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Reducing the radiation dose for low-dose CT of the paranasal sinuses using iterative reconstruction: Feasibility and image quality

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ABSTRACT

Purpose: To evaluate image quality of dose-reduced CT of the paranasal-sinus using an iterative reconstruction technique.
Methods: In this study 80 patients (mean age: 46.9 ± 18 years) underwent CT of the paranasalsinus (Siemens Definition, Forchheim, Germany), with either standard settings (A: 120 kV, 60 mAs) reconstructed with conventional filtered back projection (FBP) or with tube current–time product lowering of 20%, 40% and 60% (B: 48 mAs, C: 36 mAs and D: 24 mAs) using iterative reconstruction (n = 20 each). Subjective image quality was independently assessed by four blinded observers using a semiquantitative five-point grading scale (1 = poor, 5 = excellent). Effective dose was calculated from the dose-length product. Mann–Whitney-*U*-test was used for statistical analysis.
Results: Mean effective dose was 0.28 ± 0.03 mSv(A), 0.23 ± 0.02 mSv(B), 0.17 ± 0.02 mSv(C) and 0.11 ± 0.01 mSv(D) resulting in a maximum dose reduction of 60% with iterative reconstruction technique as compared to the standard low-dose CT. Best image quality was observed at 48 mAs (mean 4.8; $p < 0.05$), whereas standard low-dose CT (A) and maximum dose reduced scans (D) showed no significant difference in subjective image quality (mean 4.37 (A) and 4.31 (B); $p = 0.72$). Interobserver agreement was excellent (κ values 0.79–0.93).
Conclusion: As compared to filtered back projection, the iterative reconstruction technique allows for significant dose reduction of up to 60% for paranasal-sinus CT without impairing the diagnostic image quality.

1. Introduction

Computed tomography (CT) of the paranasal sinus has evolved as the gold standard for imaging inflammatory sinus disease [1–3]. Radiation exposure during this examination has always been a major concern, as the radiation-sensitive optic lens, with its vulnerability to radiation-induced cataract development, is included in the scanning field. This factor is emphasized given the predominantly young patient population and frequent need for follow-up examinations. Dose-reduction strategies have thus far been mainly based on tube-current reduction [2,4]. Although this has effected a considerable dose reduction, further tube-current reduction is impeded by the increasing image noise. However, the "iterative reconstruction in image space" (IRIS) technique provides a new option for further reducing the tube current without increasing the image noise. Compared to conventional filtered back projection (FBP), an algorithm that converts the raw data into image data with filtering and back projection to the image plane, the iterative reconstruction process includes an additional "correction loop" in which the sectional images are gradually approximated to their actual density distribution, thereby reducing image noise. So far, this technique has been applied for CT of the thorax or abdomen, enabling dose reductions of 35% and 66%, respectively [5–8], without loss in diagnostic image quality. Thus application of IRIS may constitute an option for further dose reduction in paranasal sinus CT.

The purpose of this study was to evaluate image quality of dose-reduced paranasal sinus CT using IRIS as compared to non-dose-reduced CT scans reconstructed with conventional FBP.

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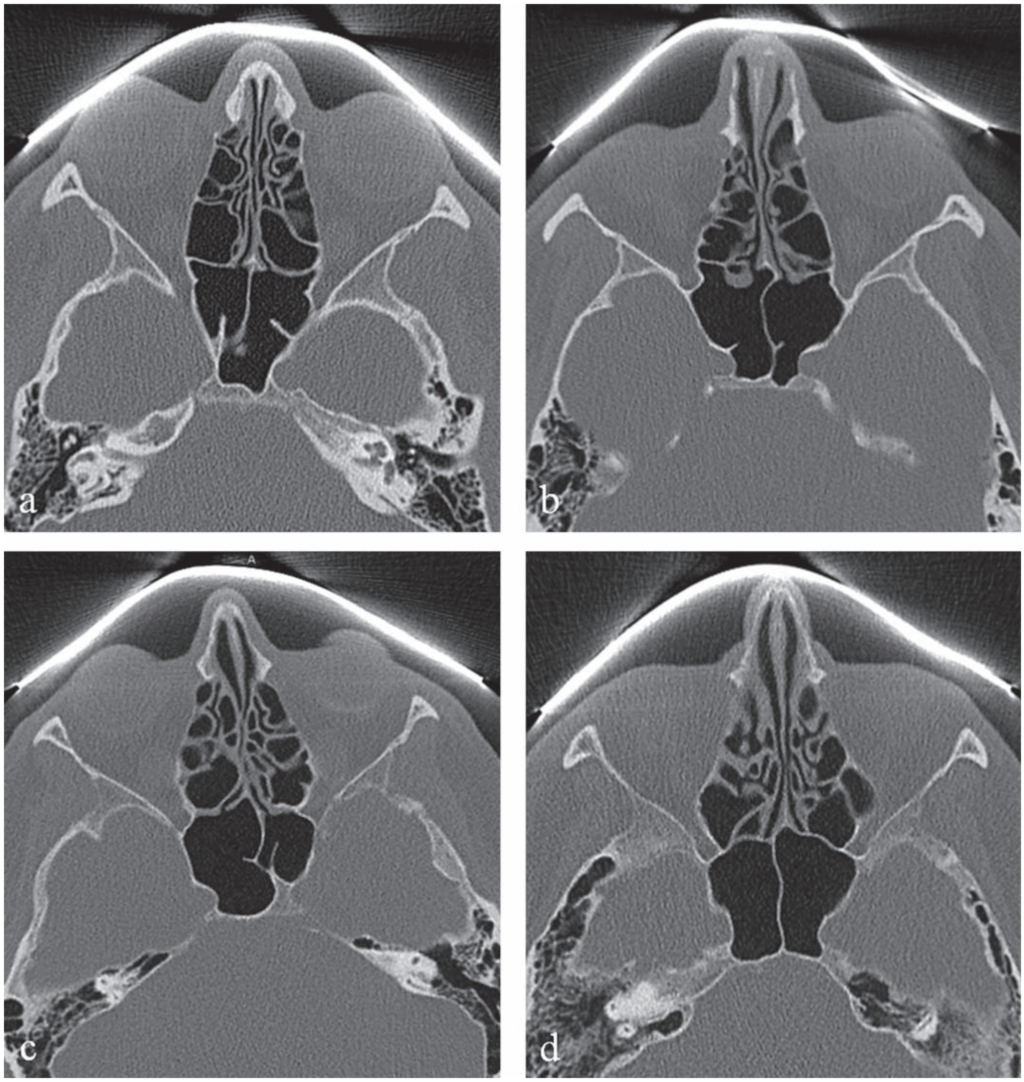

Fig. 1. Axial image plane for assessing subjective image quality in four different patients. Standard setting acquisition at 60 mAs reconstructed with filtered back projection (a) compared with tube current reduced scans of 20% (b), 40% (c) and 60% (d) processed with iterative reconstruction in image space. Subjective image quality was rated diagnostic for all four scans.

2. Materials and methods

This study was institutional review board-approved; written informed consent was obtained. Between June and October 2010, all adult patients referred for CT of the paranasal sinus for ruling out acute or chronic sinusitis were candidates for study inclusion. To investigate the bottom dose limit, we conducted a stepwise dose reduction by assigning patients to non-overlapping groups of 20 patients each in a prospective manner.

2.1. CTA data acquisition

All CT examinations were performed using a dual-source scanner (Somatom Definition; Siemens Medical Solutions, Forchheim, Germany). Patient position was supine with a slight reclination of the head to obtain parallel alignment of the upper jaw to the gantry so as to minimise impairment by dental prosthesis artefacts. A custom-made eye lens bismuth shield (CT EyeProteX, Somatex Medical Technologies GmbH, Teltow, Germany) was placed over the eyelids to minimise lens exposure. A scout view of the skull was obtained to plan CT data acquisition. Scan range extended from the roof of the frontal sinus down to the maxilla. Data were acquired in craniocaudal direction. Four non-overlapping patient groups were examined with either our routine protocol (Group A: 120 kV; 60 mAs) or with a 20% stepwise reduction in the tube current–time product: group B: 48 mAs (20%), group C: 36 mAs (40%) and group D: 24 mAs (60%). An online real-time angular modulation was not applied. Remaining scan parameters were kept constant: collimation 64 mm × 0.6 mm; rotation time 1 s; pitch 0.9. As 23 mAs represent the minimal tube-current that can be chosen at the given rotation time, no further dose reduction was conducted.

2.2. Image reconstruction

Transverse images were reconstructed with conventional filtered back projection (FBP) (Group A) or with iterative reconstruction (Groups B–D) with 0.7 mm slice thickness (0.7 mm increment) using a bone reconstruction kernel H70 h or J70 h, respectively. Additionally 2 mm coronal multiplanar reformations were generated using the same kernels. All data sets were transferred to a common picture archiving and communication system (PACS) and ImpaxEE was used for image analysis (Agfa Medgraph, Bonn, Germany).