# Incomplete cusp fractures: Early diagnosis and communication with patients using fiber-optic transillumination and intraoral photography

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The diagnosis of incomplete cusp fractures has primarily relied on patient symptoms, which sometimes results in late treatment approaches. The transillumination of tooth structure by a fiber-optic light source can be considered an important adjunct tool in the diagnosis of incomplete cusp fractures before they reach their end stages. Furthermore, transilluminated teeth can be documented by intraoral photography, using a two-handed technique by holding a transillumination device and an intraoral camera simultaneously, with the resulting images shared with the patient. This simple, painless, and noninvasive technique can be incorporated easily into daily practice to evaluate high-risk sites, regardless of patient symptoms. This article reviews incomplete cusp fractures, explains how to detect them using transillumination and intraoral photography, and addresses how to discuss the results with patients.

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Incomplete cusp fractures are oblique dentinal fractures that usually originate at the internal line angles of intracoronal preparations; they can result in complete cuspal fracture, with or without root involvement, if they are permitted to progress to a natural conclusion.[1] Although one study demonstrated that complete cusp fractures of posterior teeth are a common occurrence, with an incidence of 69.9 per 1,000 person-years, incomplete cusp fractures are very subtle and can be a challenge to diagnose.[2,3]

Cusp fractures are seen most commonly in teeth weakened by large intracoronal restorations, where restoration effects are thought to be associated with a reduced amount of dentin supporting the cusps of restored teeth.[2-5] In addition, the risk of cusp fractures increases with the presence of excursive interferences and parafunctional occlusal habits, carious lesions, and aging.[1,3,5-9] In a tooth with healthy pulp tissue, incomplete cusp fractures can be symptomatic and are reported most commonly as persistent sensitivity to cold and chewing; however, they also can be asymptomatic.[3] Early diagnosis is most important in the management of incomplete fractures to limit the propagation of the crack and subsequent microleakage, involvement of the pulpal or periodontal tissues, or catastrophic failure of the cusp.[7,8,10]

As incomplete cusp fractures propagate along the internal line angles of intracoronal preparations and toward enamel, diagonal or horizontal crack lines will become more visible near the enamel surface; they also may be complicated by a vertical component when the crack crosses a buccal or a lingual groove or a proximal marginal ridge.[11] Although visual observation can

Fig. 1. Maxillary second premolar. *Left:* Occlusal view of cusps weakened by an intracoronal metallic restoration. *Center:* Buccal view. *Right:* Buccal view of a transilluminated buccal cusp showing an incomplete fracture.

Fig. 2. Mandibular first molar. *Far left:* Occlusal view. *Center left:* Lingual view. *Center right:* Lingual view of a transilluminated mesiolingual cusp. An oblique fracture warrants further investigation. *Far right:* Oblique fracture involving both mesiolingual and distolingual cusps viewed under the light source of the intraoral camera.

detect what appears to be a crack or a fracture of the tooth structure, it may be difficult or impossible for the clinician to differentiate it from an insignificant craze line.[12,13] When teeth with significant fractures are transilluminated using a fiber-optic light source, they will show a well-defined demarcation of blocked illumination at the fracture lines (Fig. 1); meanwhile, structurally sound teeth, including those with craze lines, will transmit the light throughout the tooth structure.[9,10,12]

Magnification is a key element in the codiagnosis of incomplete cusp fractures. While dentists can rely on various magnification devices to assist in their diagnosis, patients have a clear view of incomplete cusp fractures only with intraoral photography, especially when intraoral cameras with 40–50x magnification are used. As a result, these images can be used to clearly communicate the conditions that many patients have a difficult time understanding through verbal explanations and can satisfy their concerns regarding the treatment plan.[14] These images also create valuable records of the patient's condition prior to the start of dental restorative procedures.[14]

## Devices and techniques

Capturing high-quality intraoral images of transilluminated teeth that demonstrate incomplete cusp fractures requires a two-handed technique. This technique is not difficult to master, but it requires practice and patience. The dentist uses one hand to hold the transillumination device and the other hand to hold the intraoral camera and keeps his or her eyes on the screen. The only assistance that may be needed from a staff member is retraction and saliva control.

A pen-sized cordless transillumination device that emits an intense beam of cool, white light powered by an LED and transmitted through a focused glass fiber-optic element (Microlux Transilluminator, AdDent, Inc.) is used along with a wand-like intraoral camera that has the ability to automatically compensate for the intensity of incoming light (Advance Cam intraoral camera, TPC Advanced Technology).

The dental operating light is turned off to reduce the other sources of light to a minimum. The intraoral camera is positioned in the lingual or buccal vestibule and stabilized so that it covers the lingual or buccal surfaces of the tooth. The transillumination device is positioned on the suspected cusp tip and moved around the cusp until the incomplete fracture is well-defined on the screen, at which point the image is captured.

Placement of the light source at a right angle to the fracture plane will result in the light beam being interrupted by the fracture, thereby illuminating only the fractured portion while the rest of the tooth remains dark. On the other hand, if no crack is present, the light beam will not be interrupted and will dissipate gradually.

Once an incomplete cusp fracture is identified, removing the existing restoration together with its liner and any present caries is recommended to directly visualize the extension of the fracture.[1,8] Oblique fractures usually will be visible at internal line angles of the preparation. Some of these fractures can appear lighter than the rest of the tooth structure due to refraction of the illuminating light of the operatory or the intraoral camera along the fracture line (Fig. 2). Old fractures under metallic restorations may be accentuated due to the presence of stains

Fig. 3. Maxillary second molar. *Left:* Lingual view of a transilluminated distolingual cusp. *Right:* Intracoronal surface of a distolingual cusp. An old fracture is accentuated by the presence of a stain.

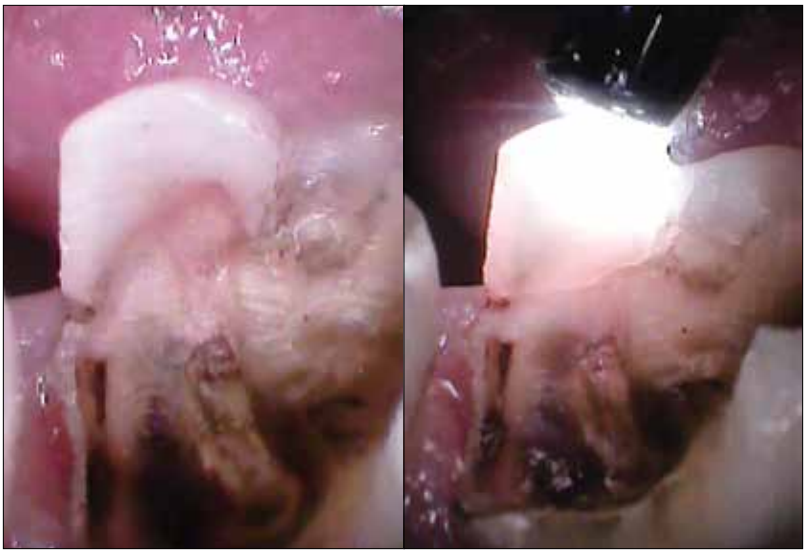

Fig. 4. Intracoronal surface of a mesiolingual cusp on a mandibular first molar. *Left:* The oblique fracture is not completely visible under the light source of the intraoral camera. *Right:* The extension of the oblique fracture is more visible with fiber-optic transillumination.

(Fig. 3). However, the extension of some other fractures may be determined only by fiber-optic light transillumination (Fig. 4).

## Discussion

A variety of transillumination devices have been used to reveal incomplete fractures; however, pen-sized cordless units specifically manufactured for this purpose are best-suited for such a diagnostic technique. Their light portal is easily and closely adapted to different sections of the tooth in different directions. They emit adequate light intensity to highlight fractures by being completely interrupted at the fracture line. They also can be viewed directly by the eye without a protective device.

The transillumination device can be considered an important adjunct tool in the diagnosis of incomplete cusp fractures before they reach end stages. However, a slight variation in the position of the transillumination device will yield a less-demarcated fracture line. The presence of deep restorations and caries also can block fiber-optic light transmission, making the use of fiber-optic transillumination problematic.[1] As a consequence, other diagnostic tests such as magnification and tactile examination should be considered.[9]

At the same time, evaluating the restoration's structural and marginal integrity, carious lesions, occlusal interferences, and heavy occlusal forces is advised. If removal of the restoration is indicated for reasons other than incomplete cusp fractures, the transillumination device can still be used (after complete removal of the restoration and caries) to detect any incomplete fracture that might not have been visible during the initial examination process.[3]

Although extraoral cameras offer higher resolution, most wand-like intraoral cameras are capable of capturing images with adequate resolution that can be magnified and viewed on computer monitors and printed for further documentation purposes. Intraoral cameras also have small heads that are easily positioned and stabilized at the lingual or buccal side of the transilluminated tooth to capture images without requiring the use of a mirror as an additional device. Because of their ability to automatically compensate for the intensity of incoming light, intraoral cameras can easily capture details of the brightly transilluminated fracture line and the surrounding tooth structure when used with the intense light emitted by the pen-sized cordless units.

Once an incomplete cusp fracture is diagnosed, it should be considered structurally unsound,

and protection from occlusal forces to minimize fracture propagation is indicated.[1,11] Many techniques have been described to protect teeth with fractured cusps. Definitive treatment has included occlusal adjustment, pin-retained amalgams, bonded amalgams, bonded composites, cusp overlay restorations, and full-coverage crowns, with excellent prognosis.[6,8,10] However, future research may indicate that intracoronal restorations and occlusal adjustments are insufficient to stop structural breakdown and that more protective extracoronal coverage is indicated.[11]

## Summary

Fiber-optic transillumination and intraoral photography are some of the most accessible technologies that dentists can incorporate into their practices. When used simultaneously, these technologies are worth even more in terms of diagnosis, treatment planning, documentation, education, and presentation of treatment to today's more visually focused patients. These devices can be implemented regularly as a part of the examination process to detect incomplete cusp fractures and to evaluate high-risk areas such as cusps weakened by large restorations, occlusal trauma, and carious lesions, regardless of patient symptoms.

## Disclaimer

The author has no financial, economic, commercial, and/or professional interests in any of the companies whose products or devices are included in this article.

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## Manufacturers

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203.778.0200, www.addent.com

TPC Advanced Technology, City of Industry, CA
800.560.8222, www.tpcdental.com