Role of Cone-beam Computed Tomography in Diagnosis of Vertical Root Fractures: A Systematic Review and Meta-analysis

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Abstract

Introduction: The detection of vertical root fractures (VRFs) is a significant challenge for clinicians. Cone-beam computed tomographic (CBCT) imaging has been used recently in this field with high accuracy and sensitivity. Research results about its superiority over periapical radiographs (PRs) are mixed and inconclusive. The aim of this review and meta-analysis was to provide evidence about the accuracy of CBCT imaging in diagnosing VRFs in human teeth with and without endodontic treatment compared with conventional/digital radiography and to establish optimal imaging parameters for accurate VRF detection using CBCT imaging through a systematic approach. **Methods:** A search for eligible studies was conducted from January 1990 to November 2013 in PubMed, Embase, and Cochrane Central Register of Controlled Trials. The Quality Assessment of Diagnostic Accuracy Studies 2 and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis checklists were used to assess the quality of the included studies. Statistical pooling of sensitivity, specificity, and the diagnostic odds ratio were calculated using random effects meta-analysis model and depicted through paired forest plots. The presence of heterogeneity of the included studies was also estimated. **Results:** Eleven studies qualified for systematic review, and 4 studies were considered for meta-analysis. Pooled sensitivity, specificity, and the diagnostic odds ratio of CBCT imaging and PR in filled and unfilled teeth were as follows: CBCT imaging (filled): 0.752, 0.652, and 5.527; PRs (filled): 0.242, 0.961, and 8.586; CBCT imaging (unfilled): 0.776, 0.946, and 94.26; and PRs (unfilled): 0.425, 0.939, and 14.42, respectively. Overall, studies presented heterogeneity varying from moderate to high. **Conclusions:** Results showed better sensitivity and specificity of CBCT scans than PRs in the detection of VRFs in unfilled teeth, particularly when a voxel size of 0.2 mm was used. Low pooled sensitivity and specificity of CBCT imaging was noted in detecting VRFs in endodontically treated teeth. *(J Endod 2016;42:12–24)*

Key Words

Cone-beam computed tomography, diagnostic imaging, meta-analysis, root canal therapy, tooth fractures

Vertical root fractures (VRFs) have been described as longitudinally oriented fractures of the root, extending from the root canal to the periodontium. They may involve the whole length of the root or only a section of it (1, 2). They represent 2%–5% of crown root fractures, with the greatest incidence occurring in endodontically treated teeth and in patients older than 40 years of age (3). The clinical presentation and low sensitivity of conventional radiographs in the detection of VRFs frequently pose a diagnostic dilemma to the clinician. The lack of a definitive diagnosis often leads to unnecessary invasive surgery and/or extraction of the tooth. Often, exploratory surgery is resorted to in order to visualize the fracture (4, 5). The 2-dimensional nature of a conventional radiographic image with superimposition of bony structures may obscure a root fracture, particularly when the orientation of the x-ray beam is not parallel to the plane of the fracture (6, 7). In addition, there may also be geometric distortion of the anatomic structures being imaged. As a result, a fracture may be missed when interpreting the image (8).

The inability to accurately visualize VRFs using conventional imaging modalities calls on the need for the development of alternative imaging systems for the improvement of diagnosis of VRFs. Cone-beam computed tomographic (CBCT) imaging represents an advancement in dentomaxillofacial imaging and has fundamentally replaced conventional tomography for several diagnostic tasks in dentistry (9, 10). The main advantage of CBCT imaging is its lower acquisition time and patient dose when compared with medical computed tomographic scanning (11, 12). CBCT imaging uses a cone-shaped x-ray beam centered on a 2-dimensional sensor to scan a 180° to 360° rotation around the patient's head to acquire a full 3-dimensional volume of data, thus allowing the precise visualization and evaluation of teeth with VRFs. A CBCT diagnosis achieves more sensitivity, specificity, and accuracy in the detection of VRFs compared with periapical radiographs (PRs) as shown by previous studies (6–8, 13–20).

The selection of the reconstruction plane (axial, coronal, and sagittal) used for the detection (21) and a number of variables such as the scanning unit, the field of

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TABLE 1. Criteria for the Selection of Studies in Third Phase Screening

Inclusion criteria	Exclusion criteria
1. Studies that mention CBCT as a diagnostic tool in detection of VRFs 2. Studies performed on human permanent teeth *in vitro* or *in vivo* 3. *In vivo* studies that have verified VRFs by surgical exploration 4. Studies that have mentioned all exposure parameters for both radiographs and CBCT (kVp, mA, field of view, voxel size, and resolution) for image acquisition 5. Studies in which accuracy parameter such as sensitivity, specificity, or receiver operating characteristic curves were used (at least 1 of them)	1. *In vitro* studies in which baseline evaluation to confirm the absence of VRF in the samples was missing 2. Studies that do not have a minimum of 2 calibrated examiners to evaluate VRFs in the CBCT/radiography group 3. Studies not consistent with the appearance of VRFs on radiographs/CBCT according to its definition (ie, complete or incomplete fracture initiated from root at any level)

CBCT, cone-beam computed tomography; VRF, vertical root fracture.

view, examination time, tube voltage and amperage, and spatial resolution defined by the voxel size could have an influence on the ability of CBCT imaging to detect VRFs (22, 23). In addition, the validity of a CBCT diagnosis of root fractures may be reduced by the presence of radiopaque materials in the root canal such as gutta-percha and metallic posts (7, 21, 15, 24, 25), which may be associated with beam hardening and streak artifacts that might mimic a fracture line (7).

Although the majority of investigations have shown that the sensitivity of CBCT imaging in detecting VRFs was significantly higher than PRs, few studies have found conflicting results. These studies have not reported any significant difference in performance between CBCT imaging and radiographs (26, 27). The range of reported results is extensive and contradictory. Systematic reviews are important to summarize the advances in health care for practitioners in order to ensure the correct implementation and adoption of research

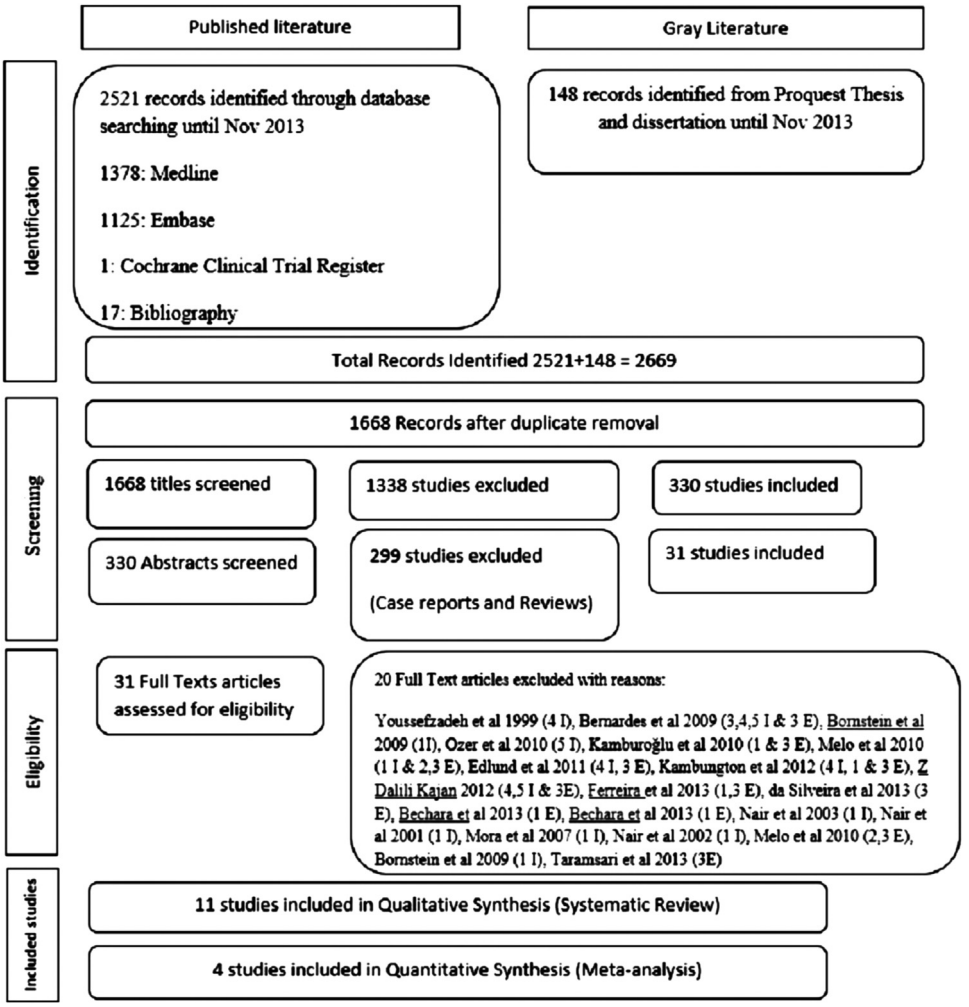

Figure 1. Study selection flow.