

# The Utility of MR Imaging Using the HASTE and True FISP Sequences in Diagnosing Bowel Obstruction<sup>1</sup>

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**Purpose:** To determine the value of magnetic resonance imaging (MRI) using HASTE (half-Fourier single-shot turbo spin-echo) and true FISP (fast imaging with steady-state precession and heavy T2-weighting) sequences in diagnosing bowel obstruction.

**Materials and Methods:** Thirty-one consecutive patients in whom suspected bowel obstruction was revealed at plain abdominal radiography, barium study, and computed tomography (CT) were admitted during an eight-month period. Eighteen of 27 in whom bowel obstruction was confirmed underwent MRI using HASTE and true FISP sequences.

**Results:** At MRI, bowel obstruction was diagnosed in all patients. Using the HASTE sequence, the site of obstruction was correctly identified in 16 patients (89%) and the cause of obstruction was correctly diagnosed in 15 (83%). Using the true FISP sequence, the corresponding figures were 16 (89%) and 16 (89%). Of the 18 patients with confirmed bowel obstruction, 33% (6/18) showed better lesion conspicuity at true FISP, for 39% (7/18), conspicuity was equal at both sequences, 28% (5/18) showed better conspicuity at HASTE.

**Conclusion:** MRI can be useful for evaluation the presence, site and cause of bowel obstruction. On comparing the findings of HASTE and true FISP sequences, no significant differences were observed.

**Index words :** Intestines, obstruction  
Intestines, MR

MRI has been widely applied in the evaluation of various abdominal diseases (1, 2), but its use for the evaluation of gastrointestinal disease has been slow to develop because of long acquisition times (resulting in increased motion artifacts, mostly from either respiration or peristalsis) and the unavailability of good MR contrast

agents for the gastrointestinal tube (3, 4). As a result, only a small number of published studies have focused on the appearance of intestinal disease processes evaluated by MRI and there have been few reports concerning bowel obstruction (5 - 8). Several recent reports have described the use of fast MRI in small bowel disease, including small bowel obstruction (9 - 11). In this study, we investigated bowel obstruction using HASTE and true FISP sequences.

Our purpose was to evaluate the efficacy of MRI using HASTE and true FISP sequences in demonstrating bowel obstruction, in identifying the sites involved, and in determining the cause of obstruction.

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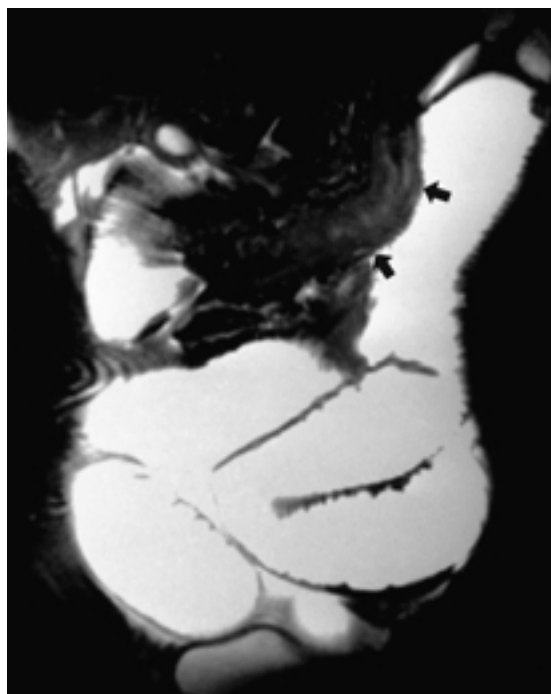
## Materials and Methods

Thirty-one consecutive patients in whom suspected bowel obstruction was revealed at plain abdominal radiography ( $n=18$ ), barium study ( $n=7$ ), and computed tomography (CT) ( $n=10$ ), were admitted during an eight-month period. In 26 of the 31, bowel obstruction was confirmed at surgery, and one case was confirmed at colonoscopic biopsy. Of these 27 with confirmed bowel obstruction, 18 underwent MRI using the HASTE and true FISP sequences, and these 18, in whom the respective conditions had been pathologically proven, comprised our series. The remaining nine, whose condition had been pathologically proven but who did not undergo MRI, were excluded from our study. Among the 18 patients [M:F=8:10; age range=25 - 93 (mean, 53) years], the common clinical symptoms were nausea, vomiting, abdominal pain, and distention. Thirteen patients had a history of prior surgery (gastrointestinal malignancy,  $n=10$ ; bowel perforation due to trauma or ulcer,  $n=3$ ).

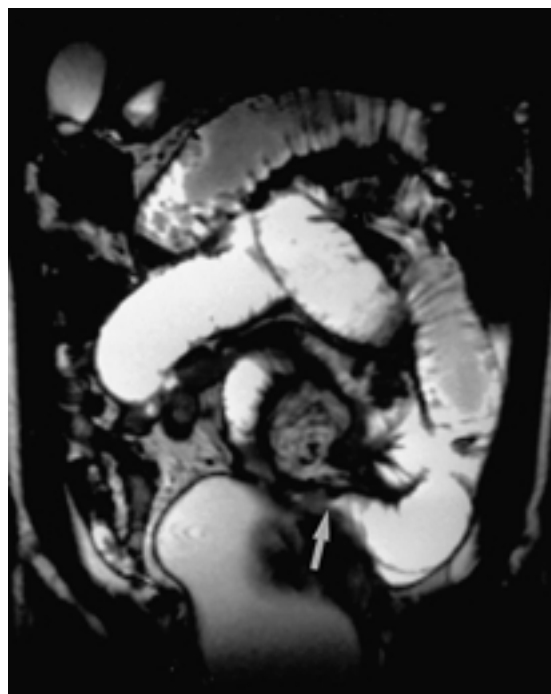
For MR examinations, a 1.0 Tesla scanner (Magnetom

Impact Expert, Siemens, Erlangen, Germany) with a 15 mT/m gradient system and a body phased array coil was used. HASTE (repetition time [TR], infinite; echo time [TE], 87 ms; flip angle, 150 °; number of excitations, 1; matrix number, 192 × 256; field of view [FOV], 350 × 350 mm; slice thickness, 6 mm) and true FISP (TR, 7.6 ms; TE, 3.5 ms; flip angle, 80 °; number of excitations, 1; matrix number, 192 × 256; FOV, 300 × 400 mm; slice thickness, 6 mm) images were obtained during single breath-holds lasting an average of 19 seconds. Axial and coronal scans were obtained using both MRI sequences; fat suppression and cardiac or respiratory gating were not used. No medications for suppressing bowel peristalsis and contrast agent were given, and enteric contrast material or water were not ingested. The total examination time did not exceed 10 minutes.

Two radiologists reviewed the images in terms of the presence, site and cause of bowel obstruction, comparing the image quality of the two MRI sequences and reaching their decisions consensually. Obstruction was diagnosed if a definite transition zone was observed, with dilated fluid and/or air-filled loops of small bowel proximal to the site of obstruction and collapsed loops of



**Fig. 1.** A 33-year-old man who had total gastrectomy for gastric cancer with recurrent tumor in transverse colon. Coronal true FISP MR image (TR/TE 7.6/3.5, FA 80 °) shows wall thickening of distal transverse colon (arrows) and dilated small bowel loops, suggesting malignant obstruction. Surgery revealed recurrence.



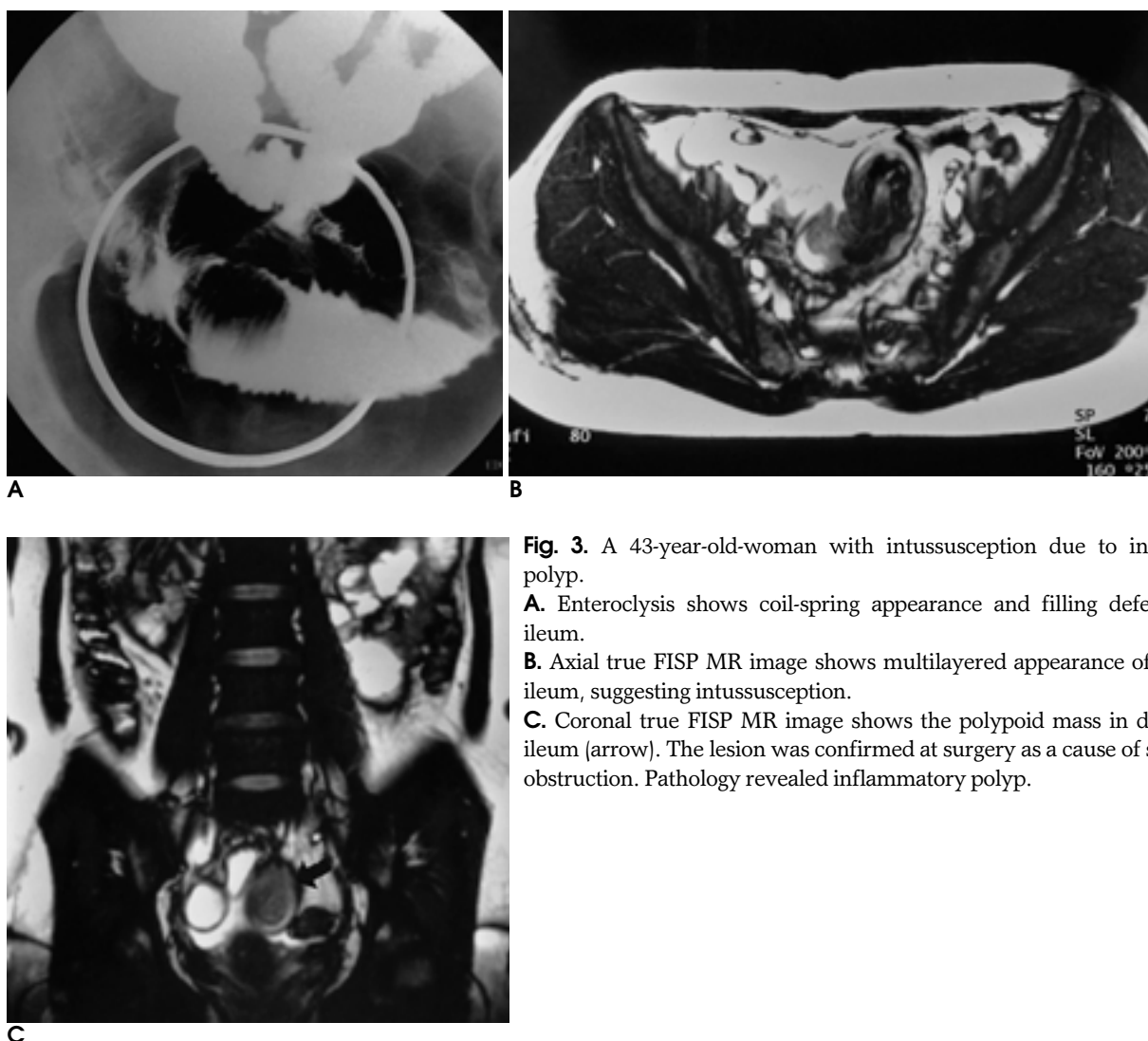
**Fig. 2.** A 47-year-old man who had subtotal gastrectomy for gastric cancer with small bowel obstruction due to postoperative adhesion. Coronal true FISP MR image shows multiple dilated, fluid-filled small bowel loops and an abrupt transition (arrow) of dilated and collapsed bowel loops. No mass lesions are seen around site of transition. It was confirmed by surgery.

small or large bowel distal to this site, and whether obstruction involved the proximal or distal small bowel, or the large bowel, was determined. Small and large bowel were differentiated according to their morphology and the central location of small bowel loops versus the peripheral position of the colon, best appreciated at coronal imaging (10). The cause of bowel obstruction was determined by evaluating the appearance of the obstruction site and the patient's past medical history. In these in whom gastrointestinal malignancy had necessitated surgery prior to MRI, post-operative adhesion or tumor recurrence was diagnosed on the basis of the following criteria: beak-like narrowing but the absence of a definite mass for post-operative adhesion, and an incriminating focal intraluminal mass or focal wall thickening of adjacent bowel for tumor recurrence (12). Intussusception was diagnosed if an intussuscepted segment and leading point were detected. Inflammatory bowel dis-

ease was diagnosed if mild diffuse bowel wall thickening was present, and colon cancer if a focal intraluminal mass or pronounced focal bowel wall thickening was observed.

## Results

In all patients, MRI using the HASTE and true FISP sequences, demonstrated the existence of bowel obstruction. The obstruction site was correctly identified in 16 of 18 cases; the exception were two cases of distal small bowel obstruction. Obstruction occurred at the distal small bowel in 13 cases, the proximal small bowel in two, the ascending colon in two, and the transverse colon in one; its cause was tumor recurrence after surgery for gastrointestinal malignancy (Fig. 1) in seven cases, postoperative adhesion (Fig. 2) in six, intussusception (Fig. 3) in two, and colon cancer (Fig. 4), bezoar, and



**Fig. 3.** A 43-year-old-woman with intussusception due to inflammatory polyp.  
**A.** Enteroclysis shows coil-spring appearance and filling defect in distal ileum.  
**B.** Axial true FISP MR image shows multilayered appearance of the dilated ileum, suggesting intussusception.  
**C.** Coronal true FISP MR image shows the polypoid mass in dilated distal ileum (arrow). The lesion was confirmed at surgery as a cause of small bowel obstruction. Pathology revealed inflammatory polyp.

tuberculosis (Fig. 5) in one case each (Table 1).

At HASTE sequencing, the site of obstruction was correctly identified in 16 patients(89%), and its cause in 15 patients(83%). For the true FISP sequence, the corresponding figures were 16(89%) and 16(89%) (Table 2). For both sequences, the two unidentified cases involved a recurrent tumor and postoperative adhesion. The cause of obstruction diagnosed only at true FISP was a bezoar in the small bowel.

Of the 18 patients with bowel obstruction, 33%(6/18) showed better lesion conspicuity at true FISP. For 39% (7/18), conspicuity was the same at both sequences, and for 28%(5/18) it was better at HASTE (Table 3).

## Discussion

The purpose of radiological imaging in patients with bowel obstruction includes the confirmation or exclusion of such obstruction, identification of the site involved, and assessment of the severity, and cause of the obstruction and whether strangulation or other complications have arisen. Conventionally, plain radiography,

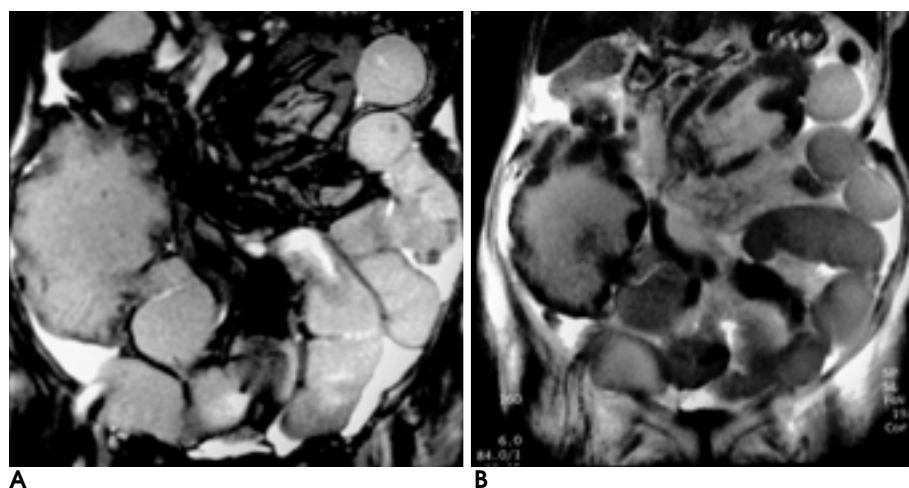
**Table 2.** Results of Presence, Site and Cause of Bowel Obstruction Using the HASTE and true FISP Sequences in 18 Patients

	Presence	Site	Cause
HASTE	18/18 (100%)	16/18 (89%)	15/18 (83%)
True FISP	18/18 (100%)	16/18 (89%)	16/18 (89%)

**Table 1.** Site, Cause and MR Findings of Bowel Obstruction in 18 Patients

No.	Site	Cause	MR findings
1	Proximal small bowel	Recurrent colon cancer	Recurred mass
2	Distal small bowel	Postoperative adhesion	*
3	Distal small bowel	Recurred gastric cancer	?
4	Distal small bowel	Postoperative adhesion	*
5	Distal small bowel	Recurred colon cancer	Recurred mass
6	Distal small bowel	Recurred colon cancer	Omental cake
7	Distal small bowel	Postoperative adhesion	*
8	Ascending colon	Tuberculosis	Thickened wall of terminal ileum
9	Distal small bowel	Intussusception due to polyp	Polypoid mass
10	Transverse colon	Recurrent gastric cancer	Recurred mass
11	Distal small bowel	Postoperative adhesion	*
12	Distal small bowel	Recurred colon cancer	Irregular mass in pelvic cavity
13	Distal small bowel	Postoperative adhesion	*
14	Ascending colon	Primary colon cancer	Thickened wall of ascending colon
15	Distal small bowel	Recurred colon cancer	Irregular soft tissue mass
16	Distal small bowel	Postoperative adhesion	*
17	Distal small bowel	Intussusception due to lymphoma	Intussuscepted segment of bowel
18	Proximal small bowel	Bezoar	Foreign body on only True FISP

\*: abrupt transition of dilated and collapsed bowel loops without any mass



**Fig. 4.** A 93-year-old-woman with small bowel obstruction due to primary ascending colon cancer.

Coronal true FISP (A) and HASTE (B) (TR/TE 10.9/87, FA 150 °) MR images show dilated small bowel loops and markedly dilated proximal portion of ascending colon. Another scan shows focal wall thickening of distal portion of ascending colon. She refused surgery. This case was confirmed by colonoscopic biopsy.

barium studies and CT have been widely used (13).

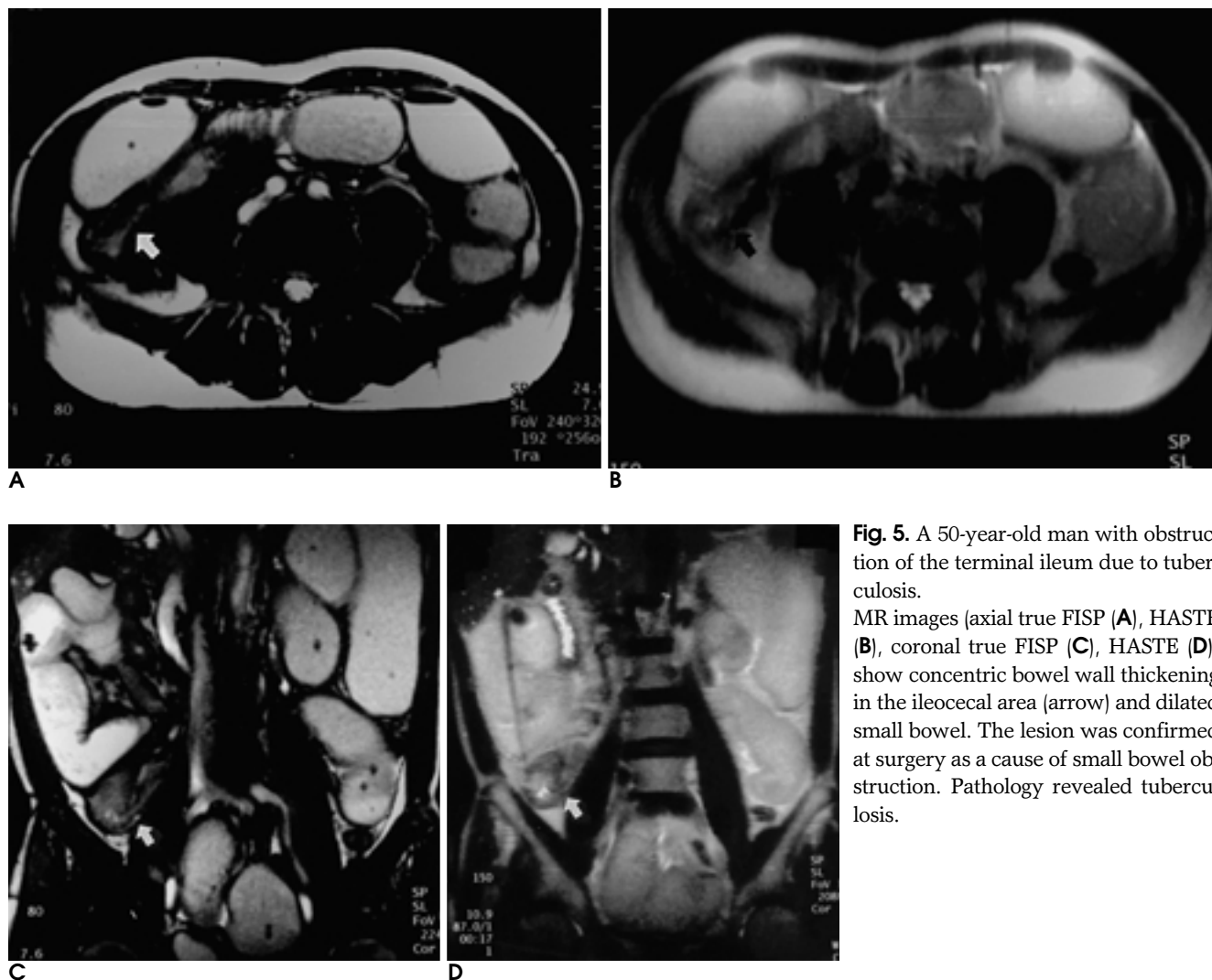
Plain film findings are thought to be diagnostic in about 50 - 60% of cases and equivocal in about 20 - 30% (14). One report showed that enteroclysis correctly predicted the presence of obstruction in 100% of cases and its absence in 88%; the level of obstruction in 89%, and its cause in 86%(15). When small bowel obstruction was classified as high or low grade; CT showed a sensitivity of 81% for high-grade and 48% for low-grade obstruction (16).

Initially, T1-weighted SE imaging along with various types of contrast agent was used, but was limited by

long imaging times, relatively poor image quality, and the expensive nature of the examination. The limitations of MRI in imaging of the bowel include long imaging times and poor spatial and contrast resolution; MR studies suffer from image degradation due to respiration-induced ghosting and peristaltic motion artifacts (12). The use of abdominal MRI has increased in recent years, aided by the availability of respiratory triggering and breath-hold sequencing, used to prevent motion artifacts, and the use of MRI with fast imaging sequences has recently been attempted. An alternative MRI technique is a fast T2-weighted sequence such as HASTE, the advantages of which include its very short imaging time, the fact that a contrast agent is not required, and its possible use in conjunction with barium studies. The value of MRI in patients with inflammatory bowel disease or small bowel tumors is well documented (17 - 19), and the use of new scanning sequences is likely to increase its use for the detection of processes involving

**Table 3.** Conspicuity of Lesions in 18 Bowel Obstructions Using the HASTE and true FISP Sequences

Conspicuity	Number (percentage)	
True FISP > HASTE	6/18	(33%)
True FISP = HASTE	7/18	(39%)
True FISP < HASTE	5/18	(28%)



**Fig. 5.** A 50-year-old man with obstruction of the terminal ileum due to tuberculosis.

MR images (axial true FISP (A), HASTE (B), coronal true FISP (C), HASTE (D)) show concentric bowel wall thickening in the ileocecal area (arrow) and dilated small bowel. The lesion was confirmed at surgery as a cause of small bowel obstruction. Pathology revealed tuberculosis.

the gut wall and adjacent mesentery (3). In addition, the introduction of T2-weighted breath-hold sequencing has increased the usefulness of MRI in patients with acute bowel obstruction (10).

In this study, HASTE and true FISP sequences were used as scanning modalities. The recent development of the former, a T2-weighted single-shot fast spin-echo pulse sequence known in full as the half-Fourier acquisition single-shot turbo spin-echo sequence allows the acquisition of breathing-independent T2-weighted images in less than 1 second per section. Because of the short acquisition time per image, the HASTE sequence is not sensitive to patient movement or respiratory artifacts, making it suitable for use with uncooperative or pediatric patients. It is, furthermore, susceptibility insensitive (11, 19).

True FISP displays fluid homogeneously, with a high signal-to-noise ratio, and permits high resolution regardless of the type of tissue. Motion, however, causes heavy signal loss. Gradient-echo sequences such as true FISP have a number of important advantages over spin-echo sequences: 1, shorter measurement times; 2, increased signal-to-noise (SNR) and contrast-to-noise ratio (CNR), with the same imaging time; 3, three-dimensional imaging; 4, better overall image quality and good anatomic demonstration of the small bowel on T2-like images; 5, fewer motion artifacts. Their disadvantages, however, include artifacts caused by magnetic susceptibility and the effects of field inhomogeneity (4, 20 - 22).

MRI is similar to CT in that the images obtained demonstrate the overall topography of the abdomen. In addition to its lack of ionizing radiation, the inherent advantages of MRI over CT include its multiplanar imaging capability and high soft-tissue contrast; its multiplanar capability is also an important advantage. The lesion itself or the relationship between it and contiguous alimentary tract are better demonstrated on coronal or sagittal images (23 - 26).

In diagnosing bowel obstruction, careful appraisal of MR images may reveal other abnormalities and reduce the number of differential diagnoses. However, the value of MRI findings for specific diagnosis is still to be determined. In patients with suspected bowel obstruction who are about to undergo surgery or are acutely ill, MRI may be the imaging technique of choice: because of the short imaging time and the fact that enteric contrast material is not needed, diagnostic study is possible. The ability of MRI to identify the cause of bowel obstruction could, furthermore, influence clinical management. As

in CT, the major advantage of MRI over contrast studies in evaluating bowel obstruction is its ability to demonstrate extraluminal abnormalities, a fact that is especially important in patients with malignant abdominal lesions (6, 8).

In this study, MRI was able, in the majority of cases, to discriminate between malignant and benign obstruction in postoperative patients who had undergone surgery to resolve a gastrointestinal malignant tumor. MRI also correctly diagnosed intussusception, colon cancer, bezoar, and obstruction associated with inflammatory bowel disease.

Subjective comparison indicated that HASTE and true FISP sequences showed the same diagnostic accuracy, and lesion conspicuity was also similar. True FISP imaging, however, more clearly demonstrates a lesion than does HASTE: with HASTE there is blurring in the phase-encoding direction, but on true FISP images, the bowel is surrounded by a sharp hypointense line (though this is a kind of artifact). Thus, the major advantage of the true FISP sequence is superior bowel delineation. Its disadvantages, however, include the variable signal intensity of intra-abdominal fat and the ferromagnetic artifact in patients with surgical clips. Because they show intra-abdominal fat as hyperintense, HASTE images provide better evaluation of extraluminal structures.

In using MRI with HASTE and true FISP sequences, there are pitfalls and limitations. First, a dilated bowel can show either very high or very low signal intensity, depending on the nature of intraluminal fluid or gas. The presence of hypointense gas might on occasion be mistaken for a tumor, so careful image analysis is essential. In addition, MRI cannot indicate the possibility of bowel strangulation or intramural gas, or the presence of a small amount of pneumoperitoneum. As mentioned earlier, however, the clear advantages of MRI include its multiplanar capacity and the greater ease with which bowel loops are traced.

This study suffers several limitations. First, the number of patients involved was extremely small; the accuracy of MRI in the evaluation of bowel obstruction should be tested in a larger population. Second, statistical analysis was not possible, and our findings thus have no application to clinical medicine. Third, although it is absolutely essential that MRI be compared with other widely appreciated and used imaging techniques, we have not correlated our results with these of other imaging studies.



In this report, we have shown that MRI using HASTE and true FISP sequences can provide images that permit assessment of the presence, site and cause of bowel obstruction. These techniques offer the advantages of multiplanar capacity, good spatial resolution, and the absence of ionizing radiation and barium-induced artifact. The short imaging time combined with the fact that no contrast material is used help reduce the cost of the procedure, which is likely to prove less expensive than previous MR techniques used to evaluate bowel obstruction. Our study has, we believe, highlighted the value of MRI in patients with suspected bowel obstruction and may also be useful in determining guidelines for MRI use in a given institution.

In conclusion, MRI using HASTE and true FISP sequences can be useful in the evaluation of bowel obstruction. Further clinical trials and blind comparative study with CT may, however, be needed.

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