Magnetic resonance imaging in Crohn's disease
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Citation for published version (APA):

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CHAPTER

4

MR imaging of the small bowel with the True FISP sequence: intra- and interobserver agreement of enteroclysis versus imaging without contrast material

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Submitted
ABSTRACT

Purpose: The main purpose of this study was to determine the reliability of MR imaging without luminal contrast medium (MRI) versus MR enteroclysis (MRE). A secondary aim was to compare MRI and MRE findings per observer and compare findings with scores of an expert reader to determine the influence of luminal contrast medium on morphological evaluation.

Materials and Methods: In 48 consecutive 1.5T MRI studies of the small bowel, MRI and MRE scans were performed. All scans were evaluated independently by two observers who performed a qualitative (image quality, bowel distension) and morphological (bowel wall thickness, obstruction, ulceration, polyps, extraluminal findings) evaluation. Interobserver agreement was calculated. Findings of the two observers were also compared with the findings of an expert reader. The quality of the expert radiologist was evaluated by an intraobserver agreement procedure.

Results: Image quality and the degree of bowel distension were higher on MRE than on MRI. Interobserver agreement was higher on MRE than on MRI for bowel wall thickness measurements as well as for the detection and grading of obstruction. For these items agreement with the expert reader was higher on MRE than on MRI for both observers. Regarding the detection of extraluminal findings interobserver agreement did not increase on MRE compared with MRI.

Conclusion: The use of luminal contrast medium increases reliability for luminal findings in evaluation of the small bowel.
INTRODUCTION

Magnetic Resonance Imaging (MRI) is widely used as an imaging technique of the small bowel, but there is no generally accepted way to perform this examination (1-4). While in most studies luminal contrast medium was administered, either by using an enteroclysis technique (5-8) or by oral administration (9-12), in some studies imaging was performed without any use of luminal contrast medium (13-16).

Data concerning a side-by-side comparison of MRI of the small bowel without and with use of luminal contrast are lacking, both with regard to accuracy and with regard to reliability. However, information about the contribution of luminal contrast medium is important; if administration of luminal contrast medium would not be a prerequisite for MRI of the small bowel, this would have an effect on patient planning, the duration of scanning and patient acceptance.

The purpose of our study was to compare image quality, degree of bowel distension and interobserver variability of MR enteroclysis (MRE) and MRI of the small bowel without luminal contrast medium (MRI). A secondary aim was to compare MRI and MRE findings per observer and compare findings with scores of an expert reader to determine the influence of luminal contrast medium on morphological evaluation.

MATERIALS AND METHODS

Study population

From November 2003 till August 2004, consecutive patients referred to the radiology department of a teaching hospital for evaluation of the small bowel by MRE were included in this prospective cohort study. Patients were referred by the gastroenterological or surgical department on suspicion of small bowel pathology. The general exclusion criteria to MR imaging (e.g. claustrophobia, pregnancy) were applicable. Also, patients were excluded in case of suspicion of an intra-abdominal abscess or post-operative suture leakage. Informed consent was waived by the Institutional Review Board.

MR imaging

Patient preparation

The cleansing preparation of the small and large bowel consisted of a low-residue diet, ample fluids, and laxatives (15 grams of magnesium sulphate [hospital pharmacy] and two tablets of bisacodyl [hospital pharmacy; twice a day)] on the day prior to the exam, and nil per mouth on the day of the examination. Under fluoroscopic guidance, a 10 F nasoduodenal catheter (Flocare, Nutricia, Châtel-St-Denis, Switzerland) was placed in the distal part of the duodenum. After intubation, patients were transferred to the MR unit (1.5 T Magnetom Symphony, Siemens, Erlangen, Germany) where the catheter was connected to an electric infusion pump (Roentgen Contrast Mittel Pumpe, Nicholas, Sulzbach-Taunus,
Germany). The small bowel was distended with 1,000-3,000 mL of a solution containing 0.5% methylcellulose at an infusion rate of 80-200 mL/min. The amount administered and the infusion rate depended on the degree of bowel distension, the occurrence of gastric reflux, and the grade of bowel obstruction present.

MRI technique
MR imaging was performed using a torso phased-array surface coil. At baseline (i.e. before starting contrast infusion) a fat suppressed (fs) True Fast Imaging with Steady-state Precession (True FISP) sequence (TR 5.04 ms, TE 2.52 ms, matrix 151 x 256, FOV 400 x 400, slice thickness 5 mm) was performed in coronal and axial planes. These sequences were repeated approximately every five minutes during the filling process. To monitor the filling process, a coronal fs Half-Fourier Single-shot Turbo spin Echo (HASTE) sequence (TR 849 ms; TE 58 ms; matrix 218 x 256; FOV 250 x 250; one slice of 50 mm thickness) was performed repeatedly during infusion of luminal contrast medium. When maximum bowel distension was obtained, as judged on the coronal HASTE images, the TrueFISP sequence was again performed in the coronal and axial planes, as well as a coronal and axial fs T1-weighted Fast Low Angle SHot (FLASH) sequence (TR 212 ms; TE 308 ms; matrix 157 x 256; FOV 400 x 350; slice thickness 5 mm). The T1-weighted FLASH-sequence was repeated 60 seconds after intravenous administration of 0.1 mmol/kg of bodyweight of Gadolinium (Magnevist, Schering, Germany). No spasmolytic medication was administered.

Image evaluation
To determine the contribution of luminal contrast medium for assessment of the small bowel, the True FISP images made at baseline were compared with the True FISP images made when maximum bowel distension was obtained. Comparison of the T1-weighted FLASH sequences was not performed, as intravenous contrast medium was administered only once per examination. In order to be able to independently assess the baseline images and the images with maximal distension, two datasets were made for each patient. One set of images consisted of the coronal and axial True-FISP images made before contrast administration (MRI), and one set consisted of the images acquired after contrast administration by enteroclysis (MRE).

For evaluation of the images, the small bowel was divided in four segments: duodenum, jejunum, proximal ileum, and distal (last 30 cm) ileum. If patients had previously undergone ileocecal resection, the neoterminal ileum was scored as distal ileum. Small bowel loops left of an imaginary line from the liver dome to the roof of the left acetabulum were considered jejunum, all bowel loops located right of this imaginary line were considered ileum.

The MR images were evaluated both qualitatively and morphologically. For the qualitative assessment, image quality and degree of bowel distension were scored. Image quality was graded per examination on a 3–level scale: non-diagnostic images (with disturbing artefacts), images with numerous artefacts (without disturbing artefacts), or images of good diagnostic quality (without artefacts). Bowel distension was graded per bowel
segment as either insufficient (i.e. collapsed bowel loops), or sufficient for diagnosis (small bowel lumen measuring >0.5 cm). For morphological evaluation bowel wall thickness was measured for each bowel segment using hand-held calipers at the location that visually showed the most thickened bowel wall. The observers could use both the axial and coronal images for this purpose. Abnormal bowel wall thickness was defined as a wall thickness > 3mm. Bowel obstruction was scored on a 3-level scale as absent, low-grade (luminal reduction without prestenotic dilatation), or high-grade (luminal reduction with prestenotic dilatation). Bowel obstruction was considered present if it could be observed in both imaging planes. Normal contraction was discriminated from low-grade obstruction in evaluating the different planes as they were made consecutively.

Absence or presence of mucosal ulcerations, polyps, and increased mesenteric vascularization (“comb sign”) was scored per bowel segment. Ulcerations were defined as mucosal irregularities. A polyp was defined as an intraluminal mass larger than the surrounding folds. The comb sign was deemed present if pronounced linear structures were noted on the mesenteric site of the bowel. Absence or presence of fibrofatty proliferation, presence of mesenteric lymph nodes, ascites, fistula and abscess was scored per examination. Fibrofatty proliferation was defined as a focal increase in mesenteric fat. Mesenteric lymph nodes were defined as round or oval structures in the mesentry. The short-axis diameter of the largest lymph node was measured. Ascites was defined as free intraperitoneal fluid. A fistula was defined as a fluid-filled connection between two organs or structures. An abscess was defined as a localized encapsulated fluid collection, with or without contained air.

Observers
The MRI and MRE datasets were presented on two different time points with a minimum interval of 6 weeks. MRI and MRE datasets were presented in random order and were independently evaluated by two observers.

With respect to the accuracy of MRI and MRE findings, no reference standard was available for the small bowel. To determine the degree of consensus, the scores of the two observers were compared to the scores of an expert reader who had an experience of over 200 MR enteroclysis assessments and 50 MRI studies of the small bowel with oral contrast medium. The reading stability of the expert reader was evaluated by an intraobserver agreement procedure. To prevent recall bias a time interval of 6 months was taken between the first and second scores of the expert reader. The findings from the first read of the expert reader were used to determine the degree of consensus between the observers and the expert reader.

The expert reader had access to patient and clinical data (including follow-up) and used these data in combination with all available MR images (including the T1-weighted images) to reach a conclusion regarding disease status. The two observers had no access to patient or clinical data. The first observer was a radiologist with 5 years experience in reading abdominal MRI (more than 100 MRI studies of the bowel), while the second observer was
a radiology research fellow who had read approximately 50 abdominal MRI examinations for Crohn’s disease with ileocolonoscopic verification prior to this study.

Statistical analysis

Intra- and interobserver agreement
For bowel distension and image quality, descriptive analysis was used. For all morphological variables with the exception of bowel wall measurements, agreement was quantified using Cohen’s kappa ($\kappa$) statistics. Kappa values range from 0 – 1, where 0 – 0.2 is considered ‘poor’, 0.2 – 0.4 is considered ‘fair’, 0.4 - 0.6 is considered ‘moderate’, 0.6 - 0.8 is considered ‘good,’ and > 0.8 as ‘very good’ agreement (17). The intraclass correlation coefficient was used to calculate agreement for measured wall thickness.

Comparison with expert reader
For comparison between the morphological scores of the expert reader and the two observers, agreement was calculated using kappa statistics.

Comparison between MRI and MRE
To determine whether significantly different scores were observed between MRI and MRE for the two observers, the McNemar test was used for all variables, with the exception of wall thickness. To calculate whether statistically significant differences in measured wall thickness were observed, the Wilcoxon signed ranks test was used. SPSS (version 14.0; SPSS, Chicago, Ill)) and StatXact (StatXact 3.0 for Windows; Cytel Software Corporation, Cambridge, MA) were used for statistical analysis. P-values <0.05 were considered to indicate statistical significance.

RESULTS

A total of 55 patients underwent MR enteroclysis. Seven patients were excluded due to the fact that the MRI scans were incomplete, hence 48 patients were included for analysis, of whom 25 were male (mean age 44.3 yrs, range 20.2-82.6). Indications for MR enteroclysis were: suspected increase in disease activity in patients with known Crohn’s disease (n=12), suspected Crohn’s disease (n=20), suspected low-grade small bowel stenosis (n=13), and suspected small bowel neoplasm (n=3). One patient with known Crohn’s disease had undergone an ileocelecal resection 5 years earlier. The mean amount of administered methylcellulose-solution was 2,600 mL (range 900-3,500 mL) at a mean infusion rate of 95 mL/min (range 40-180 mL/min). In Table 1, the clinical diagnoses of the included patients (based on MR findings, clinical history, laboratory findings, endoscopy, surgery, and/or follow up) are listed.
Qualitative analysis

Both observer 1 and 2 found that the image quality significantly improved on MRE when compared to the MRI examinations. Whereas both observers scored all MRE studies as having good image quality (100%, 95%CI 93-100%), observer 1 scored 33/48 MRI studies to be of good quality (69%, 95%CI 54-81%) while observer 2 scored 38/48 MRI studies (79%, 95%CI 65-90%) as being of good diagnostic quality. Both observers judged significantly more bowel segments as adequately distended on MRE than on MRI (p <0.001).

For MRI agreement on image quality was 85% (41/48); in 9 examinations the observers agreed that image quality was poor, in 32 that images were of good quality. For MRE agreement on bowel distension was 83% (160/192) (inadequate 18, adequate 142). The proportion of examinations in which the observers agreed on bowel distension on MRI was 84% (162/192), but on MRI most bowel segments were scored as inadequately distended (n=142).

Comparison between MRI and MRE

On MRE both observers diagnosed more segments with a thickened bowel wall than on MRI; however, this difference was not statistically significant for either observer (observer 1: p=0.86; observer 2: p= 0.22). For diagnosis of bowel obstruction no significant differences were found between MRI and MRE as well (observer 1, p= 0.45; observer 2, p=0.34).

No statistical tests were performed to determine potential differences in detection rates of ulcerations and polyps, due to the low prevalence of these findings. No significant differences were found between MRI and MRE regarding detection of extraluminal findings (data not shown), with the exception of lymph node detection; observer 1 detected lymph nodes in a significantly larger number of patients on MRE than on MRI (p=0.04).

Table 1: Clinical diagnoses of included patients

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crohn’s disease</td>
<td>18</td>
</tr>
<tr>
<td>Jejunitis</td>
<td>3</td>
</tr>
<tr>
<td>Carcinoid</td>
<td>1</td>
</tr>
<tr>
<td>Duplication cyst duodenum</td>
<td>1</td>
</tr>
<tr>
<td>Radiation enteritis ileum</td>
<td>1</td>
</tr>
<tr>
<td>Sclerosing encapsulating peritonitis</td>
<td>1</td>
</tr>
<tr>
<td>Colitis</td>
<td>4</td>
</tr>
<tr>
<td>Transmural endometriosis</td>
<td>1</td>
</tr>
<tr>
<td>No abnormality</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
</tr>
</tbody>
</table>
Interobserver agreement for MRI and MRE

Interobserver agreement for diagnosis and grading of bowel obstruction increased from moderate to good after administration of luminal contrast medium. Bowel wall measurements were also more reliable on MRE. With regard to extraluminal findings no changes in interobserver agreement were observed for the detection of the comb sign and creeping fat, whereas for detection of lymph nodes and ascites agreement decreased from good to moderate (Table 2). Interobserver agreement for the detection of ulcerations, polyps, fistula, and abscess was not determined, due to the low prevalence of these findings.

<table>
<thead>
<tr>
<th>Obstruction</th>
<th>MRI</th>
<th>MRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa (95% CI)</td>
<td>0.39 (0.14-0.64)</td>
<td>0.60 (0.40-0.80)</td>
</tr>
<tr>
<td>Comb sign</td>
<td>0.70 (0.52-0.87)</td>
<td>0.72 (0.56-0.88)</td>
</tr>
<tr>
<td>Creeping fat</td>
<td>0.38 (0.02-0.75)</td>
<td>0.38 (0.02-0.75)</td>
</tr>
<tr>
<td>Lymph node detection</td>
<td>0.63 (0.58-0.96)</td>
<td>0.51 (0.27-0.74)</td>
</tr>
<tr>
<td>Ascites</td>
<td>0.78 (0.48-1)</td>
<td>0.50 (0.14-0.86)</td>
</tr>
</tbody>
</table>

95% CI: 95% confidence interval

Table 2: Interobserver agreement between observer 1 and 2

Intraobserver agreement for expert reader

The intraobserver agreement was very good for the assessment of all morphological items (Table 3). For the qualitative evaluation of MRI and MRE, the expert reader reached 100% agreement with regard to the degree of bowel distension and image quality between the first and second read.

<table>
<thead>
<tr>
<th>Obstruction</th>
<th>MRI</th>
<th>MRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa (95% CI)</td>
<td>0.92 (0.77-1.00)</td>
<td>0.97 (0.90-1.00)</td>
</tr>
<tr>
<td>Comb sign</td>
<td>0.97 (0.90-1.00)</td>
<td>1.00</td>
</tr>
<tr>
<td>Creeping fat</td>
<td>0.95 (0.85-1.00)</td>
<td>0.90 (0.76-1.00)</td>
</tr>
<tr>
<td>Lymph node detection</td>
<td>0.83 (0.68-0.99)</td>
<td>0.95 (0.85-1.00)</td>
</tr>
<tr>
<td>Ascites</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

95% CI: 95% confidence interval

Table 3: Intraobserver agreement of expert reader
Comparison with expert reader

Agreement with the expert reader was higher on MRE than on MRI for luminal findings; for both observers the intraclass correlation coefficient for measured bowel wall thickness was higher on MRE than on MRI, whereas the agreement on the diagnosis and grading of obstruction increased from poor to moderate. With regard to extraluminal findings, for observer 1 agreement with the expert reader mostly was moderate on MRI. Administration of luminal contrast medium did not change this. For observer 2 agreement with the expert reader decreased from moderate to fair for creeping fat and from good to moderate for the detection of lymph nodes (Table 4). No statistical tests were performed to determine the degree of consensus between the two observers and the expert reader for the detection of ulcerations, polyps, fistula, and abscess due to the low prevalence of these findings.

Table 4: agreement between observers and expert reader

<table>
<thead>
<tr>
<th></th>
<th>MRI</th>
<th>MRE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bowel wall thickness</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>expert reader - observer 1</td>
<td>0.38 (0.25-0.49)</td>
<td>0.57 (0.46-0.65)</td>
</tr>
<tr>
<td>expert reader - observer 2</td>
<td>0.44 (0.32-0.55)</td>
<td>0.68 (0.59-0.75)</td>
</tr>
<tr>
<td><strong>Kappa (95% CI)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>expert reader - observer 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>expert reader - observer 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Obstruction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>expert reader - observer 1</td>
<td>0.11 (-0.01-0.22)</td>
<td>0.53 (0.34-0.73)</td>
</tr>
<tr>
<td>expert reader - observer 2</td>
<td>0.06 (-0.08-0.19)</td>
<td>0.53 (0.31-0.75)</td>
</tr>
<tr>
<td><strong>Comb sign</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>expert reader - observer 1</td>
<td>0.48 (0.27-0.68)</td>
<td>0.61 (0.27-0.68)</td>
</tr>
<tr>
<td>expert reader - observer 2</td>
<td>0.71 (0.52-0.90)</td>
<td>0.63 (0.44-0.82)</td>
</tr>
<tr>
<td><strong>Creeping fat</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>expert reader - observer 1</td>
<td>0.48 (0.19-0.76)</td>
<td>0.42 (0.14-0.71)</td>
</tr>
<tr>
<td>expert reader - observer 2</td>
<td>0.58 (0.31-0.85)</td>
<td>0.32 (0.04-0.60)</td>
</tr>
<tr>
<td><strong>Lymph node detection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>expert reader - observer 1</td>
<td>0.59 (0.36-0.81)</td>
<td>0.59 (0.36-0.82)</td>
</tr>
<tr>
<td>expert reader - observer 2</td>
<td>0.79 (0.62-0.96)</td>
<td>0.47 (0.25-0.69)</td>
</tr>
<tr>
<td><strong>Ascites</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>expert reader - observer 1</td>
<td>0.57 (0.24-0.89)</td>
<td>0.50 (0.14-0.86)</td>
</tr>
<tr>
<td>expert reader - observer 2</td>
<td>0.61 (0.30-0.92)</td>
<td>0.70 (0.43-0.98)</td>
</tr>
</tbody>
</table>

95% CI: 95% confidence interval
Figure 1. 28-year-old male for whom MRI was performed to differentiate between Crohn’s disease and ulcerative colitis.

**a.** Coronal fat saturated true FISP image without enteral contrast medium shows collapsed terminal ileum (arrow). Small bowel wall thickening cannot be excluded.

**b.** Coronal fat saturated true FISP MR enteroclysis image shows optimally distended terminal ileum (arrow), without bowel wall thickening. No small bowel pathology was detected elsewhere. This patient was diagnosed with ulcerative colitis during follow-up.

Figure 2. 41-year-old female with abdominal complaints and suspicion of Crohn’s disease. On colonoscopy no pathology was seen.

**a.** Coronal fat saturated true FISP image without enteral contrast medium shows collapsed ileum (arrow). Bowel wall thickening and stenosis are not detected on this image.

**b.** Coronal fat saturated true FISP MR enteroclysis image shows bowel wall thickening of the ileum with two stenotic segments (arrows).
Chapter 4

MRI of the small bowel without enteral contrast medium versus MR enteroclysis

Figure 3. 63-year-old female with abdominal pain in the right lower quadrant since 10 months. On ultrasound bowel wall thickening of the terminal ileum was observed.

**DISCUSSION**

For MRI of the small bowel, the administration of luminal contrast medium by enteroclysis leads to an increased reliability with regard to measurements of bowel wall thickness and diagnosis and grading of bowel obstruction. Reliability regarding extraluminal findings does not increase.

The increased reliability for measurements of bowel wall thickness can probably be attributed to the improvement in the image quality and the degree of bowel distension after administration of luminal contrast medium. Due to the high volume that is infused for MRE reflex atony is induced, causing peristaltic movements to diminish and consequently image quality to increase. With regard to the bowel distension and its influence on reliability: in collapsed bowel loops the bowel wall contours cannot be adequately delineated, thus measurements of bowel wall thickness could suffer from impreciseness. Also, in an inadequately distended bowel it is difficult to diagnose and grade obstruction: although a high-grade stenosis with prestenotic dilatation will be visible due to the stasis of fluid in the dilated prestenotic bowel, for a low-grade obstruction an adequately filled lumen will facilitate identification.

**Figure 3.** 63-year-old female with abdominal pain in the right lower quadrant since 10 months. On ultrasound bowel wall thickening of the terminal ileum was observed.

**a.** Axial fat saturated true FISP image shows thickened terminal ileum loops without distension (solid arrow), increased mesenterial vascularization (comb sign, open arrow) and creeping fat. Grading of stenosis is not possible on these images.

**b.** Axial fat saturated true FISP image shows optimal distension of the terminal ileum with wall thickening (solid arrow) and two segments with stenosis (arrowheads). This image shows the same extramural pathology as the baseline images; increased mesenterial vascularization (comb sign, open arrow) in increased mesenterial fat.
Although for luminal findings the interobserver agreement and the agreement between the expert and the observers increased in an adequately distended bowel, agreement between the observers and the expert reader was still only moderate for bowel obstruction. This can partly be explained by the fact that prevalence of obstruction was very low. Namely, one of the factors that can influence the magnitude of kappa is prevalence. If the prevalence index is high (i.e. the prevalence of a positive rating is either very high or very low), chance agreement is also high and kappa is reduced accordingly (18). Also, although we tried to keep the MRI ratings as objective as possible by providing clear cut-off points between scores, it is very likely that subjective interpretation played a role for each observer. The difference in experience of the observers in our study might also have contributed to the moderate agreement.

Unfortunately, no reference standard was available to determine the accuracy of MRI versus MRE. Video capsule endoscopy or double balloon enteroscopy could have provided a reference standard, but these examinations were not available in everyday clinical practice until recently, and most likely will not be applied to the full disease spectrum included in this study. However, in clinical practice the assessment of an experienced radiologist, using MRI findings in combination with all clinical information available, would be considered adequate for diagnosis. In our study findings for both observers were compared with scores of an expert reader.

Only comparison of the True FISP sequences was performed precluding determination of the reliability of postcontrast T1-weighted imaging on MRI versus MRE. In most comprehensive MR protocols for small bowel imaging postcontrast T1-weighted imaging is included as the enhancement of the bowel wall can provide information about the degree of disease activity. However, the trueFISP sequence is very useful in clinical practice as motion-related artifacts are minimal while trueFISP imaging has been shown to perform as well or better than T1-weighted imaging for evaluation of the small bowel (6, 19).

Another limitation is the fact that oral administration of contrast medium was not performed, as this would have provided the opportunity to perform a side-by-side comparison of all three methods of bowel preparation. However, in a recently published study by Negaard et al the diagnostic accuracy and the reliability of MRI using oral contrast medium and MR enteroclysis were compared (20). Although the mean luminal diameter was greater on MR enteroclysis than on MRI using oral contrast medium, both techniques were equally accurate and reliable.

In the study by Negaard et al. reliability was higher than in our study. This might be explained by the difference in the patient population under study, as in their study only patients with Crohn’s disease, mainly affecting the terminal ileum, were included whereas in our study a wide variety of pathology was evaluated, including patients without pathology.

We did not study patient acceptance of both techniques. Although patient preference for an examination without contrast medium seems obvious, this should be substantiated in further studies.
In conclusion, the use of luminal contrast medium in MRI of the small bowel improves reliability for measuring bowel wall thickness and the diagnosis and grading of obstruction.

REFERENCES
