

Original article:

Crack Lines: The Precursors of Tooth Fractures – Their Diagnosis and Treatment

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Various terms have been used to describe cracked teeth, e.g., incomplete fracture, greenstick fracture, and cracked tooth syndrome. Here the term tooth structure crack will be used to describe a line that breaks or splits the continuity of tooth dentinal surface but does not perceptibly separate that surface. This line cannot be wedged, or separated apart. Tooth structure cracks should be differentiated from craze lines of tooth enamel or vertical fractures of the tooth (Figs. 1 and 2). These cracks can be found in symptomatic or asymptomatic teeth. The crack itself can be an etiological factor in pulpal disease if it extends to the pulp cavity and irritates the pulp physically, or through leakage of liquids and bacterial toxins. In other situations, the crack is of no etiological relationship to the pulp disease and happens to be present in a pulpally involved tooth. Finally a crack line can be considered a precursor to a tooth fracture.

Clinical Survey

The information presented here is based on clinical analysis of 120 instances of symptomatic cracked teeth from the University of Southern California School of Dentistry, the Watts Health Clinic, and private practice over a 9-year period. Of these, only 16 teeth have been extracted

because of treatment failure. The limitations of this report are those inherent to any clinical survey.

Incidence of Crack Lines

Analysis of 120 cases indicates that the mandibular first and second molars and maxillary premolars and second molars are most often affected. The cracks usually extend in a mesiodistal, buccolingual, or distolingual direction. Often, crack lines are limited to the mesial or distal aspect of the tooth (Table 1).

The crack lines usually appear near the developmental groove and can extend toward the root or horizontally across the tooth. Other cracks may originate in the root and extend coronally.

Etiology of Tooth Structure Cracks

The exact causes of tooth structure cracks are difficult to ascertain. Many factors can cause changes in the structural strength of teeth. There seems to be a greater incidence of structural cracks in restored than in sound teeth (Table 2). Some probable causes are:

1. The structural design of cavity preparations,
2. Trauma from parafunctional forces,
3. Restorative procedures,
4. Injury of the face or mouth,
5. Thermal expansion.

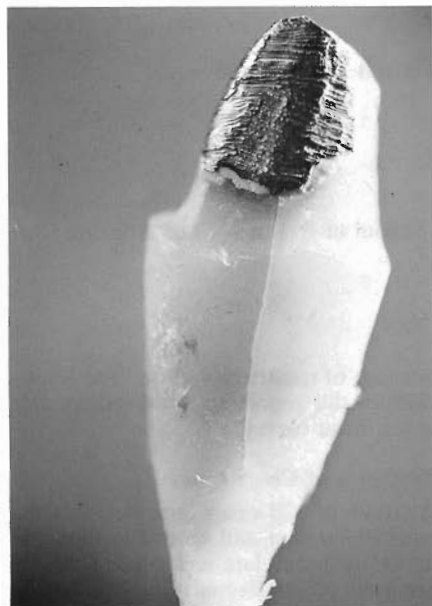


Fig. 1 Clinical difference between vertical fracture and tooth structure crack is apparent. A cracked canine tooth is incomplete and segments are united by tooth surface on lingual aspect

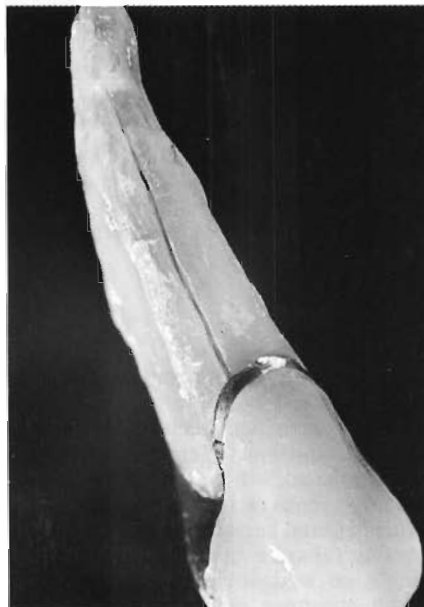


Fig. 2 On vertical fracture of premolar, cast gold crown is holding segments together. This was diagnosed by surgical exploration

The structural design of cavity preparations, such as a three-surface (MOD) preparation with extensions into the buccal and lingual grooves, may wedge and crack a tooth if it is subjected to excessive occlusal stresses or injury.

Severe tooth structure cracks may develop in some unrestored teeth¹ because of occlusal trauma, especially when:

- severe occlusal premature contacts stress a given tooth;
- teeth are adjacent to an unrestored edentulous region and a disproportionate occlusal load results; or
- malpositioned teeth (elongated, ro-

tated, or tilted) in cross-bite position receive or exert unnecessary pressure.

Restorative procedures can cause cracked teeth, as in the case of:

- an extensive alloy restoration (especially Class I) with an unsupported marginal ridge (Figs. 3 and 4).
- expansion, flow, or overloading of alloy restorations
- excessive pressure during post insertion in endodontically treated teeth
- threaded pins causing dentinal cracks to the pulp cavity²

- thermal expansion and contraction of large restorations in weakened teeth³ as well as thermal stress in tooth structure.⁴
- general trauma, such as: accidental injury, e.g., a blow to one or more teeth; biting on hard objects, especially ice or seeds; severe bruxism; or clenching of teeth during natural childbirth can also cause structural cracks in teeth.

Diagnosis of Cracked Teeth

The following tests are used to detect structural cracks:

Transillumination:

The use of fiberoptics in detection of crack lines is extremely valuable. The tooth should be cleaned of plaque, calculus, and carious material. The light source should be placed directly against the tooth surfaces.

Bite test:

A small rubber disc or object is positioned over each occlusal cusp. The patient's pain is evaluated during closing or opening of the mouth. Incidence of pain when opening the mouth is usually a strong indication of the possibility of a cracked tooth.

Removal of restorations and dye test:

The basic rule is to expose tooth structure for thorough visual examination. The patient should be told that the diagnostic procedure may require removal of a sound restoration so that the cavity preparation floor and walls can be examined. If there are chronic leakage problems related to the crack, a line of stain will appear. A dye can be used to stain a suspected crack. Methylene blue or gentian violet dye is applied with a cotton pledget to the area to be tested.

Table 1 Distribution of Structural Cracks per Type of Tooth

Tooth Involved	Number of Cases
Maxillary 1st molar	15
Maxillary 2nd molar	10
Mandibular 1st molar	36
Mandibular 2nd molar	19
Maxillary 1st bicuspid	13
Maxillary 2nd bicuspid	10
Lower cuspids	8
Maxillary centrals	9
Total	120

Table 2 Distribution of Structural Cracks per Clinical Condition Found

Condition	Number of Teeth
Nonrestored teeth	19
Class I alloy restoration	18
Class II alloy restoration	12
Three-surface (MOD) alloy restoration	17
Diagnostic surgery: root canal, plus a post single units or bridge abutments	23
Inlay restorations	7
Retrofill alloys	8
Posts	9
Previous root canal treatment	7
Total	120

To achieve maximum contact and permeability of the dye into the crack, the dye should be left on the tooth for a few minutes.

Clinically, the speed of absorption of the dye indicates the depth and width of the crack. Serious, deep cracks absorb the

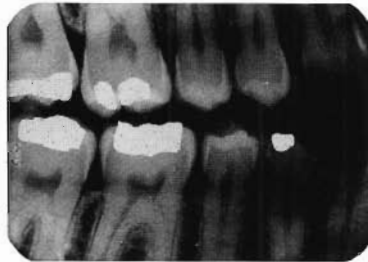


Fig. 3 Mediolateral crack was apparent on second molar and extended to pulp. Note superficiality of Class I alloy restoration



Fig. 4a A classical radiographic appearance of a cracked non-vital tooth observe the superficial Class I alloy and the vertical lesions. Tooth had no periodontal pockets or mobility. The leakage along side of the vertical crack lines may explain the mechanism of vertical lesion formation as differentiated from apical lesion usually occur at the root end. This tooth was extracted due to patient, desire and is shown in Fig. 4b

dye quickly. Transillumination of the stained area will provide even more information.

Removal of residual dye is done by wiping the tooth with cotton moistened with 2% sodium hypochlorite solution. Mixing the blue dye with a zinc oxide eugenol temporary cement filling will stain the tooth permanently and therefore is not advised.

Tracing the crack:

Using a proper high-speed bur, the crack line can be traced to determine its extent (Fig. 5). If the crack continues pulpally, it is likely that the root is involved. Sometimes the crack disappears into the dentin. Cracks on teeth with questionable vitality can be traced without the use of anesthetics. The dentist, however, should differentiate between the patient response of pain from drilling vibration, anxiety, or periapical pressure and the basic pulp stimulation.

Radiographs:

A radiograph does not disclose the presence of tooth structure cracks. If a dark line image appears on a film, by definition it is a fracture line (Fig. 6). The radiograph is effective in examining alterations in the pulp cavity. Also the (vertical) osseous defect or lesion along the length of the root is a typical radiographic finding usually associated with vertical cracks of the tooth structure.

Fragment separation:

As indicated in Table 3, a crack cannot be separated, and fragment mobility is not easily observed. Attempts should not be made to force the segments a part unless vertical fractures have already been diagnosed.

Patient history:

The patient's history may provide the substantiation of a cracked tooth. Patients with symptomatic cracked teeth



Fig. 4b Proximal view of the crack line of the tooth (Fig. 4). The crack line extended to the middle third of the mesial and distal root



Fig. 5 Photograph shows tracing of the crack line to determine its extent. Methylene blue dye test was then used to soak the surface. Crack is visible in the center of the prepared groove



Fig. 6 Radiographic appearance of dark line in middle of crown indicates vertical fracture rather than structural crack

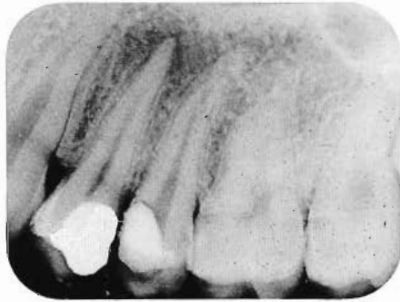


Fig. 7a Pre-treatment radiograph of the maxillary right premolar (1975). Observe the apical lesion on the first premolar

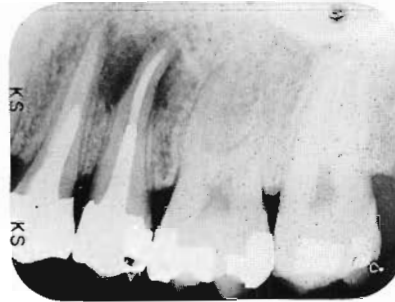


Fig. 7b In 1980 the patient returned with pain and swelling. While the previous apical lesion on the first premolar has resolved, a new lesion developed on the second premolar involving the vertical structure of the root



Fig. 7c Tissue view of the swelling area with a gutta percha point inserted into the fistulae track as a guide

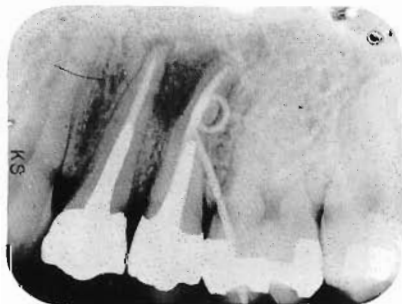
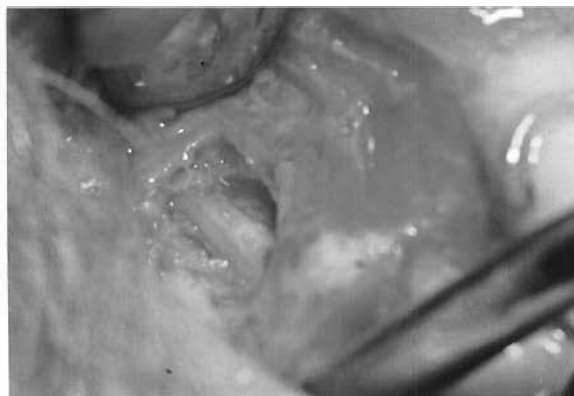


Fig. 7d The diagnostic radiograph reveals the gutta percha point reaching the second premolar root

Fig. 7e Due to the limited treatment and diagnostic options, surgical exploration of the area reveals a buccal root crack of the second premolar. Apical curettage was performed. The tooth was eventually extracted in 1981



usually report a history of uncertain diagnosis and several previous consultations that have not relieved the cause. Pain is usually episodic and occurs after mastication, biting at specific spots, or certain movements of the jaw.

Pulp testing:

Physical, or thermal, stimuli may be used to differentiate between symptoms.

1. If the pulp is healthy, a short period of stimulation (2 to 4 seconds) will elicit transient response.
2. With diseased pulp, the response either is late, does not occur, inconclusive, or begins immediately but lingers for a few seconds.
3. If the pulp is stressed by repeated previous pathologic and traumatic injury, the response usually occurs later and is weak and the patient usually describes a sensation rather than a specific pain.
4. If the pulp is necrotic and has caused initial reaction in periapical tissue, the patient will not respond to thermal stimuli. Physical stimulation, e.g., pressure, percussion biting will produce pain or discomfort.

Surgical exploration:

Surgical exploration is used when teeth are fully restored, with acceptable root canal treatment (Fig. 7) or posts, or when examination of the clinical crown is not feasible. Usually the presence, degree, severity, and location of a crack in the root structure can be determined by exploratory surgery, especially if there is an osseous defect. Surgical exploration is useful only for buccal and lingual root surfaces. Interproximal root surfaces are difficult to evaluate surgically. Often, surgical exploration can be used to detect a situation in which the patient can be spared the expense, time, and effort or further endodontic or restorative treatment.

Treatment in teeth with healthy pulps, occlusal reduction provides relief from occlusal stresses in centric and lateral relationships and immediate relief from pain, thus confirming the diagnosis of a cracked tooth and reducing the possibility of accidental tooth fractures.

All restorations are removed to examine tooth structure and the extent of the crack. If remaining tooth structure is insufficient to retain a crown, placement



Fig. 8 Root canal treatment was completed in 1970 without periapical involvement



Fig. 9 Lesion developed. Surgical exploration and curettage of buccal defect in 1978 disclosed crack



Fig. 10 Tooth was extracted in 1979 due to the persistence of fistulae



Fig. 11 Root canal therapy completed in 1970. Retrofill alloy was applied in 1972 due to chronic fistula crack formation. In 1976 the patient reported that chronic discomfort was always present and the fistula repeatedly healed and then reoccurred. Surgical exploration done in 1976 showed three cracks in the apical one-third. Three teeth were removed in 1979. It is interesting to note that the placement of retrofill alloy was totally unnecessary due to the adequate apical seal with gutta percha

of any pins or deep grooves that can injure tooth structure and pulp should be avoided.

A full crown should be prepared with utmost care to protect the tooth from pulpal injury. The tooth is cooled during preparation. Most important, the use of thermal stimuli, chemicals or procedures that can irritate pulp, such as hydrocolloid impression materials, or direct restorations with cold-curing acrylic resins, should be avoided.

Cracked teeth with multiple and extensive restorations and delayed pulpal response to thermal stimuli, or with diseased or necrotic pulps should be endodontically treated with special consideration during the treatment. Excessive condensation should be avoided and posting procedures are not advised.

The final full crown restoration should also receive minimal centric forces with no lateral occlusal contacts.

Discussion

Tooth structure cracks are common clinical findings in many restored and unrestored teeth. These teeth can be asymptomatic for a long period. If the cause of the crack, such as occlusal trauma, large leaky restorations, or undue physical stress, continues, the crack may progress to the pulp cavity or periodontium and become an etiological factor in pulpal or periodontal disease, or both.

Teeth with asymptomatic cracks should be preventively protected with full crown restorations.

Varied responses may be elicited from the patient, some of which are pulpal in character while others are periodontal. The lack of obvious pulpal, periodontal or periapical lesions usually makes the diagnosis more difficult (Table 3).

The patient's symptoms are not usually acute to require immediate care; there-

fore the problem continues for months or years until full-blown symptoms like lesion formation or vertical fracture develop. As a rule the dentist should suspect a cracked tooth in all examples of obscure etiology and mixed chronic symptoms, until proven otherwise.

The removal of previous restorations and transillumination examinations are the most valuable diagnostic techniques. Tooth structure cracks may be present in teeth requiring endodontic, restorative, periodontal or orthodontic therapy. These cracks may not be related to the cause of the treatment. However, they should be considered and described to the patient, as they may complicate the treatment process. With endodontic therapy, the crack may be increased by canal preparation, filling and post placement procedures (Figs. 8, 9 and 10).

In restorative dentistry large alloy restorations or alloy pin buildups on cracked teeth may cause cuspal fracture, tooth fracture, or pulpal exacerbation. Excessive occlusal contacts on partial coverage restorations on cracked teeth can increase the crack and develop a fracture. Post insertion in cracked teeth can lead to fractures and tooth loss. Strategic abutment teeth should be examined carefully to rule out tooth structure cracks. In surgical endodontics presence of a crack in a root may contraindicate the placement of an alloy retrofill (Fig. 11).

In periodontic therapy, the dentist may fail to differentiate between periodontal defects caused from a crack and those from periodontal disease; the localized periodontal-like lesion may be caused by bacterial invasion of the crack line into the pulp and periodontium.

Periodontal therapy alone will not resolve the lesion. Endodontic therapy also may be indicated. Tooth structure cracks on the second molar teeth adjacent to an impacted third molar or adjacent to the

Table 3 Differential Diagnosis, Treatment and Prognosis of Structural Cracks

	Craze Lines	Structural Cracks	Cuspal Fracture	Vertical Fractures
Location:	Coronal enamel	Extends into the dentin	Limited to clinical crown. Pulp may or may not be involved	Longitudinal plane. (Buccolingually or mesiodistally)
Pain:	None	Sensitivity to thermal and pressure stimuli	Tooth sensitive in one area (bite test)	Varying degrees
Separation:	Non-separable	Non-separable	Separable	Separable
Radiograph:	Non-visible	Non-visible	Non-visible	Visible in buccolingual plane only
Dye Test:	Minimal stain	Definite stain	Definite stain	Definite stain
Treatment:	None	Protective casting and R.C.T. depending upon symptoms	Remove cusp by grinding. R.C.T. may be necessary	R.C.T., restoration or extraction depending upon extent of root involvement
Prognosis:	Good	Good	Good	Variable

site of recently extracted third molar can become symptomatic from the surgical procedure, producing severe pain similar to that of a dry socket.

The diagnosis of tooth structure cracks before oral surgery is important to patient management and differential diagnosis. Finally, adult orthodontic movement of cracked teeth may increase the chances of pulpal flare-up and pain. The patient should be advised of these possibilities.

Summary

One hundred twenty clinically diagnosed cracked teeth were documented, classified and treated during a ten-year period. The exact etiology of structural cracks is unknown. Many variables seem to play a role. The mandibular first and second molars are most common sites for cracks. Fiberoptic transillumination, light, bite test, dye test, restoration removal, pulp testing and surgical explora-

tion are among useful tests to detect the cracks. Teeth with healthy pulps and sufficient tooth structure are crowned. Teeth with diseased, necrotic or stressed pulps or insufficient tooth structure are treated endodontically and then crowned. Teeth with root canal therapy and post restorations can be retreated or surgically explored to confirm the diagnosis and extent of the crack. Cracked teeth can be saved with a fair prognosis. If the crack, however, is severe and continues to progress to a fracture, the prognosis is poor and the tooth should be extracted. □

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U.K. Company to Provide Reel of "Best" Commercials

Starting next month, the theory that British advertising agencies lead the world in creativity will be put to the test by anyone willing to part with \$ 150 a month – or \$ 210 if you live on the other side of the Atlantic.

For that price, a new company, the Television Register, will send you a monthly reel of 100 new tv commercials under the title "Best of British."

By arrangement with the tv companies that transmit the commercials and the ad agencies that produce them, the Television Register will have access to the 600-plus new commercials produced every month in the U.K. The "best" 100 of these will be put on the reel – 10 commercials in each of 10 product groups – and the rest will be indexed and kept.

Thanks to a computerized index, subscribers to the Register then will be able to buy, as an extra service, a specially made reel featuring, for example, all the commercials with black female presenters. The computer index will feature 118 cross references. *(Advertising Age)*

13th International Meeting on Dental Implants and Transplants

Bologna (Italy), May 27–29, 1983

Information: G.I.S.I. c/o Prof. G. Muratori
1, Via S. Gervasio, 40121 Bologna (Italy), Tel. 0 51/22 75 05

International



dental meetings

June 25th–30th, 1983
**8th International Conference
on Oral Surgery**

Berlin, Germany

Details from:

Secretary of the ICOS,
Ifenpfad 2–4,,
D-1000 Berlin 42

June 28th–July 1st, 1983

**Meeting of the American Dental
Society of Europe**

Guernsey, Great Britain

Details from:

Brian J. Parkins, Hon. Secretary,
57 Portland Place,
London W1N 3AH, England

July 16th–21st, 1983

6th Dentistry International Congress

Rio de Janeiro, Brazil

Details from:

A.B.O.
Ave. 13 de Maio, S/1001/6,
C.E.P. 20.031, Rio de Janeiro, Brazil

August 1st–3rd, 1983

**International Association for Dental
Research**

Sydney, Australia

Details from:

Eloise A. Ullman, 734 15th Street, N.W.,
Suite 809, Washington D.C. 20005

October 2nd–6th, 1983

**American Dental Association
Annual Meeting**

Anaheim, California

Details from:

American Dental Association,
211 E. Chicago Avenue,
Chicago, Illinois 60611

November 14th–20th, 1983

Federation Dentaire Internationale

Tokyo, Japan

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Ms. Mary Barker, Japanese Dental
Association, 1-20 Kudan-kita, 4-chome,
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June 14th–17th, 1984

**3. International Quintessence
Symposium
2. International Symposium
on Ceramic**

London, Great Britain

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