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# Influence of voxel size and scan field of view on fracture-like artifacts from gutta-percha obturated endodontically treated teeth on cone-beam computed tomography images

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**Objective.** To determine the optimal scan settings (scan mode and position of field of view [FOV]) for cone beam computed tomography to reduce root fracture-like artifacts that are often observed in teeth filled with gutta-percha cones (GPCs).

**Study Design.** Fracture-like artifacts that appeared on cone beam computed tomography images of 9 extracted human mandibular premolars filled with GPCs were analyzed using I-mode (FOV, 102 mm; voxel size, 0.2 mm) and D-mode (FOV, 51 mm; voxel size, 0.1 mm) settings.

**Results.** The artificial lines were more obvious in I-mode than in D-mode. Increased distance between the center of the FOV and the GPCs produced stronger artificial lines in both I-mode and D-mode.

**Conclusion.** To reduce fracture-like artifacts, it is critical to use a mode with small voxel size and to place the target tooth in the center of the FOV. (Oral Surg Oral Med Oral Pathol Oral Radiol 2016;122:631-637)

The main advantage of cone beam computed tomography (CBCT) for diagnostic imaging of dental lesions is that it can produce a 3-dimensional representation of the tooth, root(s), and periapical tissues, unlike the 2-dimensional images produced by periapical radiographs.[1-7] Recently, CBCT has been recommended for detection of vertical root fractures, on the basis of its prominent advantages.[8] However, it has been reported that root canal filling materials, such as sealers or gutta-percha cones (GPCs), can create distinct "streak" artifacts on CBCT images that can mimic root fracture lines, resulting in false-positive findings and misdiagnosis of tooth root fractures.[9-11] Consequently, it is important to clarify the detailed artificial patterns induced by GPCs on CBCT images of tooth roots and to determine how the scanning technique can reduce such artifacts.

We recently reported on CBCT imaging of extracted human maxillary incisors, which were inserted into empty tooth sockets in the alveolar bone of a human skull after insertion of size 50 GPCs into the enlarged root canals. The images showed that artificial lines appeared in oblique directions (mesiobuccal, distolingual, distobuccal, and mesiolingual), but in the mandibular premolars they appeared in mesial and distal directions.[12] In addition, we revealed that artifacts presenting in mesial and distal directions were not seen when the premolar teeth were isolated from the skull. Therefore, we believed that the artificial lines should occur in the connection line between the GPC and the surrounding structures (such as the tooth alveolar bone) along the long axis of the alveolar bone because of the beam-hardening effect, and we suggested that this information would help to distinguish artifacts from true root fracture lines.[12] Thus, we revealed the detailed geometric patterns of the artificial fracture lines induced by GPCs; however, methods to reduce such artifacts on CBCT images are yet to be clarified.

Pauwels et al.[13] evaluated the effects of different tube current (mAs) and voltage (kVp) settings on beam hardening in CBCT images using a small-sized phantom containing an aluminum cylinder. They found that

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## Statement of Clinical Relevance

We investigated how scanning technique can reduce artifacts that mimic fracture lines produced by root canal filling materials in cone beam computed tomograph images. We recommend using a small voxel size mode with the tooth located in the center of the field of view.

a higher kVp reduced the beam hardening, but changing the mAs did not affect it. However, most commercially available CBCT machines do not allow the kVp to be changed.[14] Instead, as an another potential method to reduce the beam-hardening artifact in CBCT, Bechara et al.[15] proposed the use of metal artifact reduction (MAR) software, on the grounds that the MAR algorithm reduced the effects of beam hardening caused by metallic structures. However, applying such software to existing CBCT machines is difficult and results in increased reconstruction time whenever the MAR is used. In this study, we focus on the scanning mode and the location of the object in the field of view (FOV) to determine the best CBCT scan settings for reducing the root fracture-like artifacts due to root canal filling materials.

When dental CBCT was initially developed in 1999, it possessed only 1 scanning mode, an FOV 40 mm in diameter and 30 mm in height, and a voxel size of 0.136 mm × 0.136 mm × 0.136 mm.[1] Along with technological improvements, CBCT machines have extended their detector size, allowing for selection of more suitable scanning modes.[16] Larger FOV scans are often associated with larger voxel sizes, which reduces the spatial resolution of the scan and may thereby reduce the scan image quality; they also release a higher radiation dose compared with a smaller FOV. Additionally, with regard to the location of the object within the FOV, the spatial resolution in the central region is known to be higher than that in the peripheral region.[16] However, it is unknown how the artifacts on CBCT images are influenced by the scanning mode or by the location of the object in the FOV. Hence, the aim of this study was to clarify the influence of scan settings (e.g., selecting the scanning mode and location of the object in the FOV) on GPC-related artifacts on CBCT images. Toward this aim, we examined the artifacts produced with varied scan settings using extracted mandibular premolars filled with GPCs. For quantitative measurement of the change in artifacts produced using different scan settings, we evaluated changes in the gray value (GV) of the artifacts appearing on the mesial aspect, because artificial lines always appeared in the mesial and distal directions in the premolar region, as we previously reported.[12]

## MATERIALS AND METHODS

### Sample preparation

Nine non-root-filled human right mandibular second premolars were used in this study. After root canal preparation using a stainless steel K-file to an apical size of 50, each tooth was examined using a micro-computed tomography device (R-mCT, Rigaku, Tokyo, Japan) to confirm the absence of any root fractures or cracks. The teeth were then inserted into empty tooth sockets (right mandibular second premolar) in the alveolar bone of a human skull used as an educational dental X-ray projection (Human Skull DXTTR, Dentsply-Rinn, Philadelphia, PA). All other teeth were present in the skull. The skull, which included the C1-C4 cervical vertebrae, was soaked in water to simulate a clinical situation, based on our previous report.[12,17] Preparation of the experimental model and the procedures used in this study were based on the methods in our previous report.[12]

The research protocols for this study were approved by the Research Ethics Committee at the Tohoku University Graduate School of Dentistry (approval No. 2012/23-21) and were conducted according to the guidelines of the Declaration of Helsinki.

### Imaging procedures

The skull was positioned so that the occlusal plane was parallel with the floor. The CBCT scan (Alphard VEGA; Asahi Roentgen Co., Kyoto, Japan) was performed with a rotation of 360° for data acquisition, and the exposure factors were 80 kV, 7 mA, and 17-second exposure time. Volumetric imaging was produced using 2 different modes: I-mode (FOV, 102 mm height and 102 mm diameter; voxel size, 0.2 mm × 0.2 mm × 0.2 mm) and D-mode (FOV, 51 mm height and 51 mm diameter; voxel size, 0.1 mm × 0.1 mm × 0.1 mm). In I-mode, the relationship between the FOV and GPC locations was set at 5 different points: GPC at the center of the FOV (I-center, Figure 1A) and at 10 mm (I-10, Figure 1B), 20 mm (I-20, Figure 1C), 30 mm (I-30, Figure 1D), and 40 mm (I-40, Figure 1E) out of the FOV center in an oblique direction. In D-mode, the GPC locations were set at 3 different points: GPC at the center of the FOV (D-center, Figure 1F) and at 10 mm (D-10, Figure 1G) and 20 mm (D-20, Figure 1H) out of the FOV center in an oblique direction.

### GV density evaluation

The volumetric data of the images obtained by the CBCT scans were exported as a Digital Imaging and Communications in Medicine (DICOM) file and imported into a specially designed DICOM viewer software program (OsiriX imaging software, OsiriX Foundation, Geneva, Switzerland). Axial images (taken perpendicular to the long axis of the tooth root) were reconstructed at the alveolar bone ridge level and were then saved in the tag image file format (TIFF).

The average GV in the 1-mm (I-mode, 5 pixels; D-mode, 10 pixels) line-type regions of interest was recorded using the free ImageJ image analysis software (Image J, NIH Image, Bethesda, MD). As shown in Figure 2, the line-type regions of interest was positioned at 3 points: mesiobuccal portion (MBP) and mesial