Ability of Cone-beam Computed Tomography to Detect Periapical Lesions That Were Not Detected by Periapical Radiography: A Retrospective Assessment According to Tooth Group

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Abstract

Introduction: The detection of periapical lesions by periapical radiography (PR) can be hampered by structural noise, the impact of which differs among tooth groups. The aim of this study was to investigate the ability of cone-beam computed tomographic (CBCT) imaging to detect periapical lesions that could not be detected with PR according to tooth group. **Methods:** This study retrospectively evaluated teeth that (1) had previously undergone root canal treatment (178 teeth from 86 patients), (2) had coincidentally been located within the field of view of CBCT scans performed for endodontic reasons, and (3) had also been examined with PR. The teeth of interest for the CBCT examinations were excluded to avoid sampling bias. Two dentists evaluated both the CBCT and PR images for periapical lesions. The McNemar test was used to compare the ability of CBCT imaging and PR to identify periapical lesions ($\alpha = 0.05$). **Results:** The overall periapical lesion detection rates of PR and CBCT imaging were 31.5% and 52.2%, respectively ($P < .0001$). The ability of CBCT imaging to identify periapical lesions that were not detected by PR was statistically significant for the maxillary incisors/canines ($P < .0001$) and maxillary molars ($P < .005$). **Conclusions:** Within the limitations of this investigation, it can be concluded that CBCT imaging is effective at detecting periapical lesions that cannot be detected on PR, particularly in the maxillary incisors/canines and molars. Our findings suggest that the influence of structural noise in the maxillary anterior region and maxillary posterior region should not be overlooked during the interpretation of PR images. *(J Endod 2016;42:1186–1190)*

Key Words

Apical periodontitis, cone-beam computed tomography, periapical lesion, periapical radiography

Radiographic imaging is essential for obtaining pre-/postoperative diagnoses, developing treatment plans, and assessing outcomes during endodontic treatment (1). To establish an appropriate treatment plan, detailed and accurate information is required regarding the presence and extent of any bone defects, the morphology of the roots and root canals and any changes in these structures associated with pathological or iatrogenic events, and the spatial relationships between tooth roots and anatomic structures (1, 2). Periapical radiography (PR) is still the most commonly used method for diagnosing apical periodontitis (AP). However, PR converts 3-dimensional objects into 2-dimensional images, and, thus, there are several limitations regarding its informative yield (3). Of particular concern is the overlapping of anatomic structures with structures of interest, which can negatively influence the detection of AP-related changes and pose diagnostic challenges (4). It is widely considered that relatively small lesions that are confined to cancellous bone can be difficult to detect on PR because of the superimposition of the cortical plate (4–7) although periapical lesions do not have to erode the cortical plate to become detectable with PR (8). Clinicians should be aware of the fact that the size of AP lesions is often underestimated and that in some cases AP lesions cannot be detected with PR, and thus, the presence of AP cannot be ruled out in all teeth in which periapical radiolucency is not detected on PR (4–9).

Since the development of cone-beam computed tomographic (CBCT) imaging in the late 1990s (10), this imaging modality has been used in endodontics to overcome the previously mentioned limitations of PR (11). CBCT imaging makes 3-dimensional visualization of the target possible and minimizes anatomic noise from the overlying structures (11). Several studies have shown that CBCT imaging exhibits higher detection rates of AP and other unfavorable findings compared with PR (12–19); thus, CBCT scanning is regarded as a powerful tool for diagnosing AP (11).

The current guidelines mention that CBCT imaging should not be routinely performed during endodontic treatment. Instead, its use should be restricted to cases in which other imaging systems such as PR do not yield sufficient information (20, 21), primarily because the radiation dose delivered during CBCT imaging is higher than that delivered during PR (22). However, CBCT imaging exhibits a higher periapical lesion detection rate than PR (12–19); therefore, clinicians might face difficult decisions about whether to obtain CBCT scans in individual cases. To address this dilemma, it would be beneficial to acquire knowledge about the prevalence of AP lesions that cannot be detected with PR in different tooth groups because differences in the anatomy of teeth and the surrounding structures among tooth types might have

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an impact on the detection of AP. However, to the best of our knowledge, there is limited information available regarding the variations in the ability of CBCT imaging to detect periapical lesions that cannot be detected on PR among different tooth groups although a few studies have highlighted the advantages of CBCT scanning over PR for detecting AP in maxillary posterior teeth (23, 24).

Thus, the aim of this study was to investigate the ability of CBCT imaging to detect AP lesions that could not be detected with PR in various tooth groups via a retrospective analysis of the CBCT data of teeth that had previously undergone root canal treatment. To avoid sampling bias, we excluded the target teeth for each CBCT scan and only examined teeth that had previously undergone root canal treatment and had coincidently fallen within the field of view of a CBCT scan. The null hypothesis was that the ability of CBCT imaging to detect AP lesions that were not detected on PR does not differ among tooth groups.

Materials and Methods

Approval from the Tokyo Medical and Dental University Ethical Committee was obtained (no. 1010). The CBCT imaging examination records of consecutive patients who underwent CBCT scans between January 2012 and June 2014 were used in this study. They were selected from the database of the Clinic of Operative Dentistry and Endodontics at the Dental Hospital of Tokyo Medical and Dental University, Tokyo, Japan, and all of the patients had been scanned with CBCT imaging for endodontic reasons. Scans that included a tooth or teeth that fulfilled all of the following criteria were selected: the tooth/teeth had been endodontically treated, the tooth/teeth were not associated with the patient's main complaint, the tooth/teeth were coincidently located within the field of view of the scan, and the tooth/teeth had also been examined with PR. A total of 178 teeth from 86 patients (16 mean and 70 women) fulfilled the criteria (mean age = 55.17 [standard deviation = 11.53]).

CBCT images were obtained with the FineCube system (Yoshida Dental Mfg Co, Ltd, Tokyo, Japan). All CBCT images involved a field of view of 51 mm in height and 56 mm in width at the center of rotation. The imaging time was 16.8 seconds, the tube voltage was 90 kV, and the tube current was 4 mA. Data were reconstructed at a slice interval of 0.14 mm. Each image ran parallel to the horizontal axis of the alveolar process, and the examined teeth were placed in the center of the volume of interest. For each root, the slices were reformatted to align the root axis with the vertical plane.

The PR images were obtained by dentists or radiologic technicians using one of the following 3 dental X-ray systems: Heliodent MD (Siemens, New York, NY), MaxiX (J Morita Manufacturing, Kyoto, Japan), and Xspot (ASAHI ROENTGEN Ind Co, Kyoto, Japan). The exposure parameters were as follows: 60 kV, 7 mA, and 0.25∼0.64 seconds (HELIODENT MD); 70 kV, 7 mA, and 0.20∼0.63 seconds (MaxiX); and 70 kV, 6 mA, and 0.16∼0.40 seconds (Xspot). The exposure time differed according to the type of tooth being examined. All PR images were acquired with the freehand bisecting technique. Because this study was conducted retrospectively, 2 types of PR digitization methods were used. Before December 2013, PR images were obtained using F-speed films (InSight; Kodak, Rochester, NY) that were processed in an automatic processor, scanned with a digital scanner (Offirio ES-10000G; EPSON, Nagano, Japan), and compressed into an 8-bit grayscale JPEG format. From January 2014 onward, a digital charge-coupled device sensor (CS7600; Carestream Health Inc, Rochester, NY) was used, and the images were compressed into an 8-bit grayscale JPEG format.

A periapical lesion was defined as a periapical radiolucent area that was in contact with the radiographic apex of the root and measured at least twice the width of the periodontal ligament space (23, 25). For the CBCT images, the same definition of periapical lesions was applied, and the lesion had to be visible in multiple image planes. In multirooted teeth, the presence or absence of a periapical lesion was recorded for each identifiable root, and if at least 1 root exhibited a periapical lesion, the sample was diagnosed as lesion positive.

The CBCT images were evaluated by 2 dentists (S.U. and N.O.) who had more than 4 and 15 years of clinical experience of using CBCT imaging, respectively. The examiners were not involved in the treatment of the patients. CBCT images were examined by using the Dell Precision T3600 Workstation (Dell Inc, Round Rock, TX) and a 19-inch display with a resolution of 1280 × 1024 pixels (Dell Inc). During the observation period, examiners had access to the raw CBCT data using specialized computer software (Finecube Viewer, Yoshida Dental Mfg Co, Ltd). The presence or absence of periapical lesion–positive images was recorded for each case, and if the 2 examiners came to different conclusions, discussions were held until they reached a consensus. The results of the evaluations of the CBCT images were determined as the reference standard.

The presence of periapical lesions on the PR images was also evaluated independently by 2 dentists (S.U. and N.O.). The PR images were viewed as PowerPoint presentations (Microsoft Corporation, Washington, WA) using a laptop computer with a 15.5-inch display and a resolution of 1440 × 900 pixels (MacBook Pro; Apple Inc, Cupertino, CA). The PR images were randomly ordered and were evaluated twice at 2-week intervals. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy rate (AC) were calculated.

Statistical software (SPSS version 22; IBM, Armonk, NY) was used to analyze the data. The McNemar test was used to compare the abilities of CBCT imaging with PR to identify AP lesions ($\alpha = 0.05$). Kappa analysis was used to assess the interobserver and intraobserver agreement regarding the PR imaging findings.

Results

The overall periapical lesion detection rates of PR and CBCT imaging were 31.5% (56/178) and 52.2% (93/178), respectively

TABLE 1. Prevalence of Periapical Lesions Identified by Cone-beam Computed Tomographic (CBCT) Imaging and Periapical Radiography (PR) According to Tooth Group

		Maxillary, *n* (%)			Mandibular, *n* (%)			
CBCT	PR	Incisors and canines (*n* = 69)	Premolars (*n* = 45)	Molars (*n* = 26)	Incisors and canines (*n* = 6)	Premolars (*n* = 17)	Molars (*n* = 15)	Total (*N* = 178)
Positive	Positive	18 (26.1)	14 (31.1)	10 (38.5)	1 (16.7)	4 (23.6)	7 (46.7)	54 (30.3)
Positive	Negative	16 (23.2)	6 (13.3)	9 (34.6)	3 (50.0)	3 (17.6)	2 (13.3)	39 (22.0)
Negative	Positive	0	1 (2.2)	0	0	1 (5.9)	0	2 (1.1)
Negative	Negative	35 (50.7)	24 (53.4)	7 (26.9)	2 (33.3)	9 (52.9)	6 (40.0)	83 (46.6)
P value (CBCT vs PR)		<.0001*	.125	.004*	.25	.625	.5	<.0001*

*Significant ($P < .05$, McNemar test).