Binary Decision Trees for Preoperative Periapical Cyst Screening Using Cone-beam Computed Tomography

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Abstract

Introduction: Cone-beam computed tomographic (CBCT) analysis allows for 3-dimensional assessment of periradicular lesions and may facilitate preoperative periapical cyst screening. The purpose of this study was to develop and assess the predictive validity of a cyst screening method based on CBCT volumetric analysis alone or combined with designated radiologic criteria. **Methods:** Three independent examiners evaluated 118 presurgical CBCT scans from cases that underwent apicoectomies and had an accompanying gold standard histopathological diagnosis of either a cyst or granuloma. Lesion volume, density, and specific radiologic characteristics were assessed using specialized software. Logistic regression models with histopathological diagnosis as the dependent variable were constructed for cyst prediction, and receiver operating characteristic curves were used to assess the predictive validity of the models. A conditional inference binary decision tree based on a recursive partitioning algorithm was constructed to facilitate preoperative screening. **Results:** Interobserver agreement was excellent for volume and density, but it varied from poor to good for the radiologic criteria. Volume and root displacement were strong predictors for cyst screening in all analyses. The binary decision tree classifier determined that if the volume of the lesion was >247 mm^3, there was 80% probability of a cyst. If volume was <247 mm^3 and root displacement was present, cyst probability was 60% (78% accuracy). **Conclusions:** The good accuracy and high specificity of the decision tree classifier renders it a useful preoperative cyst screening tool that can aid in clinical decision making but not a substitute for definitive histopathological diagnosis after biopsy. Confirmatory studies are required to validate the present findings. *(J Endod 2017;43:383–388)*

Key Words

Binary decision tree, cone-beam computed tomography, cyst screening, differentiation between cysts and granulomas, volumetric analysis

Significance

A preoperative cyst screening tool may aid in clinical decision making. This study developed a simple classification tree with only lesion volume and root displacement as input variables. The high specificity of the constructed decision tree renders it a meaningful preoperative cyst screening tool.

Periradicular granulomas and cysts are the most common lesions associated with periradicular pathologies, with their combined incidence exceeding 90% (1–3). A significant clinical question remains—whether the presence of a periradicular cyst may affect root canal treatment success. It has been suggested that "pocket" cysts may regress after root canal treatment because of their association with the infected root canal system (4). On the other hand, "true" cysts are completely separate from the root canal, are thought to be self-sustained, and are perhaps less likely to heal by nonsurgical root canal therapy alone (5). Currently, the gold standard diagnosis of periradicular lesions is by histopathological analysis. Histopathological assessment is a definitive yet inevitably postoperative diagnostic test that requires surgical excision of the lesion. Therefore, it cannot contribute to the preoperative assessment of periradicular lesions or shape clinical decision making. Timely identification of cysts may alter the therapeutic approach and considerations for surgical intervention. To date, accurate and reliable methods for preoperative cyst screening are not available. A cyst screening could be an invaluable tool to clinicians in the decision-making process that is involved in the treatment of cases with periradicular pathology.

Several studies have attempted to develop a method to preoperatively differentiate between granulomas and cysts (6–11). Water-soluble contrast media, Papanicolaou smears, albumin tests, computed tomographic imaging, and ultrasound have been some of the methods investigated for periapical cyst screening with either limited accuracy or practicality (6–11). Studies have also tested more practical chairside methods, such as radiologic examination of 2- (2D) and 3-dimensional (3D) radiographs for cyst screening; nonetheless, the majority of previous studies have reported poor reliability and moderate accuracy for these techniques (12, 13). Indeed, limitations of 2D radiographs include the frequent misrepresentation of the actual size of the lesion or the associated bone destruction, which makes it clinically impossible to develop a

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valid and reliable method for cyst screening. On the other hand, cone-beam computed tomographic (CBCT) imaging has been shown to more accurately detect and measure periapical lesions than 2D radiographs (14). Despite the latter, studies have been contradictory in regard to cyst screening based on CBCT assessment and have reported varying reliability mainly because of the use of categoric radiologic criteria as predictors (12, 13, 15).

Dedicated software applications have been developed that allow the extraction of a large breadth of data from CBCT scans and offer applications such as bone density and lesion volume measurements. These continuous measures could potentially aid in CBCT assessment for diagnostic purposes. Indeed, Simon et al (16) assessed bone density at the lesion site as a possible diagnostic method for cysts and showed that the diagnosis based on CBCT density was consistent with the pathological report in 13 of 17 cases. Lesion volume has not been previously used for preoperative cyst screening but has been recently used as an outcome measure in multiple studies (17–19). In fact, CBCT volumetric analysis has been shown to accurately measure lesion volume in *in vitro* defects (20). We hypothesized that lesion volume assessment alone or combined with bone density and/or radiographic assessment can aid as a cyst screening tool. Therefore, the purpose of this study was to develop and validate a cyst screening method based on CBCT volumetric analysis.

Materials and Methods

Data Collection

The study received approval from the Institutional Review Board of the University of Texas Health Science Center at San Antonio (UTHSCSA), San Antonio, TX. The subject population was outpatients who underwent apicoectomies at the Department of Endodontics Clinic at UTHSCSA and Wilford Hall Endodontic Clinic at Joint Base San Antonio-Lackland (US Air Force) from June 1, 2010, through January 31, 2016. Inclusion criteria incorporated records of presurgical CBCT imaging and accompanying records of surgical biopsy of the periapical lesion with histopathological diagnosis of either a cyst or granuloma. The principal investigator (V.C.) identified eligible subjects and subsequently deidentified each CBCT scan by assigning a number (ie, #001) to each subject to ensure patient confidentiality. The subjects' deidentification numbers were assigned to the corresponding histopathological report that included a diagnosis of either a cyst or granuloma. The CBCT scans at the UTHSCSA endodontic clinic were obtained with the Kodak 9000 3-D (Carestream Health Inc, Rochester, NY) using the following settings: field of view of 4 × 5 cm, 70 kVp, 10 mA, and a 0.076-mm voxel size. The scans at the US Air Force clinic were obtained with the 3D Accuitomo (J. Morita USA, Irvine, CA) at 4 × 4 cm field of view, 90 kVp, 5 mA, and a 0.08-mm voxel size. Two endodontists (A.A. and B.P.) and 1 oral and maxillofacial radiologist (M.N.) served as independent and blinded examiners for this study. The examiners were trained and underwent a calibration session using CBCT imaging showing periapical lesions not included in the present study. Finally, all the included CBCT scans were imported to specialized imaging software (Amira 5.3.4; Visage Imaging GmbH, Berlin, Germany) in preparation of the independent volumetric, densimetric, and radiologic assessment by the 3 reviewers.

Lesion Volume and Density

Periapical lesion volume was measured by following a segmentation procedure in the specialized software as previously described (17). Briefly, each reviewer traced out the lesion borders in all 3 CBCT planes with the use of a lasso tool followed by a 3D reconstruction of the radiolucency with the use of an interpolation feature. Finally, the volume of the selected area was calculated in mm^3 in the software (Fig. 1).

In regard to density, we used the average gray value from the mapped area as calculated by the software. We further recorded gray values of dentin tissue from 5 different scans using the Kodak or Accuitomo system for internal calibration purposes because different CBCT devices may vary in density measurements (21, 22). Then, we calculated the ratio of the mean dentin density value given by Accuitomo and Kodak, and we used this ratio (R = 2.84) to adjust the lesion density measurements for between-unit standardization before data analysis.

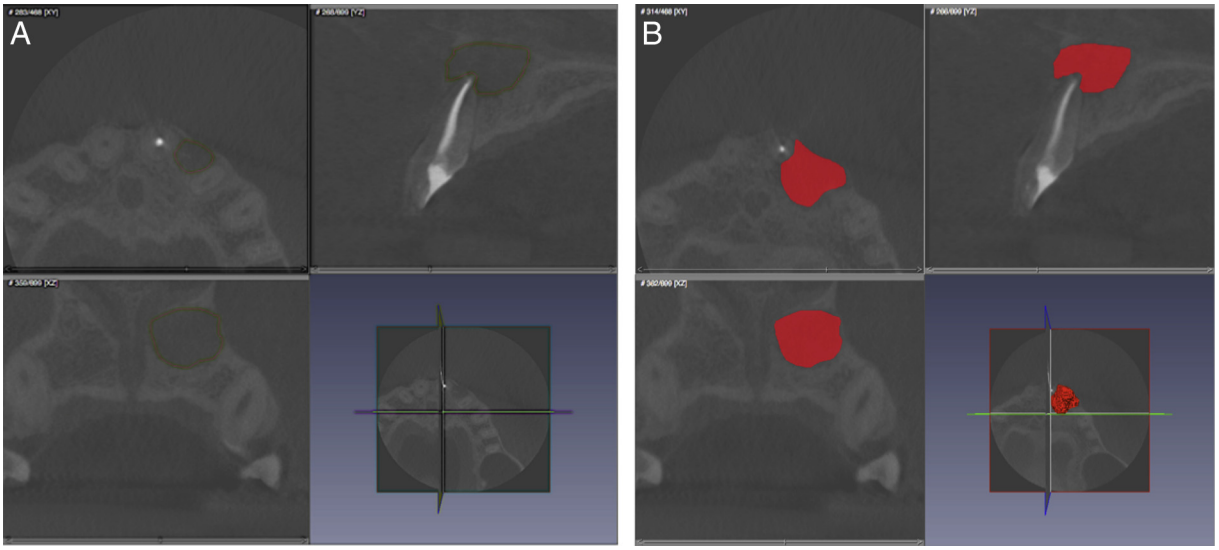

Figure 1. A segmentation procedure with the use of specialized software. (*A*) Tracing of periapical lesion borders in all 3 CBCT planes with the use of a lasso tool. (*B*) 3D reconstruction of the radiolucency with the use of an interpolation feature. The software calculates volume and density at the end of the segmentation process.