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MR colonoscopy at 3.0 T: comparison with 1.5 T in vivo and a colon model

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Abstract

Purpose: Retrospectively, magnetic resonance (MR) colonography images obtained from a colon model and in routine examinations of patients screened for polyps were compared in terms of whether, and to what degree, image quality improved at a higher field strength of 3.0 T compared to 1.5 T. **Materials and methods:** One hundred twenty-eight MR colonography images from 40 patients, of whom 20 had each been scanned at 1.5 and 3.0 T, respectively, using a four-element phased-array torso coil, were compared. At both field strengths, imaging included T1-weighted fat-suppressed spoiled gradient-echo (T1-fs-GE), T2/T1-weighted fast imaging employing steady-state acquisition (FIESTA), and T2-weighted single-shot fast spin-echo (T2-SSFSE), with breath-hold technique. Using receiver operating characteristic analysis performed by seven readers, the three types of images from the colon model and from 20 patients each at 1.5 and 3.0 T were compared. While a time window of 20 s was allowed for picture assessment in a chance-generated succession of images on a monitor, image quality was rated with a score of 1–5 (1=*very good*; 5=*very bad*). Statistical significance was calculated with Mann–Whitney *U* test. **Results:** At both field strengths, T2-SSFSE images received the best ratings, followed by FIESTA images (P=.001). Although, overall, the 3.0-T images obtained scores worse than those of the 1.5-T images, a better detection of phantom polyps was noted in the colon model (P=.001). **Conclusion:** Although MR colonography with the breath-hold technique using the same four-element phased-array coil at 3.0 and 1.5 T does not perform better at a higher field strength in general, an improved detection of small polyps may be obtained.

Keywords: MR colonoscopy; 3.0 T; Colon polyps; Susceptibility

1. Introduction

Magnetic resonance (MR) colonography plays an important role in the diagnosis of tumors, as well as in inflammatory tissues [1–5]. MR colonography resolution is able to detect polyps with a minimal diameter of ca. 5–6 mm [6]; however, the sensitivity of detecting polyps smaller than 10 mm is low [7]. These results are below the possibilities that computed tomography (CT) colonography is capable of achieving [8]. Therefore, the techniques of MR colonography should be optimized to obtain results as good as those of CT. If possible, the argument of using radiological colon diagnostic exams for early detection examinations in the majority of patients would be much easier without the need for radiation exposure.

We wanted to find out if there was a difference in MR colonography examinations in terms of detection of polyps and image quality at 3.0 and 1.5 T.

2. Materials and methods

We performed a retrospective analysis of clinically indicated MR colonography examinations.

2.1. Preparation of patients and performance of examination

The examination was performed on 40 patients: female, 21 (age, 53±17 years); male, 19 (age, 50±13 years).

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The patients evacuated their bowels after taking a laxative (5 mg of Bisacodyl Präpacol; Guerbet GmbH, Sulzbach, Germany) on the day before the examination and maintained an empty stomach until the examination. Immediately before the examination, up to 1.5 l of water at a temperature of 37°C was instilled into the patients via a rectal tube. The maximum amount of fluid instilled depended on the tolerance of each patient. To reduce bowel movement, patients received an intravenous injection of 10 ml of the spasmolytic butylscopolamine (Buscopan; Boehringer Ingelheim, Germany).

2.2. Technical parameter

2.2.1. 1.5 T

Twenty of 40 patients were scanned with a four-element torso coil with a 1.5-T scanner (TwinSpeed; GE Healthcare, Milwaukee, USA). The examination protocol contained, besides the planning sequence, the following three sequences, which were performed with breath-hold technique:

(1) Two-dimensional fast imaging employing steady-state acquisition (2D-FIESTA): repetition time T_R=6.9 ms, echo time T_E=1.7 ms, flip angle=55°, band width BW=125 kHz, matrix=256×256, examination field=40 cm, slice thickness, SD=5 mm, slices=70 in 3 min
(2) T2-weighted single-shot fast spin-echo (T2-SSFSE) imaging: T_R=2500 ms, T_E=95 ms, BW=62.5 kHz, matrix=256×192, SD=5 mm, examination field=40 cm, slices=45 in 1 h 50 min
(3) T1-weighted fat-suppressed spoiled gradient-echo (T1-fs-GE): T_R=3.9 ms, T_E=1.7 ms, flip angle=12°, BW=62.5 kHz, matrix=256×160, SD=4 mm, slices=40 in 25 s
(4) 2D-FIESTA: T_R=6.9 ms, T_E=1.7 ms, flip angle=55°, Empfangsbandbreite BW=125 kHz, matrix=256×256, examination field=40 cm, slice thickness, SD=5 mm, slices=70 in 3 min
(5) T2-SSFSE: T_R=2500 ms, T_E=95 ms, BW=62.5 kHz, matrix=256×192, SD=5 mm, examination field=40 cm, slices=45 in 1 h 50 min
(6) T1-fs-GE: T_R=3.9 ms, T_E=1.7 ms, flip angle=12°, BW=62.5 kHz, matrix=256×160, SD=4 mm, slices=40 in 25 s.

2.2.2. 3.0 T

The other half of the patients were also examined with the four-element torso coil, but with a 3.0-T scanner (Signa 3.0 T; GE Healthcare). The examination protocol contained, besides the planning sequence, the following three sequences, which were performed with the breath-hold technique:

(1) 2D-FIESTA: T_R=5.5 ms, T_E=1.1 ms, BW=31.25 kHz, matrix=256×128, examination field=38 cm, SD=4 mm, slices=48 in 27 s
(2) T2-SSFSE: T_R=6000 ms, T_E=90 ms, BW=62.5 kHz, examination field=40 cm, SD=8 mm, gap=2 mm, matrix=256×256, slices=20 in 18 s
(3) T1-fs-GE: T_R=160 ms, T_E=5 ms, flip angle=70°, BW=62.5 kHz, examination field=36 cm, matrix=256×192, SD=4 mm, slices=40 in 2 min.

2.3. Interpretation of examinations

Three radiologists and four students analyzed 128 images taken with the 1.5-T scanner and with the 3.0-T scanner. Twenty-one images with T1-GE sequence, 22 with FIESTA sequence, and 21 with T2-SSFSE sequence were presented on a thin film transistor screen. The same procedure was performed with 118 images of a bowel model, examined with the 1.5-T and the 3.0-T scanner. Nineteen images with T1-GE sequence and 19 with FIESTA and T2-SSTSE sequences were presented (21 images at 1.5 T and 20 images at 3.0 T). Examinations were score according to a scale (1=*very good*; 2=*good*; 3=*moderate*; 4=*bad*; 5=*very bad*). The valuation of each picture was performed in 20 s.

Important for the valuation of each image was the subjective impression of picture quality (contrast, sharpness) by each estimator. Each concentrated specifically on the bowel model.

Using this procedure, the 128 images were estimated seven times. All 896 single valuations were combined in a tabular form and statistically analyzed with Mann–Whitney *U* test. The data were then graphically portrayed in the form of box plots.

2.4. Bowel model

In separate examinations, magnetic resonance tomography scans of a colon model (Fig. 1) were analyzed. The model was made of pipe (PVC; Ostendorf, HTU DN 40, DIN EN 1451 B), with a 33-cm length, a 11.5-cm coiled surface, and a 21.5-cm smooth surface. The diameter of the pipe was 5.5 cm. In the colon model, at a distance of 60°, there were six imitations of polyps (1.0 mm diameter, 2; 1.5 mm diameter, 2; 2.0 mm diameter, 2) made of synthetic materials (Fig. 1).

The 118 images of the colon model were analyzed by receiver operating characteristic (ROC) analysis, according to the following criteria: picture quality, portrayal of polyps, susceptibility artifacts, and general impression of the picture. Furthermore, the localization of polyp imitations had to be marked. A result of g1h meant that the localization and the size of the polyp imitation in the colon model had been seen correctly by the estimator; g−1h meant that the polyp imitation was not found or that, for example, an artifact was estimated as a polyp.

The sequences marked with g1h were capable of detecting polyps. The valuation of the 118 pictures was performed by four radiologists.