

Diagnosis, Treatment and Prognosis of Cracked Teeth
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Longitudinal Fractures

Types of Longitudinal Fractures

- Craze Lines
- Cusp Fracture
- Cracked Tooth
- Split Tooth
- Vertical Root Fracture

Diagnosis and Treatment is difficult due to varying symptoms, lack of radiographic information and these often mimic other disease processes.

Diagnostic Aids for Identification and Diagnosis

- Thorough Dental History
- Tooth Slooth
- Transillumination
- Periodontal Probe
- Pulpal testing
- Radiographs
- Periapical testing
- Dye-staining
- Surgical exploration

Craze Lines

- Confined to enamel, usually extend over marginal ridges and along Buccal and Lingual surfaces
- Occur naturally but incidence increases with restorations or impact injury.
- Increase with age
- Little clinical significance

Treatment is not required

Craze Lines Characteristics

- Location: Crown
- Direction: Variable
- Orientation: Occlusal
- Symptoms: None
- Signs: None
- ID: Transillumination
- Treatment: None
- Prognosis: Excellent

Fractured Cusp

- Frequently occur in teeth with extensive restorations
- Generally the pulp is not exposed
- Patients may exhibit thermal sensitivity or pain to biting pressure
- Pulp tests generally indicate tooth vitality
- Periradicular structures are generally normal
- Fractures can be complete or incomplete
- Lack of cuspal support
- Undercut-type blow to the mandible jamming teeth together
- Often occurs in conjunction with large restoration
- Treatment depends on the pulpal status and restorability

Cracked Tooth

Definition

- An incomplete fracture initiated from the crown and extending subgingivally, usually in a mesial-distal direction
- The fracture may extend through one or both marginal ridges and through the proximal surfaces

Cracked Tooth Characteristics

- Location: Crown of the tooth
- Direction: Mesial-Distal
- Orientation: Occlusal to gingival
- Symptoms: Highly variable
- Signs: Variable
- ID: Transillumination, dye stain, remove restoration, biting, non-separable segments
- Treatment: Varied
- Prognosis: Questionable

Split Tooth

- Begins as cracked tooth and progresses
- Non-restorable!
- Evolves from the cracked tooth
- The tooth segments are entirely separate and the fracture is easier to identify
- It is important to identify the extent and severity of the fracture before developing a treatment plan

Split Tooth Characteristics

- Location: Crown extending onto root
- Direction: Mesial-Distal
- Orientation: Occlusal to sub-gingival
- Symptoms: Acute with mastication
- Signs: Separable segments, occasionally presents as periodontal abscess
- ID: Separable segments
- Treatment: Remove segment & restore, or extract
- Prognosis: Hopeless to maintain an intact tooth

Vertical Root Fracture

- Location: Roots
- Direction: Facial-Lingual
- Orientation: Root, extending coronal and apical
- Symptoms: Usually none, may present as a periodontal problem
- Signs: Variable
- Radiograph: Bone loss pattern
- Probing: an isolated narrow probing depth can suggest VRF
- ID: Visualization, flap reflection
- Treatment: Removal
- Prognosis: Hopeless

Cracked Teeth

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Cracked Tooth Characteristics

- Described as an incomplete fracture
- More devastating
- Often occurs in minimally restored posterior teeth
- Cracks generally run in a mesial to distal direction
- Originate from the occlusal surface
- Occur primarily in mandibular molars
- The fracture may or may not involve the pulp
- Symptoms include pain to mastication and thermal sensitivity
- Occurs from damaging habits, weakened tooth structure
- The pulp may or may not be vital

Cracked teeth are a Diagnostic Dilemma!!!

- Medical History is usually non-contributory
- Dental History can be important, especially, if recent "biting event" has occurred!

Treatment depends on the signs, symptoms, pulpal status, and extent of the crack.

- If the pulp is vital and there are no periodontal defects, a cast restoration is placed to prevent further propagation of the crack. If endodontic and/or periodontal problems exist then they should be treated prior to fabrication of a cast restoration.
- Probing defects occur to the depth of the crack when it extends into the root structure
- Radiographic examination may reveal horizontal, vertical or furcal defects
- Transillumination, dye staining, and the tooth slooth are diagnostic aids

Diagnostic Aids

- A good thorough dental history
- Dye Staining
- Transillumination
- Periodontal probing
 - Probing depths may occur to the depth of the crack when it extends onto the root structure
- Biting on a Tooth Slooth
- Radiographic exam
 - may reveal horizontal, vertical or furcation defects
- Treatment depends on the signs, symptoms, pulpal status, and extent of the crack.
 - If the pulp is vital and there are no periodontal defects, a cast restoration is placed to prevent propagation of the crack.
 - If endodontic and/or periodontal problems exist then they should be treated prior to fabrication of a cast restoration.

Cracked Tooth Clinical Classification

- Incomplete fractures
- Affect enamel and dentin
 - And cementum if root involved
- Fragments joined but may flex
- May affect the pulp
 - If bacteria present
- Treatment requirements vary considerably
- Potential progression to be a fracture or split

Cracked Tooth Biological Aspects

- Entry point for bacteria
- Exposed dentinal tubules
 - Pulp irritation and inflammation
 - Cracks have the same effect as caries
 - Pulp irritation and inflammation

Treat cracks in the same manner as caries – try to remove them and restore.

Cracks - “Typical” Symptoms

- But the symptoms vary considerably
- Because the crack is **NOT** the disease – it is only the cause of the disease
- The symptoms may be caused by
 - Pulp disease
 - Periapical/periradicular disease
- Hence – diagnose the status of these tissues
- Symptoms will depend on
 - Whether due to a crack or a fracture

- The extent of the crack or fracture
- The position of the crack or fracture
- The stage of pulp disease at the time the patient presents for treatment

Cracked Tooth Terminology

- Do NOT use “Cracked Tooth Syndrome”
- Just use “Cracked Tooth” or “Cracks in the Tooth”
- Think of cracks as an etiology, not as a disease itself

CTS – “Cracked Tooth Syndrome”

- CTS – This term is a misnomer
- Since syndrome is defined as “*A number of symptoms occurring together and characterizing a specific disease*”
- A crack is NOT a disease nor is it a pathological entity
- But cracks may CAUSE several diseases
 - Pulpitis – reversible or irreversible
 - Pulp necrosis and infection the root canals
 - Periodontitis – lateral and/or apical

CTS – “Cracked Tooth Syndrome”

- Clinical problems with using the term CTS
- Many attempt to classify it
- Many descriptions of “classic” symptoms
- Many theories to explain the symptoms
- Many suggested way to treat

Value of Radiographs

Value of Radiographs in Identification of Cracks

CE Cameron

J Am Dent Assoc 1976, 93(5)

- Evaluated cracked teeth. Found that pulp and radiographic findings do not often contribute to the diagnosis

Managing incomplete tooth fractures

JE Ailor Jr

J Am Dent Assoc, 2000, 131(8):1168-1174.

- A radiograph is not a primary diagnostic aid...Radiographs are most useful in ruling out caries or a broken restoration.

Patterns of periodontal destruction associated with incomplete root fractures

K Nicopoulou-Karayianni, U Bragger, NP Lang

Dentomaxillofac Radiol, 1997 Nov; 26(6):321-326.

- Radiographic findings associated with incomplete root fractures are so variable that none of them can be considered individually or predictably.

Alternative Methods of Detection and Diagnosis

Ultrasound crack detection in a simulated human tooth

MO Culjat, RS Singh, ER Brown, RR Neuraonkar, DC Yoon, SD White

Dentomaxillofac Radiol 2005;34(2):80-85

- A unique ultrasound dental crack detection system using a novel transducer; a novel coupling agent; and customized electronic and digital signal processing (DSP) algorithms has been validated in a simulated tooth.
- Ultrasound has the potential to allow detection of cracks within tooth structure.

Accuracy of three different electronic apex locators in detecting simulated horizontal and vertical root fractures

AK Ebrahim, R. Wadachi

Aust Endod J 2006;32(2):64-69.

- In conclusion, the three EALs tested (Root ZX, Foramatron D10 and Apex NRG) were accurate and acceptable clinical tools in the detection of horizontal root fractures. However, the three EALs were unreliable in detecting the position of vertical root fractures.

The development of a diagnostic instrument for the measurement of mechanical allodynia

AA Khan, B. McCreary

J Endodon 2007;33(6):663-666.

- Traditional methods for measuring mechanical allodynia (reduction in mechanical pain threshold) in a tooth are not quantitative.
- This study evaluated the reliability of a new bite force transducer to measure mechanical pain thresholds, which might have application as a quantitative diagnostic aid for measuring mechanical allodynia in patients with apical periodontitis.
- The force transducer used in our study is a reliable method to measure mechanical pain thresholds in endodontic patients.

Three dimensional, non-destructive visualization of vertical root fractures using flat panel volume detector computer tomography: An ex-vivo in-vitro case report.

C Hannig, C Dullin

Int Endod J 2005;38(12):904-913.

- AIM: To detect and to visualize radiographically vertical root fractures in extracted teeth with a prototype of a novel, high resolution, three-dimensional flat panel volume detector computer tomograph (FD-VCT) system.
- The FD-VCT allows precise visualization and evaluation of vertical root fractures or cracks in extracted teeth.
- Clinical application of the system may be possible if technical modifications reduce the exposure dose: the high resolution detector systems of the FD-VCT should be combined with radiation systems that focus the radiation to the area of interest.

References and Abstracts

Dentinal defects caused by some twist drills and retentive pins

JP Standlee, EW Collard, AA Caputo

Journal of Prosthetic Dentistry 1970;24(2):185-192.

- Twist drills did not produce dentinal cracks during the first 25 pinholes, however, cracks did occur with the increased use of the drill.
- The average width of the cracks was 10.6 microns.
- Cracks developed during pin placement may propagate with the application of occlusal forces.
- The crack may also serve as a portal of entry for bacteria.
- Demonstrated retentive pin placement produces high installation stresses which results in cracking or crazing of dentin.
- Friction lock pins produced lateral stress.
- Threaded pins produced lateral and apical stress.

Incomplete crown-root fracture in pulpal-periodontal disease

WW Hiatt

J Periodontal 1973;44:369-379.

- Looked at 100 cracked teeth in 64 patients
- Teeth with incomplete crown–root fractures have good cusp/fossa relationships
- Mesial-Distal direction
- Posterior teeth only
- 74%--no proximal restorations
- 71%--mandibular molars
- The primary diagnostic symptom is pain when chewing.

The cracked tooth syndrome: additional findings.

CE Cameron

J Am Dent Assoc 1976;93(5):971-975.

- 102 teeth with cracks
- 2/3 of 102 fractures occurred in mandibular molars
- 35%--history of previously cracked tooth
- 25% of patients could make their own diagnosis from previous experience
- Most complained of multiple symptoms
 - 72 reported pain on chewing
 - 68 reported sensitivity to pressure
 - 47 reported sensitivity to cold
- Pulp testing and radiographic findings are often non-contributory to the diagnosis
 - 75% of the fractured teeth were vital
 - 81 % of the teeth revealed normal radiographic structures

Crack lines: The precursors of tooth fracture: Their diagnosis and treatment

M Abou-Rass

Quintessence Int 1983;14(4):437-447.

- Definition: line that breaks or splits the continuity of tooth dentinal surfaces but does not perceptibly separate that surface.
- Crack itself can be an etiological factor in pulp disease if it extends to the pulp cavity and irritates the pulp physically. Or through leakage of liquids and bacterial toxins.
- 120 cases of symptomatic cracked teeth
- 9 year follow-up period

- Only 16 cases had to be extracted
- Mand 1st and 2nd molars and maxillary premolars and 2nd molars most often involved.
- Usually extend in a mesiobuccal, buccolingual or distolingual direction
- Diagnosis:
 - Transillumination
 - Bite test
 - Removal of restoration and dye tests
 - Tracing the crack with a bur
 - Radiographs do NOT disclose the presence of a crack
 - Fragments are not separable
 - Patient history
 - Pulp testing
- Various responses can be elicited from the patient
- The lack of obvious pulpal, periodontal or periapical lesion usually makes the diagnosis more difficult.
- Removal of a previous restoration and transillumination are the most valuable diagnostic techniques.

Treating the cracked tooth with a full crown

RC Guthrie, PM DiFiore

J Am Dent Assoc 1991;122:71-73.

- Twenty-eight teeth diagnosed as having a crack were immediately treated with full coverage acrylic resin crowns.
- Twenty-five of these teeth (89%) became asymptomatic after full coverage acrylic crown placement and continued to be asymptomatic one year after restoration.

HH Liu . SK Sidhu

Cracked teeth - treatment rationale and case management: Case reports.

Quintessence International. 1995;26:485

- Reported successful management of six teeth with cracks in the form of incomplete vertical fractures.
- Further crack propagation was prevented by placement of either stainless steel orthodontic bands or aluminum or acrylic resin provisional crowns, and endodontic treatment was subsequently carried out. The teeth were restored with intraradicular amalgam cores and complete veneer crowns.
- The teeth were re-examined periodically for up to 3.5 years after treatment.
- During the period of review, all teeth remained asymptomatic.

Preliminary estimates of the incidence and consequences of tooth fracture

JD Bader, JA Martin, DA Shugars

J Am Dent Assoc 1995;126(12):1650-1654.

- Risk of having a tooth fracture
 - 1 in 20 people fracture a tooth each year
 - 1 in 23 fracture a posterior tooth each year
- Reported consequence of fractures
 - 4% - no consequences
 - 7% - require extraction
 - 8% - involve the pulp or pulp chamber
 - The others needed various restorations

Coping with the cracked tooth syndrome

FW Benenati

Journal of the Oklahoma Dental Association 1996;86(3):16-18.

- The cracked tooth syndrome poses a diagnostic challenge for the dentist. Symptoms include tenderness to biting, often poorly localized, and occasional thermal sensitivity.
- Treatment of the tooth depends on the degree of pulpal involvement and the extent of the crack.
- Cuspal coverage is required of all cracked posterior teeth that are retained.
- Root canal therapy is included if symptoms persist or if pulpal pathosis exists at the outset.
- Cracks extending beyond the osseous crest indicate a poor prognosis.

Efficient, conservative treatment of symptomatic cracked teeth

JD Griffin, Jr

Compendium 2006;27(2):93-102.

- Every practitioner should be aware of the existence of Cracked Tooth Syndrome and the myriad of diagnostic and treatment alternatives for symptomatic teeth. Nothing can replace listening to the patient's history, thoroughness of clinical examination, or experience of the practitioner.

A six-year evaluation of cracked teeth diagnosed with reversible pulpitis: Treatment and prognosis

KV Krell, E Rivera

J Endod 2007;33(12):1405-1407

- The purpose of this investigation was to report on the clinical findings of cracked teeth that were initially diagnosed with a reversible pulpitis (RP).
- All cases had subjective histories, radiographs, pulpal and periapical diagnosis, periodontal probings, direct identification of crack(s) with transillumination, and biting responses on various cusps
- Examined 8175 patients during a 6 year period. Identified cracked teeth in 796 (9.7%) patients.
 - Incidence of Cracks
 - mandibular 2nd molars 30%
 - mandibular 1st molars 29%
 - maxillary 1st molars 21%
 - Reversible Pulpitis in 127 cases
 - Mandibular first molars 32% N=41/127
 - Maxillary first molars 25% N=33/127
 - Mandibular second molars 23% N=29/127
- Treatment planned for crowns only
- Recall at 1 year unless additional treatment was needed before then
- Of the 127 patients diagnosed with Reversible Pulpitis, 27 (21%) eventually required root canal treatment
 - 21 converted to Irreversible Pulpitis in 58 days
 - 6 converted to Necrotic in 149 days
 - Maxillary first molars 33%
 - Mandibular second molars 29%
 - Mandibular first molars 26%
 - Maxillary second molars 11%
- If a crack is identified early, pulpal diagnosis is Reversible Pulpitis and the tooth is restored with a crown, root canal treatment may be necessary in about 20% of the cases within an 8-month period.

Sixteen Year Evaluation of Cracked Teeth Diagnosed With Reversible Pulpitis: Treatment and Prognosis

KV Krell

- Comparison from the six-year evaluation (16 year vs. 6 year)
 - 1965 cases with cracked teeth seen out of 28,654= 7% of practice vs. 9.7%
 - RP cases=377 (19% vs. 16%)
 - IP cases = 695 (41% vs. 39%)
 - Nec cases=567 (28% vs. 29%)
 - Previously treated=326 (17% vs. 13%)

 - Mandibular 2nd molars = 32% vs. 30%
 - Mandibular 1st molars = 27% vs. 29%
 - Maxillary 1st molars = 20% vs. 21%

- What has changed in the extra ten years?
 - Initial Reversible pulpitis eventually requiring NsRCTx
 - 72/377(19%) vs. 27/127(21%)
 - Reversible converted to Irreversible pulpitis=
 - 54/72 (75%) vs. 21/27 (77%)
 - Reversible converted to necrosis
 - 18/72 (25%) vs. 6/27 (23%)

- If teeth with a crack are identified early enough in cases with a diagnosis of RP, and a crown is placed, root canal treatment (RCT) will be necessary in about 20% of these cases within a 6 month period.

Fate of vital pulps beneath a metal-ceramic crown or a bridge retainer.

GS Cheung, S C Lai, RP Ng

Int Endod J 2005;38(8): 521-530.

- The survival of the vital pulp in teeth restored with a single-unit CMC was significantly higher (103/122=85%) than those serving as an abutment of a fixed-fixed bridge (52/77=68%). Maxillary anterior teeth used as bridge abutments had a higher rate of pulpal necrosis than any other tooth types.
- The survival rates for pulp vitality were 84.4% (CMC) and 70.8% (BR) after 10 years, and 81.2% (SC) and 66.2% (BR) after 15 years. The difference between the two groups was significant.
- Incidence of teeth requiring endodontics following single crown or fixed bridge abutment is similar to need for endodontics following restoration of cracked teeth with original diagnosis of reversible pulpitis.

Seven year clinical evaluation of painful cracked teeth restored with a direct composite restoration.

N Opdam, J Roeters, B Loomans, E Bronkhorst

J Endod 2008;34(7):808-811.

- 41 patients presented with cracked tooth syndrome and a pulpal diagnosis of Reversible Pulpitis and followed at 7 years.
 - 18 maxillary teeth
 - 23 mandibular teeth
- Restorations placed
 - Direct composite restoration without cuspal coverage
 - Direct composite restoration that included reduction and coverage of the involved cusps
- Of the 41 cases with Reversible Pulpitis, 40 were able to be evaluated.
 - 3 required root canal treatment

- Molar treated at 2 weeks was eventually extracted due to VRF
- Molar treated at 5 weeks was eventually hemisected due to VRF
- At 7 years
 - No failures of the cuspal coverage teeth
 - The 3 teeth requiring RCT did not have cusp coverage

Predictable management of cracked teeth with reversible pulpitis

P Abbott, N Leow

Aust Dent J 2009;54(4):306-315.

- 100 teeth with reversible pulpitis with cracks
- Removal of the cracks, caries and restorations
- Placed a sedative lining and interim restoration
- Monitored after 3 months for up to 5 years
- 80/100 did not require root canal treatment
 - 1 uncertain at follow-up
 - 15 required root canal at the initial treatment
 - 4 due to carious pulp exposure
 - 2 cracks extended in to the pulp
 - 9 required posts for restoration
 - 4 others required root canal later
 - 1 due to continued pulpitis
 - 2 had pulpitis after the core restoration
 - 1 had pulp necrosis
- **Conclusion:** provided there is accurate diagnosis of the pulp status and its cause, teeth with reversible pulpitis due to cracks can be treated conservatively without endodontic treatment in about 80% of the cases.

Cracked tooth syndrome: Part I: Aetiology and diagnosis

S Benerji, SB Mehta, BJ Miller

British Dental Journal 2010;208(10):459-463

- Prognosis is dependent on a multitude of factors.
- Location and extent of the crack is a key determinant.
- Fractures limited to a single marginal ridge which doesn't extend more than 2-3mm below the periodontal attachment – the prognosis is reported to be excellent.
- Prognosis for fractures that involve both marginal ridges, communicating with the dental pulp or those that extend vertically through the pulp or involve the sub-pulpal floor have been described as poor.
- Early recognition will help to avoid propagation of the crack into the pulp chamber or subgingivally.

Cracked tooth syndrome: Part II: Restoration options for the management of cracked tooth syndrome

S Benerji, SB Mehta, BJ Miller

British Dental Journal 2010;208(11):503-514

- The aim of the restorative protocol is to immobilize the segments of the tooth that may move upon loading.
- More rapidly a tooth with a crack is treated, the easier it will be to avoid irreversible damage.
- Presents several various options for the provisional restoration of cracked teeth.

Fracture necrosis: Diagnosis, prognosis assessment and treatment recommendations

LH Berman, S Kuttler

J Endod 2010;36(3):442-446.

- When a tooth presents with a nonvital pulp, and there is no significant restorations or caries, in the absence of a luxation injury, it is suggested that the necrosis is likely caused by a significant longitudinal crack that extends from the occlusal surface and into the pulp.

