
Early Diagnosis and Treatment of Asymptomatic Enamel and Dentin Cracks
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Outline:

- Pathological Consequences
- Incidence
- Definitions and Traditional Classifications
- Diagnosis
- Etiology and Prevention
- Modern Classifications and Treatment
- Treatment Presentation and Patient Education
- Rationales for Early Management
- References

Pathological Consequences: The call for action

- Caries, pulpal and periodontal involvement: Cracks are pathways of bacteria to the →
 - Dentino-enamel junction leading to caries
 - Dentinal tubules and the pulp leading to reversible pulpitis, irreversible pulpitis, and pulp necrosis
 - Root surface leading to inflammation of the periodontium and bone loss along the fracture line. A narrow isolated pocket and radiographically linear bone loss along the root surface can be seen
- Complete tooth fractures: is the 3rd common cause of tooth loss after caries and periodontal disease. Seen either in the form of a cusp fracture or a split tooth, where cusp fractures are less catastrophic than split teeth
- A Dental Practice-Based Research Network, funded by the National Institute of Dental and Craniofacial Research, recently found that 27% of the cracked teeth observed have shown progression in just one year and thus a “watch and wait” approach must be used with caution. The network further reported that 92-95% of the time cracked teeth have been recommended for restorative treatment, resulting in less need for more invasive treatment such as endodontic therapy or extraction.

Incidence

- The incidence of stained and unstained asymptomatic cracks in posterior teeth (with and without restoration) was reported to be 33.71% (Ratcliff et al: 51 patients examined)
- In the Dental Practice-Based Research Network, 70% of the 400 randomly selected subjects had at least one posterior cracked tooth where 93% of these teeth were asymptomatic
- The incidence of cracks will increase in the future as more patients retain more teeth into older age
- Although cracks are mostly seen in restored teeth, they are also seen in non-restored teeth. In the absence of restorations, caries, or luxation injuries, all of the 27 teeth diagnosed with pulp necrosis were found in a study to have a longitudinal fracture extending from the occlusal surface and into the pulp. Other studies also found 28% to 48% of the diagnosed cracks in non-restored teeth.

Definitions and Traditional Classification:

- Definitions:

- Complete Tooth Fracture: A fracture where there is a visible separation and mobility at the interface of the segments along the line of fracture
- Incomplete Tooth Fracture (i.e. Crack): A fracture without visible separation and without mobility of the segments along the plane of the fracture
- A crack line that extends from mesial to distal or from buccal to lingual does not necessarily indicate a complete fracture yet if the 2 segments are neither separable nor mobile
- Traditional Classification
 - Type: Complete/Incomplete
 - Direction: Horizontal/Oblique/Vertical. Vertical cracks extend towards the center of the tooth in mesiodistal and/or buccolingual directions. Horizontal/Oblique cracks extend under the cusps. Vertical cracks are more likely than oblique cracks to propagate into underlying structures and render the tooth nonrestorable
 - Location: Enamel/Dentin/Root
 - Pulp Involvement: With/Without

Diagnostic Tools:

- Objective visual examination with magnification and illumination of the absolutely dried tooth
- Tactile examination with a sharp explorer: can detect gaps up to 36 um wide
- Periodontal probing: determines crack extension to the subgingival root surface and periodontium's involvement
- Staining with methylene blue dye: detects cracks as the dye pools in the crack
- Transillumination with cool, white light powered by an LED and transmitted through a focused glass fiber-optic element: results in a well-defined demarcation of blocked illumination at the crack lines; while structurally sound teeth will dissipate the light gradually throughout the tooth structure
- Bite test with tooth slooth: assesses the presence of symptoms and thus the location of symptomatic cracks only
- Radiographic examination: rarely reveals early cracks
- Restoration removal and fissurotomy: assess the extent of cracks and determine the final condition of the tooth structure
- Emerging technologies: CBVT/CBCT (mostly detects the damage caused by a vertical root fracture rather than the fracture itself), Laser, Ultrasound, Photothermal radiometry-luminescence, Optical Coherence Tomography

Etiology

- Lynch CD, McConnel RJ. The Cracked Tooth Syndrome. J Can Dent Assoc. 2002; 68(8):470-475
Full article is available at: <http://www.cda-adc.ca/jcda/vol-68/issue-8/470.pdf>
17 examples:
 - “Restorative procedures:
 - Inadequate design features: Over-prep of cavities, insufficient cusp protection in inlay/only design, deep cusp fossa relationship
 - Stress concentration: Pin placement, hydraulic pressure during seating of tightly fitting cast restorations, physical forces during placement of amalgam restoration, non-incremental placement of composite restorations (tensile stress on cavity walls), torque on abutments of long span bridges
 - Occlusal:
 - Masticatory accident: Sudden and excessive biting force on a piece of bone
 - Damaging horizontal forces: Eccentric contacts and interferences (especially mandibular second molars)

- Functional forces: Large untreated carious lesions, cyclic forces
- Parafunction: Bruxism
- Developmental:
 - Incomplete fusion of areas of calcification: Occurrence of cracks in unrestored teeth
- Miscellaneous:
 - Thermal cycling: Enamel cracks
 - Foreign body: Lingual barbell
 - Dental instruments: Cracking and crazing associated with high-speed handpieces”
- Structural and Mechanical properties of Enamel and Dentin:

Enamel	Dentin
Hardest Tissue: 96% HA, 4% CLG & H2O	Softer: 70% HA, 20% CLG, 10% H2O
More brittle, tends to fracture earlier. Low resistance to initiation and growth of cracks	Higher force resistance, absorbs forces better.
Inherent internal defects: enamel cracks initiate from hypocalcified defects at DEJ, filled with organic matter, a fracture source within enamel.	
Enamel cracks > Dentin cracks	
Cracks along prism boundaries, is weakest parallel to rods in the interprismatic organic matter.	Deep dentin has lowest resistance to crack initiation and highest incremental fatigue crack growth rate (due to less intertubular dentin). Molars with deep restorations are more likely to crack due to the lower fatigue crack resistance of deep dentin

- Most common etiologic factors:
 - Structural design of cavity preparations: Excessive removal of tooth structure and lack of dentinal Support. The prevalence of cusp fractures in amalgam-restored teeth and resin-based composite–restored teeth is not significantly different
 - Parafunctional Habits: Excursive interferences were precursors to cracks in restored teeth
 - Occlusal Trauma

Prevention

- Early management of caries
- Preventive and conservative restorative designs:
 - Adhesive restorations and occlusal coverage restorations when teeth have already been weakened due to lack of dentin support
 - Conservative cavity preparations that preserve tooth structure without connecting multiple occlusal preparations
 - Rounded internal lines angles to avoid stress concentrations
- Non-restorative approaches
 - Protective occlusal guards

- Occlusal adjustment of non-functional cusps of teeth predisposed to cracking including teeth with excessive cuspal wear, heavy wear facets, worn restorations, or posterior malocclusion

Reviewing the Treatment of Symptomatic Cracks - i.e., the Cracked Tooth Syndrome:

- Occlusal adjustment
- Bonded intracoronal restorations and occlusal adjustment
- Occlusal coverage restorations (onlay/full crown restorations)

Modern Classifications and Treatment Approaches for Asymptomatic Cracks

- Modern classification of asymptomatic enamel cracks based on the risks of underlying pathology (dentinal cracks, decay, undermined enamel) and their treatment:
Clark DJ, Sheets CG, Paquette JM. Definitive diagnosis of early enamel and dentin cracks based on microscopic evaluation. J Esthet Restor Dent. 2003;15(7):391-401.

Article in PDF is available online at:

http://www.osteocom.net/osteocom/modules/Friend/images/crack_dx-clark_52722.pdf

Google search: Definitive diagnosis of early enamel and dentin cracks based on microscopic evaluation

- *“Type I - Little or No Risk of Underlying Pathology:* Craze lines, cracks that result from polymerization shrinkage of composites, cracks with superficial stain, cracks that follow natural anatomic grooves.
Treatment: No treatment, continued observation, occlusal adjustments, protective occlusal splints
- *Type II - Moderate Risk of Underlying Pathology:* Cracks with wedge-shaped enamel ditching and cracks that detour from or do not follow anatomic grooves.
Treatment: Preventive measures, review of patient history of thermal and functional sensitivity, restorative investigation, and definitive restorative treatment if the current restoration is deemed compromised
- *Type III - High Risk of Underlying Pathology:* Diagonal cracks, cracks that house debris, pairs of cracks that outline an area of discolored enamel, and cracks with a brown, gray, or white corresponding “halo”.
Treatment: Removal of the old restoration, if decay or microleakage is the underlying pathology, standard treatment is recommended. If a dentinal (structural) crack is the underlying pathology, protection of the incomplete fracture from occlusal forces is indicated. The presence of enamel cracks, even dramatic ones, does not necessarily indicate the presence of dentin cracks.”

Additional observations: _____

- Approaches to managing Asymptomatic Cracks by a sample of general dentists:
Alassaad SS. Approaches to managing asymptomatic enamel and dentin cracks. Gen Dent. 2014;62(6):58-62; quiz 63.
 - Methodology:
 - 4 different study clubs in the Sacramento region
 - 54 general dentists attended
 - Asymptomatic cracks were projected on a screen to ensure uniformity in the referenced cases

○ *“When to intervene for enamel cracks (n=51)*

	Response (%)
Stained vertical enamel cracks in posterior teeth and detectable by explorer	73
Oblique or horizontal enamel cracks originating from line angle of restoration	62
Un-stained vertical enamel cracks in posterior teeth, but accepting methylene blue dye	29
Stained vertical enamel cracks in posterior teeth, but undetectable by explorer	25
Un-stained vertical enamel cracks in posterior teeth, detectable by transillumination, not accepting methylene blue dye	12
Do not recommend the removal of intracoronal restoration to my patients to explore the extension of asymptomatic enamel cracks when the restoration is not compromised and no evidence of decay is present	20

○ *When to intervene for dentin cracks (n=51)*

	Response (%)
Stained vertical dentin cracks in posterior teeth	86
Stained oblique dentin cracks in posterior teeth	84
Un-stained vertical dentin cracks in posterior teeth	65
Un-stained oblique dentin cracks in posterior teeth	65
Do not recommend my patients to have asymptomatic dentin cracks treated	8

○ *The treatment of choice (TOC) for asymptomatic vertical and oblique dentin cracks chosen by general dentist survey participants (n=47)*

	TOC for vertical dentin cracks	TOC for oblique dentin cracks
Full crown restoration	51	40
Indirect occlusal coverage restoration such as porcelain onlay restoration	19	32
Direct bonded composite intracoronal restoration	17	13
Direct occlusal coverage restoration such as bonded composite onlay restoration	4	2
Protective occlusal hard bite plate*	21	23
Occlusal adjustment of opposing tooth*	17	17
Occlusal adjustment of cracked tooth*	13	19

* Occlusal treatments were mostly ranked 1 in conjunction with restorative treatments. As a result, the responses do not add up to 100%.”

- Assessing the evidence:

“Evidence-based dentistry (EBD) integrates the dentist’s clinical expertise, the patient’s needs and preferences, and the most current, clinically relevant evidence. All three are part of the decision-making process for patient care.”
<http://ebd.ada.org/en/>



- Treatment modalities that can be utilized for Asymptomatic Cracks:

- Occlusal Adjustment
- Restorative:
 - Bonded intracoronal restorations and equilibration to stop crack progression
 - Protection of the incomplete fracture by occlusal coverage (Onlay/full crown restorations)
 - Altered restoration design: placing core/build-ups, beveling cracked cusps
 - Fiber reinforcement
 - Conclusion:

- Occlusal Guards

Pulp Vitality Assessment - to rule out asymptomatic pulp necrosis when there is no clinical or radiographic evidence of pulpal pathology:

- Preoperative electric and/or thermal testing?
- Chasing cracks to determine their accurate proximity to the pulp without risking further damage?
- Assessing pulp vitality while the tooth has a temporary restoration? (The added challenge of single visit CAD/CAM indirect restorations)

4 Keys for Treatment Plan Presentation (Spears Seminars) – utilize visual tools to:

1. Make the patient aware of the problem you found
2. Tell patients what problems mean to them if no treatment is done and how consequences will change with intervention
3. Ask the patient if wishes to treat the problem
4. Present treatment options that will fix the problem starting with the best option and ending with least favorable option

Rationales for Early Management

- Pathological consequences if no intervention
- Available diagnostic tools to identify high-moderate risk cracks
- Available conservative treatment approaches

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