due to the presence of pulpal inflammation, a feature that may aid in the diagnosis of CTS. Other researchers, on

the other hand, believe that applying pressure to teeth with questionable symptoms may promote further crack propagation, and hence do not recommend point load and bite testing.

Figure 4: Tooth Slooth tool for the bite test

Radiograph

Radiographs can help to determine a tooth's pulpal and periodontal health, but it's rare to see a crack on one.[23,24]Conventional periapical X-rays (PR) only provide a when the root fracture is deviated[20], however, cone-beam computed tomography(CBCT) can identify minor periapical bone loss during Vertical root fractures (VRFs).[77]However, because CBCT has a resolution of just about 80μm, it is not useful for clinical diagnosis of cracked teeth or detecting early VRFs.[25]

Yuan et al[23] showed in an in vitro study that using meglumine diatrizoate as a contrast agent can improve scanning with CBCT as compared to the usual approach because it can objectively and effectively highlight hidden cracks. As a result, some researchers regard this as an auxiliary method for imaging the periapex of the tooth.

Recent advances in diagnosing enamel crack

a. **Swept-Source Optical Coherence Tomography (SSOCT)**
b. A promising method for identifying and assessing early CTS and early enamel caries is SS-OCT. SSOCT is a variation on the fast Fourier transform method that produces several wavelengths of light using a variable wavelength laser source (the enamel has high transparency and the cracks have excellent contrast at the near-infrared wavelength of 1300 nm). With thehelp of a laser scanner and a semiconductor camera, this nondestructive imaging approach uses low-coherence interferometry to detect the reflection signals of biological tissues at different depths facing weak coherent light and creates two-or three-dimensional structural images (Figure 4).[26]Lee et al[24]discovered that SS-OCT has higher diagnostic

accuracy than micro CT, FOTI, and visual inspection.[27]Although SS-OCT increases resolution, it has a low specificity for detecting full-thickness cracks because the enhanced image of deep enamel cracks frequently overlaps with the enamel plexus. The coronal section of the SS-OCT has a confined depth of penetration of 3mm that can be laser irradiated. As a result, its main applications are restricted, and it is only suitable for early diagnosis.[28]

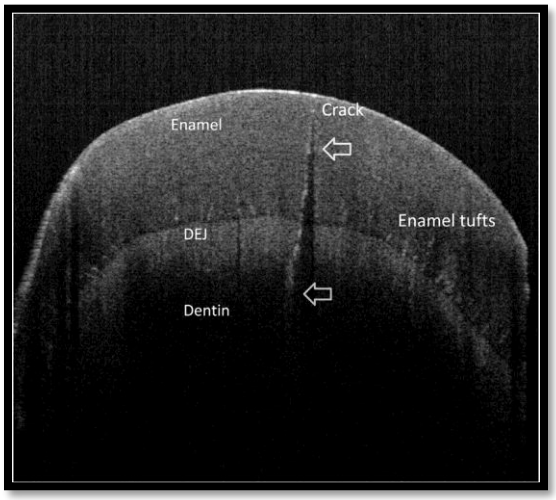

Figure 4: SS-OCT image of the dentin crack. The crack extended beyond the DEJ and displayed as a bright white line.

Lee SH et al[24] compared optical coherence tomography (OCT) to other diagnostic procedures such as conventional visual inspection, transillumination, and micro-computed tomography to determine the reliability of OCT in detecting broken teeth and its relative clinical effectiveness (micro-CT).The accuracy of swept source OCT (SS-OCT) was demonstrated by comparing the number of crack lines found on 109 surfaces of 61 teeth to those discovered using other methods. Crack lines that were invisible to the naked eye were visible in SS-OCT images when compared one to one. SS-OCT had detection abilities that were better or comparable to micro-CT (100%) and transillumination. SS-OCT pictures revealed fracture lines with unique properties, and structural crack lines and craze lines could be distinguished. As a result of its detection ability, SS-OCT is an acceptable diagnostic tool for cracked-tooth syndrome.

Imai K et al[29]conducted a study on current methods for the detection of enamel cracks that are not very sensitive. Optical coherence tomography (OCT) is a potential diagnostic technique that provides cross-sectional imaging of internal biological structures by measuring echoes of backscattered light. This work examined the use of swept-source optical coherence tomography (SS-OCT), a kind of OCT that scans the near-infrared

wavelength at a rate of 30 kHz over a range of 110 nm centering at 1,330 nm, as a diagnostic tool for enamel defects. A photo-curing unit was used as transillumination for SS-OCT on sites where the presence of an enamel fracture was suspected during visual inspection.A confocal laser scanning microscope (CLSM) was then used to analyze the teeth after they had been sectioned using a diamond saw. SS-OCT provided a clear visual representation of the presence and size of enamel cracks on backscattering signal-based images. Beyond the dentin enamel junction, the extension of enamel cracks could also be verified. The results indicate that SS-OCT has higher diagnostic accuracy than conventional visual inspection for the detection of enamel cracks and whole-thickness enamel cracks (visual inspection: 0.69 and 0.56, SS-OCT: 0.85 and 0.77, respectively). Enamel cracks can be easily identified by increased backscattering of light corresponding to the crack position; the results showed a good correlation with the CLSM.

c. Near-Infrared Imaging

Li et al[13]have verified the feasibility of using indocyanine green-assisted near-infrared fluorescence (ICG-NIRF) imaging to locate enamel-dentin and enamel cracks in vitro. Compared to using only the first region of near-infrared light, the second region can identify more cracks because it can detect the cracks and their depths that are not found by CT and X-ray. However, it is unable to discern between different types of cracks or obtain precise crack depth information.

Li et al[13] used transmission excitation light to demonstrate the feasibility of indocyanine green near-infrared fluorescence (ICG-NIRF) dental imaging for the detection of enamel cracks and enamel-dentin cracks in vitro in the first (ICG-NIRF-I, 700-950 nm) and second (ICG-NIRF-II, 950-700 nm) imaging windows and compared ICG-NIRF with conventional NIR illumination-II (NIRi-II).CT scans revealed dentin cracks, but NIR images revealed most enamel flaws that were invisible on X-ray imaging.We observed that ICG-NIRF-II identified cracks more efficiently than NIRi-II, and that light direction is a key component in fracture detection: an angled exposure produced better image contrast of cracks than a parallel exposure because it casts a shadow beneath the crack.The crack shadow in ICG-NIRF and NIRi-II images could be used to measure crack depth and differentiate enamel–dentin cracks from craze lines; using this shadow, we could determine crack depth and identify enamel–dentin cracks from craze lines. ICG-NIRF images with 1-min ICG tooth immersion revealed cracks clearly, though extended ICG immersion gave images with better contrast. ICG-NIRF dental imaging appears to be a promising technique for the early diagnosis of tooth cracks, based on our overall findings.

Jun MK et al[27] conducted a study to detect dental cracks and measure their depth, which would allow crack progression and treatment success to be predicted. The in vitro experiment aimed to see how well quantitative light-induced fluorescence (QLF)

technology could identify enamel cracks.Photo-curing equipment was used to examine naturally occurring or suspected cracked teeth surfaces on 96 removed human teeth.The ability to detect enamel fractures was determined using QLF images taken with a digital camera (QLF-D), which were then analyzed using the QLF-D software. The samples were then sectioned and examined under a polarized light microscope for a histologic evaluation. To examine the relationship between ΔFmax and the histology results, the Spearman rank correlation was employed. The sensitivity and specificity were computed to evaluate the suitability of using QLF-D to evaluate inner-half cracks in enamel and cracks that extend to the dentin-enamel interface. With a correlation coefficient of 0.84, the results of histologic evaluations of enamel cracks and the ΔFmax value had a strong correlation. For enamel inner-half cracks, QLF-D had a sensitivity of 0.87 and a specificity ofo.98, whereas cracks extending to the dentin-enamel junction had a sensitivity of 0.90 and a specificity of 1.0. These results imply that QLF technology, given its nondestructive nature, may prove to be an advantageous therapeutic tool for detecting enamel abnormalities.

d. Cone-beam Computed tomography (CBCT)

Contrast-enhanced cone beam computed tomography (CBCT) to improve the detection of cracked teeth and crack depth evaluation accuracy. The author created an artificial cracked tooth simulation model in vitro.All cracked teeth (n=31) were exposed to pre-experimental CBCT and micro-computed tomography (micro-CT). The crack was subsequently penetrated with ioversol under vacuum conditions for contrast-enhanced CBCT. Pre-CBCT, micro-CT, and contrast-enhanced CBCT results were all recorded. SPSS v.26softwarewas used to perform the statistical analysis for the study. Contrast-enhanced CBCT under vacuum conditions with a contrast medium can only significantly improve the crack detection rate of cracked teeth, but not measure the crack depths accurately.

Other Techniques

a. Ultrasonic System

b. Ultrasonic detection of CTS offers a bright future because of its capacity to penetrate hard tissue (including some radiopaque restorations) and the absence of risks related to ionizing radiation.Culijat et al[28]used an integrated ultrasonic system to successfully detect known cracks in simulated teeth.

c. Infrared thermography

When other diagnostic techniques fail, infrared thermography technology can assist in the detection of small cracks (4–35.5 m). Because ultrasonic power vibrates the smaller cracks (the amplitude and detection angle should be 0.89W within 45°, respectively), local friction that develops as a result of the vibration generates heat.[30]The dentin's

microcracks can then be seen thanks to the thermal imager's operation. When it comes to identifying broad cracks, this method is severely limited.

d. Near-Infrared

A near-infrared diode laser with a wavelength of 810 nm can be employed as a new technology to help control systematic CTS. When laser energy is irradiated on teeth that have suspicious symptoms, the majority of patients experience sharp pain, with only a few feeling dull pain. This may be because the energy applied to the pulp when the laser beam enters the depth of the crack generates an analogous irritation.[31]The most commonly used diagnostic methods and new technologies in clinical diagnosis should pay attention to problems that arise earlier in the process.

Zheng Y et al[31]created a dental imaging system that used a near-IR light source to identify enamel cracks and analyse the association between anterior enamel cracks and age in vivo. A total of 68 participants were separated into three age groups: young, middle, and elderly. Enamel cracks in anterior teeth were detected using 850 nm near-infrared radiation.The number of enamel cracks on the teeth grew significantly with age, according to the findings of the quantitative examination. The results of the qualitative examination revealed that there was no correlation between the severity of the enamel cracks and age.As a result, the occurrence of anterior cracked teeth increased significantly with age in both the young and middle age. The length of anterior enamel cracks also tended to increase with age, however this was not a significant finding.The silicon charge-coupled device (CCD) with an 850 nm wavelength has good performance in detecting enamel cracks and is very clinically useful.

Strassler HE et al[32]evaluated four distinct methods for diagnosing tooth cracks, which may give some theoretical foundations for early crack detection. The Stomatology Hospital of Guangzhou Medical University in Guangzhou, China, collected 123 freshly extracted human teeth. Three observers independently examined crown cracks using the naked eye, microscope, methylene blue dye, and methylene blue dye with magnification microscopic examination methods. Two criteria (crack lines in the dentin and enamel) were used to diagnose tooth cracks, and statistical analysis was carried out using the statistical programs SPSS and MedCalc. 120 teeth were remaining after three were removed due to the observer's eye tiredness. For both criteria 1 and 2, the methylene blue with microscope technique had the lowest Kendall's W values.According to criteria 1 and 2, the overall areas under curve (AUC) values were greater than 0.7 in both the microscopic and methylene blue plus microscopic methods, as well as in the naked-eye approach. In criterion 2, there was a significant difference between A, B, and C in the methods of naked-eye, microscope, and methylene blue plus microscope (P 0.05). The use

of methylene blue with a microscope to detect tooth cracks has a better level of consistency among experienced endodontists. The tooth crack was diagnosed using a microscope and methylene blue dye with magnification microscopic examination. Experienced endodontists can detect more cracks, and the difference remained even when microscopes and methylene blue dye were used.

Table 2Shows the available technologies.

Table 2: Four common methods for identifying cracked teeth[41]

Features	**Transillumination**	**Intraoral X-ray**	**CBCT**	**SS-OCT**
Distinguish the type of crack	× [33]	× [28]	× [38]	○ [29]
Show root fractures	× [33]	○ [1]	○ [23]	× [29]
Determine the crack depth	× [34]	× [38]	○ [37]	○ [17]
Produce radiation	× [32]	○ [35]	○ [36]	× [34]

○: meet the description, **×:** does not meet the description

Conclusion

When a patient complains of pain or discomfort when chewing or biting, CTS should always be considered. Even though CTS is a difficult diagnosis, dental professionals with understanding and awareness of the illness should be able to diagnose it, preventing further crack propagation and the problems that come with it.

Clinical Significance

Because of the lack of awareness of this condition and its peculiar clinical features, accurate diagnosis and treatment are challenging.Early diagnosis has been connected to successful restorative management and a favorable outcome.

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