Perimeter as an Adjunctive Tool for the Diagnosis of Vertical Root Fractures: Report of Two Cases.

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Abstract

Vertical root fractures (VRF's) continue to be a diagnostic challenge. These teeth often present with non-specific symptoms. Clinical and radiographic findings included pain to percussion, pain on biting, , deep isolated pocket, multiple sinus tracts, thickened periodontal membrane, and abscess with periodontal or furcal involvement. Definitive diagnosis can often only be accomplished with direct visualization of the fracture either through exploratory surgery or atraumatic extraction. This case report illustrates the periometer used as an adjunctive tool in the process of diagnosing a vertical root fracture. Radiographic evidence, clinical signs and symptoms, periodontal evaluation, and visual confirmation are presented in addition to graphic analysis from the periometer . Distinct differences in the shapes and characteristics of the graphic analysis of the fractured teeth suggest the periometer may potentially prove to be a useful adjunct in our diagnostic armanterium.

Introduction

Vertical root fractures (VRF) present clinical challenges of diagnosis and treatment (1,2,3). The clinical assessment of a suspected root fracture may be based more on subjective findings rather than on objective clinical findings, making the diagnosis difficult (4). A vertical root fracture is a fracture originating from the apical segment and propagating coronally in a longitudinal direction (5). According to Walton, a true VRF is initiated on the internal canal wall and extends outward to the root surface (6). Weakened dentinal walls due to endodontic or restorative preparations, excessive obturation forces, and/or heavy occlusal loads are all possible causes of VRF (7,8,9).

The clinical presentation is often with minimal symptoms. Meister reported the majority of these cases presented with only mild discomfort to dull pain (10). Most often a vertical root fracture is suspected with a previously endodontically treated tooth with or without a post, that presents with an isolated narrow deep periodontal pocket (7,10). Typically, the lesion that is correlated with a root fracture is a narrow periodontal defect which develops along the site of the fracture line (11). In many cases, it will radiographically resemble a "halo or J-shaped lesion" (12). Clinically and radiographically, however, we can not always distinguish these presentations from: failing endodontic therapy, missed canals, long standing iatrogenic perforations, and periodontal disease. In 1999, Tasme evaluated teeth clinically and radiographically, prior to extraction and found that general practitioners only correctly identified vertical root fractures in one-third of the teeth evaluated (13). More recently the same research group showed a tooth that demonstrated all variables of "periodontal" or "halo" osseous radiolucencies, bifurcation involvement, and amalgam dowels were predictors of a vertical root fracture with a sensitivity of 77.6% and specificity of 82.7% (11). Currently, a definitive diagnosis of vertical root fractures can only be confirmed with direct visualization often during a surgical flap procedure, or atraumatic tooth extraction. In a recent systematic review of the literature on the diagnosis of VRT in endodontically treated teeth using clinical and radiographic indices. It was concluded, that "the diagnositic accuracy and clinical effectiveness of clinical and radiographic dental evaluation for the diagnosis of VRF in endodontically treated teeth is lacking" (14).

Recently, an alternative technology, the periometer, has been introduced as an aid in conjunction to the pre-existing clinical diagnostic criteria for identifying and diagnosis of root fractures. It has been proven to be a useful tool in evaluation of implant stability and osteointegration thus far (15). The periometer uses a hand-held impact probe for creating a non-destructive quantitative measurement of the percussion response of natural teeth and restorations. However it's application in diagnostics of structural defects including vertical root fractures is still in its infancy. The purpose of this article is to highlight the graphical presentations found in confirmed vertical root fractured teeth, and how it differed from asymptomatic teeth as controls. The following cases included two teeth, both determined to be non-restorable, and confirmed to be vertically root fractured during exploratory surgery and root extraction.

Case 1

A 22 year old female presented to USC dental clinic with chief complaint that tooth #30 has been hurting for a long time. Clinically the tooth presented with sinus tract buccal to #30, and probing depths of 14 mm in the buccal furcation. The tooth had class II mobility and was sensitive to both percussion and palpation. Radiographically, #30 showed a previously endodontically treated tooth, with adequate crown margins, a large cast post in the distal canal and a diffuse radiolucency around the mesial root.

The patient was examined with the periometer. One examiner evaluated tooth #30 and its contralateral tooth #19. Testing was completed per manufacture's directions. Exploratory surgery showed extensive bone loss to the apex with no confirmation of vertical root fracture on the buccal. The patient was then advised to have the tooth extracted due to extensive periodontal bone destruction. Upon examination of the extracted tooth, the mesial apex had resorbed with a crack visualized in the apical third. A post extraction radiograph was taken to verify that no root fragment remained in the extraction socket. Results are illustrated in Figure 1 below.

Case 2

A 50 year old female presented to USC dental clinic with a chief complaint of long standing sensitivity to biting on tooth #19. Clinically the tooth presented with a local 10mm periodontal pocket, all other probings were normal. Tooth presented with a class II mobility and was sensitive to both percussion and palpation. Radiographically tooth #19 presented with an endodontically treated tooth with composite access fill and without cuspal coverage restoration. Root canal treatment radiographically appears adequate with 3 canals obturated to length. Radiographic bone loss is evident on the distal root extending into the furcation.

The patient was examined with the periometer. One examiner evaluated tooth #19 and its adjacent tooth #18. Testing was completed per manufacture's directions. Surgical exploration confirmed a vertical root fracture on the distal root. The patient was then advised to have the tooth extracted due to extensive periodontal bone destruction, and confirmation of vertical root fracture. Results are illustrated in Figure 2 below.

Discussion

These cases describe the outcomes of two patients that were suspected of having vertical root fractures. These patients each presented with a localized periodontal defect. For many clinicians, this local defect is the most confident diagnostic criteria in identifying a fractured tooth with a hopeless prognosis (16, 17). However, other conditions, such as sinus tracts from failing endodontic therapy are possible etiologies, etiologies that are treatable. Clinicians can choose to confirm this diagnosis with surgical exposure or with extraction. Both of which, are rather aggressive treatments if a less invasive one is available. Cone beam computed tomography (CBCT) is currently being investigated to meet this need (18,19). Current available methods to clinically diagnose root fractures include surgical exploration with a microscope, direct visual examination (2), fiber optic illumination, traditional periapical radiographs (PR), periodontal probing, staining, bite test, (18, 19, 20), and optical coherence tomography (3). Although the use of cone beam computed tomography is actively being looked at to aid in diagnosis, it is also currently in its early stages. In a recent study, the use of CBCT as compared to periapical radiographs was shown to increase sensitivity from 37.1% to 79.4%, however its specificity was reduced from 95% to 92.5% (18). This was due to the "radiopaque substances creating distinct star-shaped streak artifacts on tomographic slices that can mimic fracture lines on CBCT images, which may decrease the observers confidence in diagnosing VRFs" (21). Given such lack of certainty in our diagnostic capabilities in vertical root fractures, current research is being conducted to develop alternative and adjunctive diagnostics. Currently the gold standard for this diagnosis is direct visualization, often a surgical flap or atraumatic extraction. However, given these are aggressive procedures, we should strive to develop diagnostic modalities that are minimally invasive to our patients.

The periometer, has been theorized to identify discontinuity in coronal tooth structure as well as root structure. Prior in vitro studies with the periometer have shown its capability in detecting macro and micro destructions of various composites materials, and the level of osseointegration of implants to bone (1, 22, 23, 24). To this date, there has not been an in vivo studies or case report documenting the periometer evaluation of vertical root fractured teeth. The periometer provides two pieces of diagnostic information: the loss coefficient of the structure and an analysis of the shape of the energy return vs. time response. Depending on the severity of the defects, such as fractures, loose implant fixtures, or defective restorations, the shape of this response will deviate from the bell-shaped peak obtained for a defect-free tooth or restoration. This change in shape is due to the fact that a significant defect acts as a localized instability in the structure.

The relative extent to which a material deforms inelastically and dampens strain energy may be characterized by the loss coefficient,

$$LC = D/2\pi U$$

where D is the total energy dissipated per unit volume, and U is the input kinetic energy per unit volume provided by the tapping rod (22). The mechanical loss coefficient of damping coefficient measures the degree to which a material dissipates input energy, and therefore its overall stability. In general, microstructural processes that give rise to internal friction will increase the loss coefficient of a material (22). Thus it is reasonable to conclude that damages occurring in root fractures, dental restorations, and implants will augment the damping capacity, as characterized by the loss coefficient, to increase in damaged regions (1, 22, 23, 24).

When comparing the above two clinical cases, it is consistent that the energy return peaks of the fractured teeth resided over a greater time distance than the controls. All energy peaks for the controls did not surpass the 0.25ms marking on the graph. In contrast, all fractured teeth did display energy peaks at or beyond the 0.25ms. A characteristic additional peak is also clearly evident. This additional peak is consistent with the theorized deviation from the Gaussian bell curve one would expect with an inelastic mode of deformation from a fracture in a tooth.

Although these are only a few clinical cases it is quite interesting that the confirmed fractured teeth all have a similar graphical appearance of a late peak after .25ms. It is also an observation that the amplitude of the peak corresponds with the radiographic amount of bone loss. Although this is not definitive evidence of a diagnostic tool, it suggests that a new less invasive diagnositic method may be out there. Both cases had a clinical presentation of a deep periodontal pocket. The graphical presentation of a late peak after 0.25ms may in fact be picking up the inelastic mode of deformation from the periodontal defect. Until more detailed in vitro and in vivo studies are completed, it is unclear if this diagnostic tool can isolate and differentiate the lack of periodontal support from an untreated canal system or failing root canal; from the lack of periodontal support created as a result of a vertical root fracture. Nevertheless, these cases are thought provoking as the hope for a definitive, non-invasive diagnostic tool for vertical root fractures may be possible. Similarities in the shape and characteristics of the graphic analysis suggest that the periometer is a device that may potentially prove to be a useful adjunct in our diagnostic armanterium in diagnosing vertical root fractures.

In conclusion, these two cases show us two terminal teeth with confirmed root fracture having a different graphical presentation with the periometer than either asymptomatic, non-root fractured controls. Further investigations should be done to fully understand the practicalities and limitations of this new diagnostic tool. Evaluation of controls, evaluation of fractures versus bone loss, and evaluation of normal periometer reading for large sample sizes should be performed to gather the information necessary to fully understand the data this instrument has to offer.

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Figures:

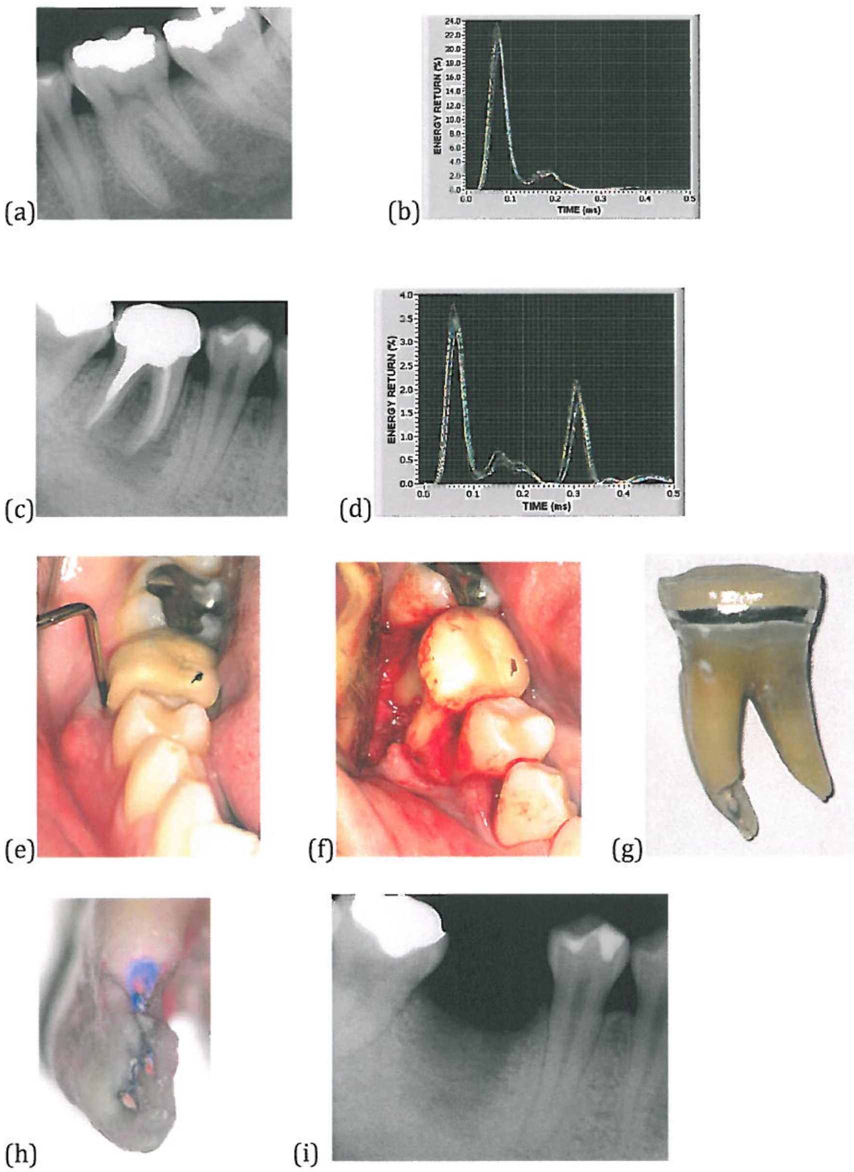

Fig. 1. Images for case 1. (a) Periapical radiograph of the contralateral tooth #19 (lower left first molar) (b) Periometer reading for #19; (c) Tooth #30 with large periapical radiolucency and a 14 mm pobing defect noted on the buccal aspect; (d) Periometer reading of tooth #30; (e) confirmation of a localized deep probing pocket on tooth #30; (f) exploratory surgery noting fenestrated mesial and distal roots; (g) lingual view noting apical resorption of the mesial root; (h) methylene blue staining noting the apical ramifications of the mesial root; (i) post-surgical radiograph confirming no residual tooth structure remains within the site of extraction

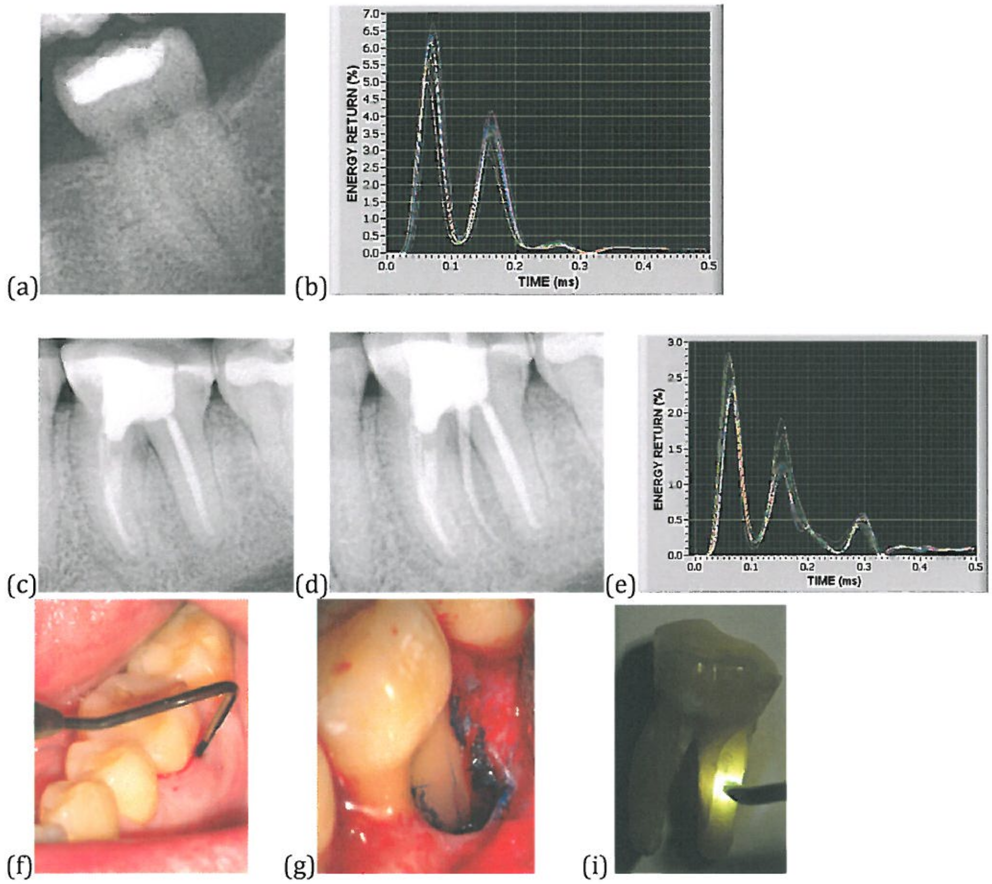

Fig 2. Images for case 2. (a) Radiograph of the lower left molar, tooth #18, taken from the panoramic xray at the time of extraction of tooth #19; (b) Periometer reading for tooth #18; (c,d) periapical radiographs of tooth #19 with a gutta percha sinus tract tracing; (e) Periometer reading of tooth #19 (f) localized periodontal probings noting a 10 mm pocket on the facial aspect of tooth #19; (g) surgical exploration confirming a vertical root fracture on the distal root; (i) atraumatic extraction showing the vertical fracture along the distal root and transillumination of the distal root.