SHORT COMMUNICATION

The Use of Fiber-optic Transillumination in the Diagnosis of Fracture Line in Teeth: A Method of Standardization in Fracture Strength Studies

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Abstract

The use of fiber optic transillumination (FOTI) has been witnessed in the clinical scenario for many decades but has not been used in *in vitro* studies. The present paper highlights the use of FOTI as a method of standardization while conducting fracture strength studies *in vitro*.

Keywords: Diagnosis, Fracture resistance, Intracanal medicaments.

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Introduction

A cracked tooth is defined by the American Association of Endodontists (AAE) as a crack extending from the occlusal surface of the tooth apically without separation of the two segments.[1] Early enamel cracks are often neglected as they are asymptomatic, however, when the cracks are in the deeper layers of enamel or superficial dentin, the teeth tend to show hypersensitivity, but once the crack reaches the deep dentin layers or pulp, it will lead to more serious complications such as pulpitis and apical periodontitis.[2]

The cracks pass in a mesiodistal direction as observed by Seo et al.,[3] whereas Roh and Lee[4] suggested the most common direction observed is mesiodistal, but however, it can also present in a buccolingual direction. Considering the clinical aspects of cracks, the prognosis is very poor based on the extent of its involvement in the deeper layers of the teeth. Diagnosis and treatment require precise information regarding the location and depth of the crack. There are many methods for the diagnosis of cracked teeth. When the crack extends to the mesial and/or distal marginal ridges, it can be easily diagnosed through macroscopic observation, iodine staining, transillumination methods, and other methods in combination with clinical manifestations.[5]

This article outlines the various appropriate and newer modalities used for the detection of cracks *in vitro*, with special emphasis on FOTI.

Micro-computed Tomography (CT)

Micro-computed tomography (CT) visualizes and creates a three-dimensional model without damaging the object. The micro-CT device is considered superior to the conventional CT machine because the X-rays used in micro-CT are in the high-energy range; thus they can pass through thicker layers and require more time for exposure leading to the enhanced signal-to-noise ratio, which in turn will offset the loss in signal, therefore has better clarity. A micro-CT device includes an X-ray source, a rotating platform for the sample, a detection array, and 3D reconstruction software. The device irradiates the object and records attenuated intensities of the X-ray beam, whereas the object rotates on its own axis, thus allowing the device to collect projection data of the object from all angles.[6]

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However, this technique cannot be used in *in vivo* conditions. Also, the cost and time taken for analysis are high.

Scanning Electron Microscope (SEM)

Scanning electron microscope (SEM) uses a focused beam of high-energy electrons to determine the external morphology, crystalline structure, and chemical composition of the sample.[7] SEM technique has the advantage of the possibility to view the three dimensional external shape of an object, also of being a nondestructive and highly sensitive technique.[8] But the images produced by this method can visualize cracks less than 1 nm in size and cannot visualize the extent of the crack into the dentin.[9] Also, the tissue assembly in the microscope requires vacuum-causing surface defects and is expensive.

Sectioning Methods

Sectioning requires preparation of the tissue into thin slices, so this method is an inherently destructive method. This cross-sectioning technique causes further damage to the fragile and thin sections of the tooth, thus leading to incorrect results. However, sectioning methods have been used in a large number of endodontic research

and not in fracture strength studies. But it still remains the gold standard in histopathological studies.

Stereomicroscope

The sectioned samples are further visualized by the stereomicroscope systems. This device provides magnification and illumination (a ×16 magnification level), which aids in better observation of the cracks. Most often endodontic research uses the stereomicroscope for better visualization. However, an increased rate of false positive interpretation has been noticed, and this could be due to erratic reflection of light.[10]

Transmission Electron Microscope (TEM)

A transmission electron microscope (TEM) works on the principle of a high energy beam that aids in better resolution and magnification in comparison to the SEM. Production of the image is produced by illuminating the sample with the electron beam in a high vacuum and detecting the electrons that are transmitted through the sample onto a phosphorescent screen or through a camera, as suggested by Marco A.[6] High-resolution images with propagation patterns of dentinal defects have been obtained using TEM. However, this method includes false-positive result interpretation of dentinal defects and needs expertise.

Fiber-optic Transillumination (FOTI)

In dentistry, it was first used as an improved light source for surgical retractors. In 1970, Fried man and Marcus suggested the use of FOTI in the detection of carious lesions.[11] But later, as recognized by the AAE[12] which states that FOTI is one of the most ideal tools in the armamentarium for the diagnosis of fracture lines. The beam of light will traverse through the enamel until it reaches a fracture line, beyond which the light beam gets reflected. This results in a light and dark area separated by the fracture line. Based on a study by Wilcox et al.,[13] FOTI is one of the most commonly used diagnostic tools for traditional crack diagnosis in clinics. However, one of the limitations present in its use is that it magnifies all faults causing even the most minute craze lines to be visualized as deep microcracks leading to misdiagnosis and overtreatment clinically. Thus, methylene blue dye has been widely used along with FOTI to highlight cracks. The use of FOTI has been witnessed in the clinical scenario for many decades but has not been used in *in vitro* studies. The present paper highlights the use of FOTI as a method of standardization while conducting fracture strength studies. During the process of the research, as part of the exclusion criteria, the teeth with cracks are not to be included as a study sample as it could mislead by providing false positive results on application of force on these teeth. Therefore careful evaluation has to be conducted on all the samples with the usage of transillumination.

Equipment

The fiber optic light system uses the quartz halogen lamp and rheostat to give light of variable intensity. The 150 Watt lamp generated a maximum light intensity at the end of a 2 mm diameter cable of 4,000 lx. The diameter of the fiber optic probe is 0.5 mm, and a fiber optic bundle 1/16 inch in diameter. The rheostat was set to give maximum light intensity.

Examination Procedure

Method for detecting cracks: Focusing a high intensity light directly on the exterior surface of the tooth at the CEJ may indicate the extent of the fracture line. Teeth with fracture lines block transilluminated light. The part of the tooth that is proximal to the light source will absorb this light and glow, whereas the area beyond this fracture will not have light transmitted to it and will appear gray by comparison.

Similar methods were used to detect the cracks present in the extracted premolar teeth, which were used as a method to minimize the factors that influence the fracture strength of the teeth. The teeth subjected were all young permanent teeth like mandibular premolars, those which were extracted for orthodontic reasons. The cracks present were probably because of the undue pressure that was used during the extraction procedure. The cracks though present on the coronal aspect of the teeth, it would have propagated to the root surface, which intern would alter the fracture strength of the root dentin.

Fiber optic transillumination is an operator sensitive technique. The importance of probe placement in the FOTI technique and the effect on the probes transmitting efficiently by variation in the width, shape, and presence of plaque and calculus must be investigated.

Conclusion

Since the radiographs/clinical examination cannot detect the cracks in the enamel/dentin, fiber optic transillumination has been a method of choice *in vivo* and *in vitro* situations. Exclusively used for standardization of samples in *in vitro* fracture strength studies with the advantages of detecting the enamel fracture, unlike the other methods discussed, which detect the dentinal fracture lines. The FOTI is a noninvasive technique, cost effective, and needs no expertise in handling and interpretation.

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References

1. Rivera EM, Walton RE. Cracking the cracked tooth code: detection and treatment of various longitudinal tooth fractures. American Association of Endodontists Colleagues for Excellence, Newsletter, Summer 2008;2:1–19.
2. Kim SY, Kim SH, Cho SB, et al. Different treatment protocols for different pulpal and periapical diagnoses of 72 cracked teeth. J Endod 2013;39(4):449–452. DOI: 10.1016/j.joen.2012.11.052
3. Seo DG, Yi YA, Shin SJ, et al. Analysis of fractures associated with cracked teeth. J Endod 2012; 38(3):288–292. DOI: 10.1016/j.joen.2011.11.017
4. Roh BD, Lee YE. Analysis of 154 cases of teeth with cracks. Dent Traumatol 2006;22(3):118–123. DOI: 10.1111/j.1600-9657.2006.00347.x
5. Andreasen JO, Andersson L, Andreasen FM. Textbook and Color Atlas of Dental Trauma. 4th ed. Oxford: Wiley Blackwell publishing; 2007. p. 282.
6. Versiani MA , Basrani B, Sousa-Neto MD. (Ed) The Root Canal Anatomy in Permanent Dentition. Springer, 2018.
7. Fujimoto JG, Pitris C, Boppart SA, et al. Optical coherence tomography: an emerging technology for biomedical imaging and optical biopsy. Neoplasia 2000;2(1-2):9–25. DOI: 10.1038/sj.neo.7900071
8. Yamada MK, Uo M, Ohkawa S, et al. Non-contact surface morphology analysis of CO_2 laser-irradiated teeth by scanning electron microscope and confocal laser scanning microscope. Mater T 2004;45:1033–1040. DOI: 10.2320/matertrans.45.1033
9. Dumbryte I, Linkeviciene L, Linkevicius T, et al. Enamel microcracks in terms of orthodontic treatment: a novel method for their detection and evaluation. Dent Mater J 2017;36(4):438–446. DOI: 10.4012/dmj.2016-264

10. Kfir A, Elkes D, Pawar A, et al. Incidence of microcracks in maxillary first premolars after instrumentation with three different mechanized file systems: a comparative ex vivo study. Clin Oral Investig 2017;21(1):405–411 DOI: 10.1007/s00784-016-1806-3
11. Friedman J, Marcus MI. Transillumination of the oral cavity with use of fiber optics. J Am Dent Assoc 1970;80(4):801–809. DOI: 10.14219/jada.archive.1970.0117
12. American Association of Endodontists., Transillumination: the "Light Detector". Chicago, IL: AAE; 2008 1–2.
13. Wilcox LR, Roskelley C, Sutton T. The relationship of root canal enlargement to finger spreader induced vertical root fracture. J Endod 1997;23(8):533–534. DOI: 10.1016/S0099-2399(97)80316-0