Patient-centered Outcomes Assessment of Retreatment and Endodontic Microsurgery Using Cone-beam Computed Tomographic Volumetric Analysis

Darrell M. Curtis, DDS, Richard A. VanderWeele, DMD, Jarom J. Ray, DDS, and James A. Wealleans, DMD

Abstract

Introduction: Outcomes assessment of retreatment and endodontic microsurgery (EMS) are traditionally based on clinical findings and radiographs. The purpose of this study was to assess the volumetric change of periapical radiolucencies (PARLs) by cone-beam computed tomographic (CBCT)-based analysis in retreatment and EMS cases. **Methods:** For 68 retreatment and 57 EMS cases, preoperative and recall clinical data, periapical (PA) radiographs, and CBCT imaging were retrospectively obtained. Specialized software was used by 2 board-certified endodontists for volumetric analysis of PARLs. For EMS and retreatment, clinical outcomes were determined by combining clinical data with CBCT-generated volumetric analysis (PA radiographs not used). Additionally, comparisons of percent volume reduction for EMS and retreatment were performed. Examiner interpretations of outcomes assessment using PA radiography and CBCT imaging were compared. **Results:** In teeth with or without a preoperative PARL, EMS resulted in a statistically significant difference in complete healing (49/57 [86.0%]) versus retreatment (28/68 [41.2%], $P < .0001$). EMS resulted in a statistically significant difference in combined complete healing and reductive healing (54/57 [94.7%]) versus retreatment (56/68 [82.4%], $P < .05$). Of 46 recalls in which CBCT imaging detected a PARL, PA radiography detected 30 (a 35% false-negative rate). Of the 79 recall studies in which CBCT imaging did not detect a PARL, PA radiography did detect PARL in 13 (a 16.5% false-positive rate). **Conclusions:** In this CBCT and clinical data-based outcomes assessment, EMS resulted in a greater mean volumetric reduction and a higher healing rate compared with retreatment. Postoperative CBCT imaging is more sensitive and specific than PA radiography in assessing PARL and has demonstrable usefulness in outcomes assessment. *(J Endod 2018;■:1–6)*

Key Words

Amira, apical periodontitis, cone-beam computed tomography, endodontic microsurgery, retreatment, volumetric periodontitis

Significance

This study affords the endodontic community the ability to assess the effectiveness of 2 endodontic procedures: nonsurgical root canal retreatment and root-end surgery using contemporary materials and methods.

Apical periodontitis occurs as the microbial infection of the root canal system activates the host immune response. Endodontic treatment aims to eradicate and entomb microbes, precluding interaction with periradicular tissues and resulting in regeneration or repair of the affected site (1–3). Healing of apical periodontitis can be initiated by root canal therapy, retreatment, endodontic surgery, or extraction and is evidenced by normal function, absence of clinical signs and symptoms, and radiographic evidence of osseous regeneration with reestablishment of a periodontal ligament space.

Two-dimensional periapical (PA) radiographs are the most commonly used imaging technique for endodontic outcomes assessment; they detect lesions when there is perforation of the cortical plate or erosion of the inner or outer surface of the cortex (4). Lesions that are confined to the cancellous bone may not be detected by PA radiographs. Furthermore, limitations in lesion detection with PA radiographs occur because of geometric distortion and superimposition of several radiodensities of bone and soft tissue at various depths into 1 planar image. The clinician is then required to "interpret" this planar summation of radiodensities, factoring in the possibility of geometric distortion, before determining an outcomes assessment. Often, this has the effect of inaccurate interpretations of lesion size and false-negative and, less commonly, false-positive designations (5, 6).

Historic studies using 2-dimensional radiographic interpretations show that it may take up to 4 years for healing to occur after root canal therapy (7). A 4-year observation period after endodontic surgery in cases showing uncertain healing has been proposed (8). Radiographic designations for osseous healing after endodontic surgery have classically been divided into 4 groups: complete healing, incomplete healing, uncertain healing, and unsatisfactory healing (9). Recall examinations over a 4-year period do not always occur. More sensitive and specific 3-dimensional (3D) imaging measures might provide a more clear and timely patient-centered outcomes assessment.

From the Air Force Postgraduate Dental School, Uniformed Services University of the Health Sciences Postgraduate Dental College, Joint Base San Antonio-Lackland, Texas.

Address requests for reprints to Dr Darrell M. Curtis, Air Force Postgraduate Dental School Endodontics, 2133 Pepperrell St, Lackland, TX 78236. E-mail address: dmcurtis11@gmail.com

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Cone-beam computed tomographic (CBCT) imaging uses x-ray beams to acquire multiple images that render a 3D representation of the teeth and surrounding tissues. Tissue can be analyzed in axial, coronal, and sagittal views. Recent evidence indicates an enhanced diagnostic ability of CBCT imaging over 2-dimensional radiography in the detection of periapical lesions (10–16) (Fig. 1). Mota de Almeida et al (17) found that treatment plan alterations were made in 53% of the referred endodontic patients for whom a preoperative CBCT scan was acquired. Ee et al (18) reported endodontic treatment plan alterations occurred in 62.2% of cases after CBCT imaging versus PA radiographs alone. Rodríguez et al (19) concluded that "CBCT imaging has a substantial impact on endodontic decision making among specialists, particularly in high difficulty cases." CBCT images can be imported into specialized imaging software for periapical radiolucency (PARL) volume rendering based on detailed tracings. This method might overcome interpretation errors inherent with 2-dimensional PA radiographs alone, specifically the presence or absence of osseous healing or healing trends. Counterarguments suggest that the ultimate benefit of CBCT imaging in endodontics is unclear, and its routine use for detecting PARLs is not justified (20, 21).

Given the potential gains in sensitivity and specificity in outcomes assessment, studies incorporating CBCT imaging preoperatively and at recall are warranted. A gap in knowledge is shown by cases in which an outcome seems unclear based on PAs alone but becomes clear with CBCT imaging. Recent studies have found that postoperative CBCT imaging yields a less favorable outcome assessment versus PA radiographs alone for initial root canal treatment, retreatment, and endodontic microsurgery (EMS) (22–24). The question is should CBCT imaging routinely be used in the assessment of postoperative outcomes.

The aim of this retrospective case series was to assess the treatment outcomes for retreatment and EMS through clinical assessment and a CBCT-based calculation of volumetric change. The study also compares PA radiographic interpretations with CBCT findings by examiners in identifying and characterizing PARLs.

Materials and Methods

Potential subjects were retrospectively identified using a database containing all patients who were at least 18 years of age and who had received retreatment or EMS in the endodontics residency at Wilford Hall Ambulatory Surgical Center, Lackland AFB, TX, between July 1, 2011, and July 31, 2015. Patients whose treatment included pretreatment PA radiographs and CBCT imaging and who returned for a recall examination (range, 12–53 months) with PA radiographs and CBCT imaging were included in the study. Criteria were met by 97 patients with 125 teeth: 68 retreatments and 57 EMS treatments. The mean patient age was 47.7 years with a range of 19–86 years with 54 men and 43 women. A retrospective outcomes assessment was conducted based on clinical and CBCT (instead of PA radiography) findings. The 59th Medical Wing Institutional Review Board approved the protocol.

Treatment Protocol

Treatments were completed by endodontic residents under the supervision of board-certified endodontists. Retreatment and EMS were completed using a dental operating microscope (OPMI PROergo; Zeiss, Oberkochen, Germany) and contemporary materials and techniques. The retreatment protocol involved the use of a rubber dam, 6%–8.25% sodium hypochlorite, 17% EDTA, 2% chlorhexidine, calcium hydroxide interappointment dressing for a minimum of 7 days as deemed necessary by the provider, gutta-percha and Roth 811 (Roth international, Chicago, IL, USA) sealer, and bonded orifice barriers (Vitrebond; 3M ESPE, St Paul, MN, or PermaFlo Purple; Ultradent, St Louis, MO). The apical surgery protocol involved full-thickness mucoperiosteal flap reflection, osteotomy preparation and root-end resection, ultrasonic preparation, and root-end fillings with gray or white ProRoot MTA (Dentsply, Tulsa, OK) or EndoSequence BC Root Repair Material (Brassler USA, Savannah, GA). Nine osteotomy sites were grafted with calcium sulfate and OraGraft DFDBA (LifeNet Health, Virginia Beach, VA), and 1 site was grafted with Bio-Oss Collagen (Geistlich Biomaterials, Princeton, NJ). No membranes were used.

CBCT scans with 60 × 60 mm or 40 × 40 mm fields of view at 90 kVp and 5–9 mA were generated with the 3D Accuitomo 170 (J. Morita USA, Irvine, CA). All preoperative and postoperative periapical images were taken using a paralleling technique and external cone positioning device using size 2 digital sensors (RVG 6100; Kodak, Rochester, NY). A dental x-ray machine (Planmeca Intra, Helsinki, Finland) was used to expose the sensors with adjustable kVp, mA, and time settings dependent on patient size and location in the oral cavity.

Clinical Data Collection and Interpretation

Deidentified preoperative and recall clinical data were entered into a secure digital file. A random sequence generator was used to assign each patient a number such that the clinical data obtained from patient records could be matched with corresponding radiographic imagery. Preoperative variables that were analyzed included the presence of pain, percussion and palpation findings, probing depths, the presence of a sinus tract, and the presence of

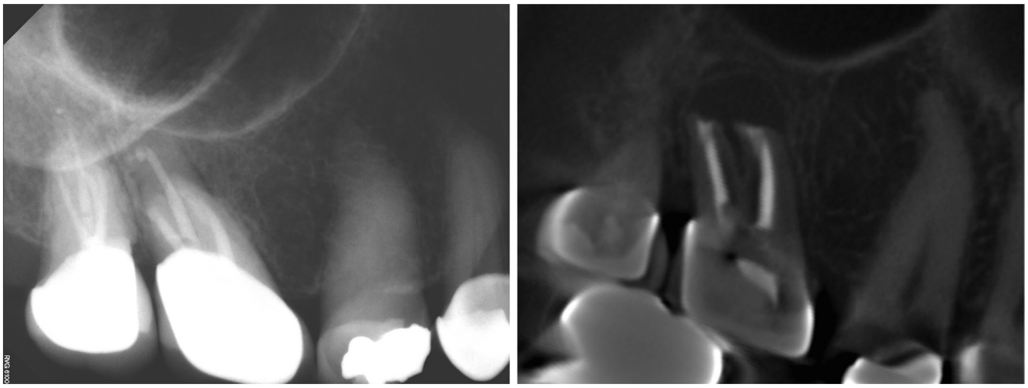

Figure 1. At 32 months after apical surgery, the PA radiograph on the left indicates no apical radiolucency associated with tooth #2. In contrast, the CBCT image on the right was taken on the same date and clearly indicates a PARL associated with the mesiofacial and distofacial roots of tooth #2.