Reduction of dark-band-like metal artifacts caused by dental implant bodies using hypothetical monoenergetic imaging after dual-energy computed tomography

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Objective. The aim of this study was to evaluate the usefulness of hypothetical monoenergetic images after dual-energy computed tomography (DECT) for assessment of the bone encircling dental implant bodies.

Study design. Seventy-two axial images of implantation sites clipped out from image data scanned using DECT in dual-energy mode were used. Subjective assessment on reduction of dark-band-like artifacts (R-DBAs) and diagnosability of adjacent bone condition (D-ABC) in 3 sets of DECT images—a fused image set (DE120) and 2 sets of hypothetical monoenergetic images (ME100, ME190)—was performed and the results were statistically analyzed.

Results. With regards to R-DBAs and D-ABC, significant differences among DE120, ME100, and ME190 were observed. The ME100 and ME190 images revealed more artifact reduction and diagnosability than those of DE120.

Conclusions. DECT imaging followed by hypothetical monoenergetic image construction can cause R-DBAs and increase D-ABC and may be potentially used for the evaluation of postoperative changes in the bone encircling implant bodies. (Oral Surg Oral Med Oral Pathol Oral Radiol 2013;115:833-838)

The outcome of dental implantation depends mainly on the extent of osseointegration between the implanted titanium body and the surrounding bone. If adverse events occur, such as pain or implant mobility, the jawbone in the vicinity of the dental implant needs to be evaluated by diagnostic imaging. Ordinarily, periapical radiography is used for postoperative assessment; however, being axiomatic, periapical radiographs do not provide buccolingual information. Computed tomography (CT), cone-beam CT (CBCT), or dental CT is widely used to provide 3-dimensional information on the bone condition before dental implantation; however, imaging artifacts that surround metallic implants critically impair the quality of these diagnostic images for postoperative assessment.[1-3]

Dual-energy computed tomography (DECT), which uses 2 X-ray tubes and 2 detectors mounted on a CT gantry with a mechanical offset of 90°, has the potential to overcome the limitations of single-energy CT systems and differentiate tissues with higher precision.[4,5] Furthermore, studies have shown that hypothetical monoenergetic reconstructed images from DECT displays can reduce artifacts from implanted metal orthopedic devices.[1,6,7] Dental implant bodies are usually smaller in size than orthopedic devices; however, dark-band-like artifacts (DBAs) around dental implant bodies can cause diagnostic problems similar to those resulting from metal orthopedic devices. Periodontal tissues and the jawbones exist in an environment where inflammatory diseases occur easily; therefore, observation after implantation is needed. However, when we focus on the presence or absence of bone resorption around implant bodies, DBAs encircling the dental implant bodies tend to cause conflict with diagnosis. Empirically, we know that constructing monoenergetic images after DECT reduces such DBAs. However, the clinical question remains as to whether images in which artifacts around implants have been

Statement of Clinical Relevance

This is the first study showing that dual-energy computed tomography imaging followed by hypothetical monoenergetic image construction may be useful for the evaluation of postoperative bone condition encircling dental implant bodies.

A part of this study was presented at the 18th International Congress of Dento-Maxillo-Facial Radiology. The title of the abstract was Dual energy CT imaging in dentistry: a clinical trial for jawbones.

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reduced are appropriate for the interpretation of bone condition. In this study, we assessed the usefulness of hypothetical monoenergetic images after DECT, focusing on the area encircling dental implant bodies.

MATERIAL AND METHODS

Subjects

DECT images of 24 dental implant bodies in 5 patients (3 females and 2 males) were studied. The average age of the 5 patients at DECT examination was 60 years, and ranged from 48 to 72 years. All the patients had undergone multiple dental implantations in the jawbone(s). Only images on which bodies were implanted in the premolar and/or molar regions of the mandibles were selected.

Clinically, every implant was uneventful, without any local symptoms such as pain, bleeding, or mobility. CT examination was performed as a preoperative assessment or for the evaluation of the results of surgical pretreatments such as sinus-lift procedures or bone grafting for other dental implantations in the jaws. Therefore, additional CT scans were not performed for this study; rather, imaging of the implants was conveniently performed at the same time as new preoperative assessments. Due to the retrospective nature of this study, an exemption was granted in writing by the Institutional Review Board of our institute.

DECT image acquisition

DECT scanning was performed with a 128-slice dual source CT system (SOMATOM Definition Flash, Siemens Medical Solutions, Forchheim, Germany). The same imaging protocol was applied to each patient; tube voltages were set at 80 and 140 kV with the system's selective photon shield, and the tube current of the low potential tube was set at approximately twice that of the high potential tube. The beam collimation was 0.6 mm, the gantry rotation time was 500 ms, and the helical pitch was 0.85 relative to the detector elements. The effective radiation dose for the whole DECT scan performed in this study was estimated according to guidelines of the International Commission on Radiological Protection.[8]

CT image reconstruction

Three sets of images were reconstructed by using the monoenergetic application of Syngo Dual Energy software, version VE31 (Siemens Medical Solutions). These were a fused image set (DE120) corresponding to a standard 120-kV spectrum, which provided the same images as those of the ordinal image (Figure 1*A*), and 2 sets of hypothetical monoenergetic images that were equivalent to images obtained with extrapolated energies at 100 keV (ME100) and 190 keV (ME190) (Figure 1*B* and *C*).

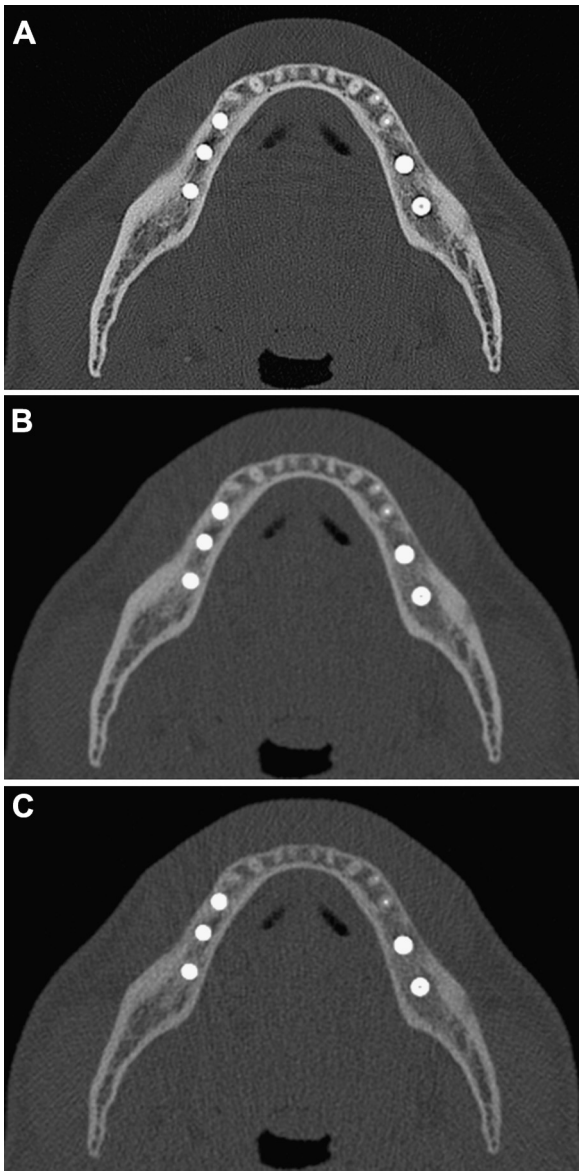

Fig. 1. Three sets of images reconstructed with the same data sets: (**A**) standard 120-kV spectrum (DE120) image set corresponding to conventional single-energy CT images; (**B**) hypothetical monoenergetic images equivalent to those obtained at 100 keV (ME100); and (**C**) hypothetical monoenergetic images equivalent to those obtained at 190 keV (ME190).

Image analysis

All images were evaluated by 9 observers who are specialists in oral and maxillofacial radiology, each of whom has more than 8 years of experience in clinical image diagnosis.

Three sets of images (DE120, ME100, and ME190) of 24 implant bodies (giving a total of 72 cross