Comparison between Radiographic (2-dimensional and 3-dimensional) and Histologic Findings of Periapical Lesions Treated with Apical Surgery

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Abstract

Introduction: The aim of this study was to evaluate the concordance of 2- and 3-dimensional radiography and histopathology in the diagnosis of periapical lesions. **Methods:** Patients were consecutively enrolled in this study provided that preoperative periapical radiography (PR) and cone-beam computed tomographic imaging of the tooth to be treated with apical surgery were performed. The periapical lesional tissue was histologically analyzed by 2 blinded examiners. The final histologic diagnosis was compared with the radiographic assessments of 4 blinded observers. The initial study material included 62 teeth in the same number of patients. **Results:** Four lesions had to be excluded during processing, resulting in a final number of 58 evaluated cases (31 women and 27 men, mean age = 55 years). The final histologic diagnosis of the periapical lesions included 55 granulomas (94.8%) and 3 cysts (5.2%). Histologic analysis of the tissue samples from the apical lesions exhibited an almost perfect agreement between the 2 experienced investigators with an overall agreement of 94.83% (kappa = 0.8011). Radiographic assessment overestimated cysts by 28.4% (cone-beam computed tomographic imaging) and 20.7% (periapical radiography), respectively. Comparing the correlation of the radiographic diagnosis of 4 observers with the final histologic diagnosis, 2-dimensional (kappa = 0.104) and 3-dimensional imaging (kappa = 0.111) provided only minimum agreement. **Conclusions:** To establish a final diagnosis of an apical radiolucency, the tissue specimen should be evaluated histologically and specified as a granuloma (with/without epithelium) or a cyst. Analysis of 2-dimensional and 3-dimensional radiographic images alike results only in a tentative diagnosis that should be confirmed with biopsy. *(J Endod 2015;41:804–811)*

Key Words

Apical surgery, cone-beam computed tomographic imaging, cyst, granuloma, periapical lesion, periapical radiography

Periapical lesions are the most frequently diagnosed pathosis of odontogenic origin in human teeth. The condition is generally described as apical periodontitis. The etiologic factor is the colonization and presence of microorganisms within the pulp canal system (1). Bacteria cause the release of intercellular mediators, humoral antibodies, and effector molecules into the periapical tissues (2). The host response is further characterized by bone resorption and an extraradicular infection resulting in radiographically visible hypodense areas. After endodontic treatment, the periapical lesion should heal with hard tissue regeneration and resolution of the radiolucency. However, in some cases, the apical periodontitis persists despite root canal treatment, and, therefore, further endodontic treatment must be considered (2). The reasons for this phenomenon have not yet been completely clarified. A complex anatomy of the root canal system, missed canals, unfilled isthmuses, leaking fillings, ineffective instrumentation, or inaccessible regions with difficult control and elimination of infection with orthograde treatment can lead to persistent apical periodontitis (3). Apical surgery is indicated when a previously root canal–filled tooth cannot be retreated by conventional endodontics (4).

To date, there is no validated method for preoperative differentiation of a granuloma from a radicular cyst. Biopsy with subsequent histopathological evaluation is the gold standard for the final diagnosis of apical lesions (5–7). The introduction of 3-dimensional (3D) radiographic imaging, specifically cone-beam computed tomographic (CBCT) imaging in 1998, has had a huge impact in dental medicine (8). Until the introduction of CBCT imaging, 3D radiographic imaging was limited to selected cases using computed tomographic (CT) imaging, but CT imaging is limited by cost, accessibility, and radiation dose exposure to patients (9). CBCT imaging has now become the 3D imaging method of choice in many fields of dentistry (10, 11). CBCT technology has been particularly recommended for cases in which apical surgery is being considered (11, 12). Periapical lesions are often missed or not clearly visible in conventional periapical radiographs (PRs) because of superimposition of cortical bone plates or other anatomic structures (13, 14). Furthermore, 3D imaging shows the correct relationship of periradicular lesions to adjacent structures. The clinician can also orient the reconstructed slices resulting in orthogonal views that are parallel or perpendicular to the long axis of the root under investigation (13, 15).

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The objective of the present study was to evaluate the concordance of 2-dimensional (2D) and 3D radiography and histopathology in the diagnosis of periapical lesions.

Materials and Methods

Case Selection

A total of 136 teeth with periapical lesions were treated with apical surgery between November 2011 and September 2013. Patients had been referred for apical surgery by their private dentists or from other departments of the dental school. Initially, clinical and radiographic examinations were performed. All of the patients signed a consent form according to the Declaration of Helsinki (www.wma.net). The protocol of the present study was reviewed and approved by the ethical committee of the Canton of Bern (approval number: KEK-BE: 098/11). Indications for apical surgery were based on the guidelines of the consensus report of the European Society of Endodontology (4). Exclusion criteria for apical surgery were advanced periodontal disease; root fracture; nonfunctional teeth; nonrestorable teeth; post perforation; absence of buccal bone plate; and general contraindications like missing compliance, mental disorders, or medical reasons (16). Patients already referred with CBCT imaging or refusing to have a CBCT scan taken at the initial examination were excluded. In some patients, the PR had been taken by the referring dentist, and this was accepted if the time gap was less than 2 weeks before CBCT imaging. Patients younger than 18 years were excluded from this study. Furthermore, in patients with multiple apical surgeries performed, 1 tooth was randomly selected (Quickcalcs; GraphPad Software Inc, La Jolla, CA) for further analysis. Finally, a total of 62 teeth in the same number of patients were enrolled in the present study.

Preoperative Radiographic Examination and Analysis

The PR was made using a paralleling technique with an x-ray film holder (Rinn XCP; Dentsply, Elgin, IL). The x-ray machine (HDX; Dental Ez, Lancaster, PA) was set at 65 kV and 7 mA; the exposure time for the periapical x-ray was 0.12 seconds. Digital imaging plates (Soredex, Tuusula, Finland) were used and read by a screen reader (Digora Optime, Soredex). The size of the imaging plates (size 0: 21 × 31 mm, size 1, 24 × 40 mm, size 2: 31 × 41 mm, and size 3: 27 × 54 mm) was chosen according to the clinical situation.

The CBCT images were obtained with the 3D Accuitomo 170 (Morita, Kyoto, Japan). The normal size of the field of view was 4 × 4 cm for the upper and lower jaw. In the posterior maxilla, a field of view of 6 × 6 cm was chosen to document any lesions expanding into the maxillary sinus. The parameters of the recordings were 3.0 mA and 80 kV with an exposure time of 17.5 seconds.

The largest diameter in millimeters of the periapical radiolucency was measured on PR and CBCT images (all 3 dimensions: axial, sagittal, and coronal) by 1 blinded examiner. All measurements were taken twice, and the calculated mean was used for further analysis. For the PR, the lesions were further divided into 4 groups according to their size: I: not visible, II: <5 mm, III: 5–10 mm, and IV: >10 mm.

To analyze the diagnostic value of the radiographic imaging procedures, 4 blinded examiners (2 certified oral surgeons and 2 residents in oral surgery) independently assessed the radiographs for the diagnosis of “cyst” versus “granuloma.” The PR and CBCT data were evaluated on a Dell 380 Workstation (Dell SA, Geneva, Switzerland) and a 19-inch Eizo monitor with a resolution of 1280 × 1024 pixels (Eizo Nanao AD, Wädenswil, Switzerland). Measurements of the CBCT images were accomplished with specialized computer software (i-Dixel version 1.8; Morita).

TABLE 1. Location and Type of the Treated Teeth (N = 58)

	Incisors	Canines	Premolars	Molars	All
Maxilla	17	1	13	6	37
Mandible	1	2	3	15	21
Total	18	3	16	21	58

Surgical Procedure

The surgeries were performed by 1 surgeon (T.v.A.) under local anesthesia and aseptic conditions. All surgeries were performed with a surgical microscope and endoscope (17). Osteotomy, root end management, and wound closure were performed as reported in previous studies (16, 18, 19). The root end and the soft tissue of the lesion were removed and immediately preserved in a 1% glutaraldehyde and 1% formaldehyde solution for histologic processing.

Tissue Processing

The specimens were embedded either in LR White resin (Sigma-Aldrich Chemie GmbH, Buchs, Switzerland) (up to 10 mm) or methyl methacrylate (>10 mm). Details of histologic tissue processing have been reported in the study by Schulz et al (20). Soft tissue specimens containing no mineralized tissue for embedding in LR White resin were placed directly in wash buffer solution, whereas samples with mineralized tissue were decalcified in 10% disodium EDTA for at least 10 days at 4°C (21). The demineralized samples were cut through their center into 2 pieces of equal size using a razor blade. When the apical root portion was present, subdivision was performed vertical to the long axis of the root. From each resin block, semithin survey sections (1-μm thick) were cut with glass and diamond knives on a Reichert Ultracut E microtome (Leica Microsystems, Glattbrugg, Switzerland) and stained with toluidine blue alone or double stained with basic fuchsin and toluidine blue. All metallic materials or remnants of gutta-percha cones within the lesions had to be removed before cutting (20). Concerning the larger samples, undecalcified samples with all foreign body materials in place were processed for embedding in methyl methacrylate (20). Light microscopic observation was performed using a Leica stereolupe M8 and a Leica Dialux 22 EB (Leica Microsystems). Digital photography was performed with a Progress C5 digital camera (Jenoptik, Jena, Germany) attached to a Zeiss Axioplan microscope (Zeiss, Jena, Germany).

Radiographic and Histologic Interpretation and Analysis

The radiographic criteria given to the observers to differentiate a cyst from a granuloma included the following characteristics: well-

TABLE 2. Dimensions of the Apical Lesions Measured with Periapical Radiography and Cone-beam Computed Tomographic Imaging (N = 58)

Periapical radiography				
Type of lesion	Type 0	Type 1	Type 2	Type 3
Number	3	17	35	3
Dimension (mm)	Mean	SD	Minimum	Maximum
	5.44	± 2.39	0	10.55

CBCT imaging			
Dimension (mm)	Coronal	Sagittal	Axial
Mean	5.45	5.44	5.75
SD	± 1.87	± 2.43	± 2.59
Minimum	2.62	1.95	2.12
Maximum	13.09	15.55	13.10

SD, standard deviation.