Accuracy of Cone-beam Computed Tomographic Image Interpretation by Endodontists and Endodontic Residents

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Abstract

Introduction: Limited field cone-beam computed tomography (CBCT) imaging has become a modality frequently used by endodontists to evaluate the teeth and surrounding tissues of their patients. Accurate image interpretation is vital to obtain needed treatment information as well as to discern coincidental findings that could be present. The goal of this study was to determine the accuracy of CBCT volume interpretation when performed by endodontists and endodontic residents. **Methods:** Eighteen deidentified limited field CBCT scans were obtained and evaluated by an oral and maxillofacial radiologist and an endodontist experienced in reading CBCT images. Their collective findings were combined as the "gold standard" of interpretation for this investigation. Using standard CBCT software, 4 practicing endodontists and 5 second-year endodontic residents evaluated each scan and recorded any notable findings and whether or not each scan warranted referral to a radiology specialist. Their interpretations were then compared with the gold standard to determine accuracy and any significant differences among the groups. **Results:** The overall accuracy was 58.3% for endodontists and 64.3% for residents. Paired *t* tests showed no statistically significant differences in accuracy between the 2 groups for findings in teeth or in bone, but residents were significantly better for maxillary sinus findings. Endodontists agreed with the gold standard 38.9% of the time and residents 49.8% of the time on necessity of referral. The Cohen kappa coefficient showed moderate agreement between the groups. **Conclusions:** Endodontists and residents had similar accuracy in CBCT scan evaluation. More training and experience are warranted for both groups in order to maximize image assessment accuracy. *(J Endod 2018;■:1–5)*

Key Words

Accuracy, cone-beam computed tomography, pathology, radiology, referral

Significance

When a CBCT image is acquired, the ability to accurately interpret the image is needed to adequately diagnose and treat patients. This study evaluated accuracy of interpretation of limited FOV CBCT images by clinicians with different levels of clinical experience.

Before any endodontic treatment modality is performed on a tooth, a thorough history should be obtained, and a clinical and radiologic examination must be completed (1). Historically, radiologic imaging in endodontics has been limited to 2-dimensional bitewing, periapical, and panoramic radiographs. The past decade has brought about the increased use of a newer imaging modality—cone-beam computed tomographic (CBCT) imaging. CBCT imaging is an excellent imaging modality for use in endodontics because it allows visualization of the oral cavity and the associated structures in a 3-dimensional aspect instead of the 2-dimensional nature of conventional radiographs (2). Cone-beam technology uses a cone-shaped beam of radiation to acquire an image volume in a single 360° rotation, similar to panoramic radiography. The type of CBCT unit used determines the anatomic area of interest viewable on the image or the field of view (FOV). This area can range from large to limited, with limited FOV being most commonly used by endodontists because of its higher resolution, lower radiation dose, and smaller volume to be interpreted (3). With the help of viewer software, clinicians are able to evaluate the entire volume and simultaneously view axial, coronal, and sagittal 2-dimensional sections, thus creating a 3-dimensional reconstruction of the area of interest (4). The axial and proximal (sagittal in the anterior and coronal in the posterior) views are of particular value to endodontists because they are typically not clearly visualized with conventional periapical radiography (5). Also, the ability to reduce or eliminate superimposition of the surrounding anatomic structures makes CBCT imaging superior to conventional periapical radiography (6). An increasing number of endodontists are using CBCT volumes to augment their diagnosis, treatment planning, and clinical procedures. (7).

Previous studies have shown that 3-dimensional CBCT imaging is able to reveal 35%–40% more findings than conventional 2-dimensional radiography alone, which has led to the increased use of this imaging modality in endodontics (1). Recently,

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the American Association of Endodontists in conjunction with the American Academy of Oral and Maxillofacial Radiology released a position article outlining recommendations for CBCT use in endodontics (3). As often occurs with newly introduced technology, a number of providers who acquire or interpret CBCT scans may not have received formal training to do so. A survey of dental schools in the United States revealed that 81% of schools provide basic training in CBCT interpretation (8). It has also been reported that variability exists among postgraduate dental specialty programs regarding the level of training in CBCT scan interpretation that their residents receive. In 1 study, 81% of surveyed oral surgery program directors reported the provision of training to their residents in CBCT interpretation (9). For orthodontic residency programs, 73% reported CBCT use (10). Any reduction in image interpretation training below an ideal level could put patients at risk if their CBCT scans contain abnormal or pathologic findings that are not correctly identified or interpreted by the prescribing provider. Likewise, dentists may need guidance on when referral to an oral and maxillofacial radiologist (OMR) for interpretation is warranted or appropriate. Publications have reported cases in which potential pathological findings that were missed by a dental specialist were found by an OMR upon referral (11). Another study showed that orthodontists were only able to diagnose 56% of the findings on CBCT scans, even after a basic training course (12). More recent studies by Parker et al (13), and Oser et al (14) showed that experience level appears to be correlated with the ability to correctly diagnose periapical lesions in CBCT volumes, and radiologists are more likely than residents to identify incidental findings in limited FOV CBCT scans.

Endodontists typically evaluate their own CBCT images immediately after acquisition, and some of those viewing the scans may not have the same background and expertise at interpreting the radiographs as experienced oral and maxillofacial radiologists. As a result, important findings such as tumors, inflammatory sinus changes, root fractures, bone abnormalities, or other pathological conditions in the images that could be detrimental to the patient could be missed or overlooked (15). Such problems can be avoided if CBCT scans are evaluated and interpreted thoroughly and accurately in the first place. It is unknown how accurate endodontists are in interpreting CBCT scans. The purpose of this study was to evaluate the accuracy of endodontists and endodontists in training (residents) in interpreting small FOV CBCT scans and to investigate reviewer recommendations as to whether referral to an OMR was warranted for any of the scans.

Material and Methods

Institutional review board approval was obtained from the Institutional Review Board at Louisiana State University (LSU) Health Sciences Center, New Orleans, LA, and informed consent was obtained from all participants in the study. The study design was similar to previous studies by Parker et al (13) and Ahmed et al (12). Eighteen deidentified limited FOV CBCT scans were used in the study. The images were selected from a database of patient scans taken at the LSU postgraduate endodontics department using the Carestream 9000 CBCT scanner (Carestream Health, Inc, Rochester, NY) as well as from a database of scans forwarded by the imaging company Carestream. The FOV was cylindrical, and the voxel size was 76 μm. Volumes were selected to include conditions or entities that one would expect to encounter in a traditional endodontic practice. Included were normal anatomic variations, periapical radiolucency or opacity, sinus variations, previous root canal therapy of varied quality, root fractures, trabecular pattern of bone, and bone tumors or cysts.

Invitations to participate were sent via e-mail to endodontists in private practice in the area and residents in the endodontics programs at LSU School of Dentistry and US Air Force Keesler Medical Center, Biloxi, MS, and those who agreed to participate were included in the study. Each CBCT volume was interpreted by 4 endodontists in private practice in south Louisiana as well as 3 second-year residents in the postgraduate endodontics program at LSU School of Dentistry and 2 second-year residents from the US Air Force Keesler Medical Center endodontics program. All residents had undergone training in CBCT interpretation in their postgraduate programs, and the participating private practice endodontists routinely evaluated limited field CBCT scans in their practices.

All participants were familiar with the Carestream CS 3D Imaging viewer software version 3.5.7 and used it to view the scans. This allowed interpretation of the scans in the axial, sagittal, and coronal planes. To accurately assess the true everyday accuracy of the participants, reviewers were asked to view the scans in the physical setting in which they usually view CBCT volumes in practice. For the private practice endodontists, this included their own monitor in their office under their usual lighting conditions; for the residents, this included the clinic monitors in the postgraduate endodontics clinics at their respective programs. Reviewers were given a disk containing the volumes and a recording sheet. Each individual was instructed to use their normal routine and pattern in reviewing each scan. They were permitted to use any pattern of planar and curved slices and oblique orientations and to manipulate each image in any way they believed was needed to properly assess the volume. They were then asked to describe and annotate the location of any finding within the scans they considered as notable or important. Additionally, for each of the 18 scans, they were asked to indicate if they believed referral of the image to a radiologist for interpretation was necessary. They were instructed to take a 10-minute break after every 30 minutes of viewing time to minimize fatigue effects. All disks and completed data sheets were returned within 30 days. All responses were entered into a spreadsheet, organized by scan and evaluator, and then grouped according to the location of the finding (ie, bone, teeth, or maxillary sinus). This data set was compared with that of the previously established "gold standard," allowing each finding to be designated as true positive (TP), true negative (TN), false positive (FP), or false negative (FN).

For findings related to location, the following were used:

1. TP: a correct location and description for a finding that was indicated as such by the gold standard
2. FP: an incorrect location or description of a finding for a site that has no finding according to the gold standard
3. TN: there is no entry on the recording sheet for a site that has no finding according to the gold standard
4. FN: there is no entry on the recording sheet for a site that actually does contain an abnormality according to the gold standard

For findings according to referral recommendation, the following were used:

1. TP: the observer refers a scan that should be referred.
2. FP: the observer refers a scan that did not require referral
3. TN: the scan did not require referral, and the observer does not refer that scan
4. FN: the scan did require referral, but the observer does not refer that scan

The accuracy of interpretation and agreement on the necessity of referral was determined by comparing the results of the reviewers with the consensus opinion of an experienced radiologist and an endodontic faculty member at LSU Department of Endodontics experienced in interpreting CBCT scans. Both independently reviewed the scans.