Comparison of the Effect of Iterative Reconstruction versus Filtered Back Projection on Cardiac CT Postprocessing

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Rationale and Objectives: To investigate the impact of iterative reconstruction in image space (IRIS) on image noise, image quality (IQ), and postprocessing at coronary computed tomography angiography (cCTA) compared to traditional filtered back-projection (FBP).

Materials and Methods: The cCTA results of 50 patients (26 men; 58 $\pm$ 15 years, body mass index 31.5 $\pm$ 6.7 kg/m^2) were investigated using a second-generation dual-source computed tomography system. Scan data were reconstructed with the use of IRIS and FBP algorithms. Two radiologists independently evaluated the reconstructions using automated coronary tree analysis software. Image noise was measured and IQ was rated on a 5-point Likert scale. The number of manual corrections after automated vessel segmentation, the time required to complete segmentation, and the number of missed segments were assessed in both IRIS and FBP reconstructions. Results were compared using paired *t-test*.

Results: IRIS significantly reduced image noise compared to FBP (23.3 $\pm$ 8.8 vs. 33.5 $\pm$ 13.5 Hounsfield units, $P < .001$). Subjective IQ improved with IRIS (IRIS 3.2 $\pm$ 1.0 vs. FBP 3.0 $\pm$ 1.0, $P < .05$). IRIS decreased the time needed for coronary segmentation from 111.9 $\pm$ 40.5 seconds to 95.2 $\pm$ 38.2 seconds with FBP ($P < .01$) and required fewer manual corrections (5.7 $\pm$ 3.0 vs. 6.8 $\pm$ 3.6, $P < .01$). The number of missed vessel segments was not significantly different (3.6 $\pm$ 1.8 vs. 3.8 $\pm$ 1.9, $P > .05$) between IRIS and FBP, respectively.

Conclusions: During cCTA postprocessing, IRIS significantly decreases the time and the number of manual corrections for a complete coronary segmentation compared to FBP. This effect is likely attributable to suppression of image noise by IRIS, which improves the performance of automated vessel segmentation and positively impacts cCTA analysis.

Key Words: Iterative reconstruction; coronary CT angiography; postprocessing.

Coronary computed tomography angiography (cCTA) has emerged as a powerful noninvasive modality for the evaluation of coronary artery disease (CAD) in patients with low-to-intermediate pretest likelihood (1,2). The thin sections used to evaluate small coronary details at cCTA are inherently more susceptible to increased image noise than are thicker-section routine body examinations. Due to the well-known tradeoffs between radiation dose, image noise, and spatial resolution, low-dose radiation protocols aggravate this relationship and possibly lower diagnostic image quality. (3).

A mainstay of contemporary cCTA image interpretation is image postprocessing using dedicated analysis software for generating curved multiplanar reformats (cMPR) of the vessel course and for addressing other diagnostic aspects obtainable from cCTA. Inaccurate attenuation classification of voxels due to image noise holds the potential to interfere with successful postprocessing, which requires time-consuming

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manual adjustments. Many studies have investigated the use of postprocessing technique, reconstruction method, and automated and semiautomated segmentation software across a variety of fields and organ systems and with different modalities to determine the possible benefits that can be achieved (4–7).

Recently introduced iterative reconstruction algorithms might be able to overcome these drawbacks, because this approach to some extent unlinks the relationship between image noise and spatial resolution, which dominates filtered back-projection (FBP). Studies have shown that with the use of iterative reconstruction, image quality (IQ) was maintained or improved despite significant radiation dose reduction (8–10). These effects are mainly attributable to substantial reductions in image noise with preserved spatial resolution and border definition (11).

Accordingly, this study investigated the impact of iterative reconstruction in image space (IRIS) on image noise, IQ, and postprocessing workflow at cCTA compared to traditional FBP.

MATERIALS AND METHODS

Patients

Scan data of 50 consecutive patients (26 men; 58 ± 15 years) who were clinically indicated to undergo cCTA between September 2010 and February 2011 were retrospectively included in this study. All patient identifiers were removed from the images before analysis. This study was approved by our institutional review board (IRB) and was Health Insurance Portability and Accountability Act compliant. Because of the retrospective nature of this study, patient informed consent was waived by the IRB.

Scanning Technique and Image Reconstruction

cCTA was performed using a second generation dual-source computed tomography (CT) system (Somatom Definition Flash; Siemens Healthcare, Forchheim, Germany). The specific scan technique was selected based on individual patient heart rate, heart rhythm, body mass index (BMI), and body habitus, with the overall goal of minimizing radiation dose exposure. The technique selected was either a prospectively electrocardiogram (ECG)-triggered acquisition protocol or a retrospective ECG-gated spiral acquisition. To attain adequate contrast enhancement, approximately 60–100 mL of iodinated contrast media (370 mgI/mL iopromide; Ultravist, Bayer, Berlin, Germany) was injected through an 18-gauge intravenous antecubital catheter at a flow rate of 4–6 mL/min using a dual-syringe injector (Stellant D; MedRad, Indianola, PA). The CT images were acquired in the craniocaudal direction from the level of the carina through the dome of the diaphragm during inspiration with 2 × 64 × 0.6 mm detector collimation, 280 ms gantry rotation time and variable tube potential and tube current–time product per rotation. In general, 100 kV tube potential was used in patients with BMI ≥20 kg/m^2

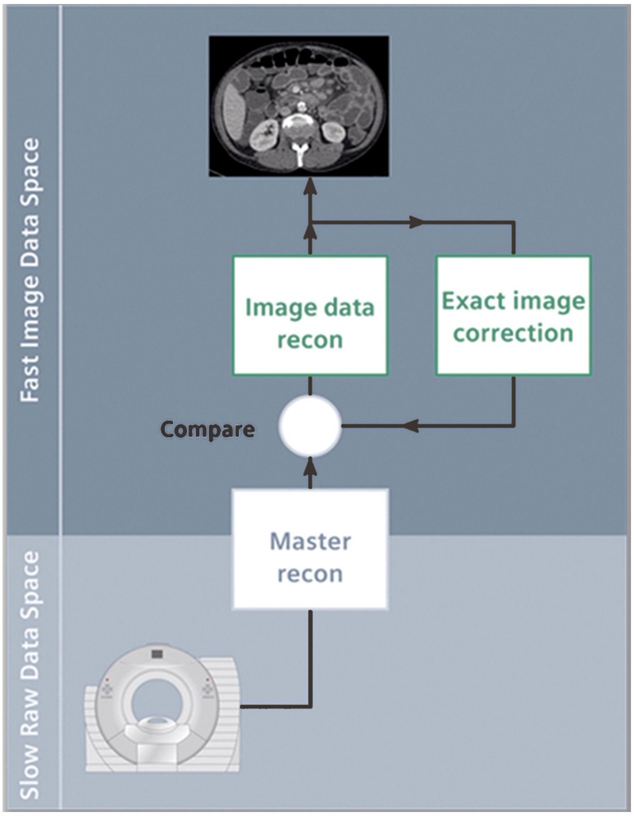

Figure 1. Iterative reconstruction in image space (IRIS) algorithm data flow chart (http://www.siemens.com/press/en/presspicture/?press=/en/presspicture/2009/imaging_it/him2009110011-01.htm). IRIS generates a master image from the raw data, which will be used as the reference image from thereon. The correction algorithm then reduces image noise using a regularization term based on several image characteristics to improve border definition and maintain image sharpness. All image corrections are performed in the image space, which allows for faster iterative reconstruction because the reference image is the master reconstruction rather than the raw data (8).

and <25 kg/m^2, 120 kV was used in patients with BMI ≥25 kg/m^2 and <30 kg/m^2, and 140 kV was used in patients with BMI ≥30 kg/m^2. The standard tube current–time product was 320 mAs per rotation; however, this value was varied per patient to minimize radiation dose, while maintaining optimal IQ. The effective radiation dose, measured in milliSievert (mSv), was determined from the product of the dose–length product (DLP) and a conversion coefficient specific to the chest (κ = 0.014 mSv × mGy^{-1} × cm^{-1}). In each patient, the scan data were reconstructed using both traditional FBP and IRIS (Siemens Healthcare; Forchheim, Germany). This iterative reconstruction algorithm performs image correction loops in the fast processing image space domain rather than in the slow processing raw data domain. IRIS does this by first generating a master image from reconstructed raw data and then using the master image as a reference; the correction algorithm aims to reduce image noise in a process of several iterations. By using the master image as a reference instead of referring back to raw data, reconstruction can be performed more efficiently (8,12,13) (Fig 1). The end result is a reduction in image noise to