Original Investigation

# Virtual Computed Tomography Colonography: Evaluation of 2D and Virtual 3D Image Quality of Sub-mSv Examinations Enabled by Third-generation Dual Source Scanner Featuring Tin Filtering

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**Rationale and Objectives:** To evaluate two- and three-dimensional (2D and 3D) image quality of sub-milliSievert (mSv) computed tomography (CT) colonography utilizing a third-generation dual source CT scanner featuring a tin filter.

**Methods:** We retrospectively evaluated 26 consecutive patients who underwent third-generation dual source CT colonography, nine with the standard-dose clinical-scan protocol (SDP) and 17 with a low-dose protocol (LDP) featuring a tin filter. Radiation dose was evaluated by volume computed tomography dose index ($CTDI_{vol}$), dose length product (DLP), effective dose (E), and size-specific dose estimate. Objective image quality was evaluated utilizing signal-to-noise ratio (SNR) derived from standardized placed regions of interest on the transverse 2D images and the ratio of $SNR/\sqrt{CTDI_{vol}}$ (normalized SNR). Two radiologists in consensus assessed subjective image quality of the virtual 3D images.

**Results:** There were no significant differences in subjective image quality ($P = .661$). All examinations were rated "excellent" or "good" for diagnostic confidence. The mean total for DLP/E was 143.4 ± 29.8 mGy/3.00 ± 0.40 mSv in the SDP and therefore significantly higher than in the LDP with 36.9 ± 8.7 mGy/0.75 ± 0.16 mSv ($P < .001$). The SNR was 8.9 ± 2.1 in the SDP and 4.9 ± 0.8 in the LDP.

**Conclusions:** Third-generation dual source CT featuring a tin filter enables consistent sub-mSv colonography without substantially impairing image quality.

**Key Words:** Computed tomography; third-generation dual source CT; tin filter; sub-milliSievert; CT colonography.



## INTRODUCTION

Colorectal cancer is the second most common cancer in Europe and the third most common in the United States (1,2). Screening colonoscopy procedures have led to a reduction of colorectal cancer incidence in Germany of 11%–19% despite relatively low screening participation (3). Nevertheless, there is the risk of complications, for example, perforations and therefore hospitalization and higher morbidity. Older patients in particular are six times more likely to experience complications (4). Furthermore, an analysis of 3.8 million screening examinations found that women age 70 years and older in particular must be indicated carefully to conventional colonoscopy, as the benefit-risk profile between the detection of a T2 carcinoma is outweighed by the risk of procedural complications, such as bleeding, cardiopulmonary incidents, and perforations (5). Although computed tomography (CT) colonography has proven to be a valuable and less invasive screening method with comparable accuracy to optical colonoscopy for polyps larger than 1 cm, it is not recommended in guidelines on colorectal cancer, including the German S3 Leitlinie, because of ionizing radiation concerns (6–9). However, especially in elderly patients, the potential benefits of CT colonography drastically outweigh the radiation risks (10). To reduce patients' effective dose (E) as much as possible, continuous efforts with different approaches, such as implementing iterative reconstructions,

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modulations in tube current and voltage, and automated dose modulation techniques, are necessary (11,12).

It is evident that tin filtration enables significant dose reduction in CT examinations with good image quality (13). However, to our knowledge, no work has been published concerning tin filtration in CT colonography. Therefore, the aim of this study is to evaluate the radiation dose and image quality of sub-milliSievert (sub-mSv) CT colonography utilizing third-generation dual source CT featuring a tin filter.

## MATERIALS AND METHODS

This retrospective study was conducted in accordance with the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of University Hospital Erlangen. The Ethics Committee waived the written informed consent requirement.

### Patient Population

The Radiological Information System was used to search for all CT colonography examinations during the 25-month experimental period between September 2014 and October 2016. In Germany, CT colonography is still an off-label examination and therefore the investigated patients received the examination because of exceptional circumstances surrounding their strong clinical needs. Indications were an impassable stenosis, incomplete conventional colonoscopy, status after mechanical ileus, fear of endoscopical perforation, or an increased tendency for bleeding. All 26 examined patients were included in the study population (9 males, 17 females, mean age = 60.7 years, age range = 30 to 78 years). To evaluate the size-specific dose estimation (SSDE), a conversion factor for each patient's body mass was estimated by summation of the anteroposterior and lateral diameter (14). The mean diameter was 54.7 cm (range = 44 to 63 cm). There were no significant differences between the groups. See Table 1 for further information.

### Patient Preparation and Examination Technique

All patients underwent bowel preparation the day before the examination. Patients' diets were restricted to fluids and orally administered 10 mg of sodium picosulfate, 3.5 g of light magnesium oxide, and 11 g of citric acid anhydrous (CitraFleet, Recordati Pharma GmbH, Germany). At the beginning of the examination, a rectal catheter was placed and the colon was inflated with $CO_2$ (PROTOCO2L, Bracco Diagnostics, NJ). Examinations consisted of a topogram and a helical scan, first in supine and then in prone position.

CT examinations were performed with a third-generation dual-source CT system (Somatom Definition Force, Siemens Healthineers, Erlangen, Germany) with the following parameters: single-source helical mode with a detector collimation of 192 × 0.6 mm, pitch value of 1.0, and gantry rotation time of 0.5 seconds. To reduce the risk of obscured polyps due to fluid levels, an additional scan in prone position was performed with a lower tube current.

The parameters for the standard-dose protocol (SDP) were adapted from the predecessor model (Somatom Definition Flash, Siemens). The tube voltage of the helical scan in the SDP was increased to 150 kV, (compared to 140 kV of the predecessor) to take advantage of the higher generator power. In supine position, the reference tube current was 22 mA with an adaptive current modulation Care Dose 4D (Siemens, Erlangen, Germany). In the supine position the reference tube current was 12 mA also with an adaptive current modulation Care Dose 4D. The topograms (supine and prone position) had a tube voltage of 120 kV and the current was maintained at a constant 20 mA.

The parameters of the low-dose protocol (LDP) were provided by the vendor. The LDP consisted of an additional prefiltration of the x-ray beam with a tin filter to harden the energy spectrum. The standard scan was performed in supine position. The tube voltage of the helical scan was 100 kV, the reference tube current in the supine position was 64 mA, and in the prone position 35 mA with an adaptive current modulation Care Dose 4D. For the topograms, no tin filtration was used, the tube voltage was 110 kV, and the current was kept at a constant 34 mA.

In both protocols, the same post-processing algorithm was used. Images were reconstructed with a collimation of 0.6 mm, a section interval of 0.4 mm, a soft (abdominal) kernel (Br64), and an advanced model iterative reconstruction strength level 2. The three-dimensional (3D) virtual colonoscopy images were generated from these images during the evaluation process.

**TABLE 1. Patient Characteristics for the Standard-Dose and Low-Dose Patient Cohort**

| | Standard Protocol | Low Dose | *P* Value |
|---|---|---|---|
| Age (years) | 58.7 ± 11.9 | 61.9 ± 10.2 | .476 |
| Sex | 1 m/8 f | 8 m/9 f | .098 |
| Diameter (cm) | 53.7 ± 6.2 | 55.4 ± 2.9 | .348 |

f, female; m, male.

Patient diameter (summation of the anteroposterior and lateral diameter) is used to calculate the size-specific dose estimation, as strongly recommended by the American Association of Physicists in Medicine. There are no significant differences between the groups.

### Objective Image Quality Assessment

Images were evaluated on a standard 3D-workstation (syngo.via, Siemens, version: VB10A). Readers were blinded to the patient's name and technical details. In the prone scan, densities (in Hounsfield Units [HU]) and standard deviations (SDs) were evaluated utilizing standard regions of interest in the liver, the left gluteus medius muscle (GM), and the ambient air. Image noise is the SD of HU values in the ambient air (15). Signal-to-noise ratio (SNR) was calculated by dividing the mean HU values (liver and GM) by the image noise.