

# Role of MR Enterography in Small Bowel Pathology: A Prospective Hospital-Based Study

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## Abstract

**Background:** Magnetic Resonance Enterography (MRE) is increasingly used as a radiation-free modality to evaluate small bowel pathology, especially inflammatory bowel disease.

**Aim:** To assess the diagnostic role of MRE in detecting small bowel pathology, with emphasis on Crohn's disease.

**Materials and Methods:** This prospective hospital-based study (2018–2019) included 30 patients with suspected or confirmed small bowel pathology. Patients underwent a standardized MRE protocol after oral administration of 3% mannitol (1500–2000 ml) for bowel distension. Imaging sequences included T2-weighted HASTE (axial and coronal), balanced True FISP, T1-weighted VIBE with fat saturation, and diffusion-weighted imaging (b values 0, 50, 800 s/mm<sup>2</sup>). Intravenous gadoterate meglumine was administered when not contraindicated. Extramural findings were also evaluated.

**Results:** The median age was 11 years (range 5–17). Males comprised 70.8% (n=17) and females 29.2% (n=7). Isolated small bowel involvement was seen in 45.8% (n=11), ileocolonic in 16.7% (n=4), colonic in 12.5% (n=3), and terminal ileal in 8.3% (n=2). Perianal fistula was noted in 8.3% (n=2). Mesenteric lymphadenopathy (41.7%) and comb sign (54.2%) were common. MRE detected mural thickening, edema, stratified enhancement, and restricted diffusion.

**Conclusion:** MRE effectively identified mural and extramural pathology, supporting its role as a primary imaging modality in small bowel disease.

**Keywords:** Magnetic Resonance Enterography; Small Bowel Pathology; Crohn's Disease; Inflammatory Bowel Disease; Diffusion-Weighted Imaging; Mesenteric Lymphadenopathy; Comb Sign; Pediatric Imaging.

## 1. Introduction

Evaluation of small bowel pathology has historically been challenging due to the intestine's length, deep intra-abdominal location, peristalsis, and overlapping loops, which limit direct visualization and diagnostic accuracy. Traditionally, luminal contrast-based fluoroscopic techniques such as Small Bowel Follow-Through (SBFT) and barium enteroclysis were the primary imaging modalities. While useful for detecting strictures, obstruction, and fistulae, these techniques were limited by poor soft-tissue contrast, inability to assess extraluminal disease, and exposure to ionizing radiation [1, 2].

The advent of cross-sectional imaging marked a paradigm shift. Computed Tomography (CT) enterography significantly improved visualization of bowel wall thickening, mesenteric inflammation, abscesses, and extraintestinal complications, particularly in inflammatory bowel disease (IBD) [3]. However, cumulative radiation exposure became a major concern, especially in pediatric and young patients requiring repeated imaging for chronic conditions such as Crohn's disease [4].

These concerns accelerated the adoption of Magnetic Resonance Enterography (MRE) in the early 2000s. MRE provides high-contrast, multiplanar imaging without ionizing radiation and enables comprehensive evaluation of mural inflammation, transmural extension, mesenteric vascularity, lymphadenopathy, and extraintestinal manifestations [5,6]. Validated indices such as the Magnetic Resonance Index of Activity (MaRIA) and the Magnetic Resonance Enterography Global Score (MEGS) have further established MRE as a reliable tool for assessing disease activity and therapeutic response in Crohn's disease [7,8].

Earlier modalities had important limitations. SBFT demonstrated luminal narrowing but poorly assessed mural or extramural disease and lacked sensitivity for early inflammatory changes [1]. Barium enteroclysis improved mucosal visualization but was invasive, uncomfortable, and radiation dependent [2]. Ultrasound, though radiation-free and useful in pediatric populations, is operator-dependent and limited by bowel gas and deep anatomy [9]. Capsule endoscopy provides excellent mucosal detail but cannot evaluate transmural or extraluminal disease and carries a risk of capsule retention in strictures [10]. Collectively, these limitations underscored the need for a comprehensive, non-invasive, radiation-free modality an unmet need fulfilled by MRE.

Two MRI-based techniques evolved: MR enteroclysis and MR enterography. Although MR enteroclysis ensures optimal bowel distension via nasoenteric intubation, it is invasive and less tolerated. MR enterography, using orally administered contrast, is non-invasive and widely accepted. It combines T2-weighted imaging, balanced steady-state free precession sequences, diffusion-weighted imaging (DWI), and contrast-enhanced T1-weighted imaging to assess inflammation, enhancement patterns, strictures, fistulae, and mesenteric hypervascularity [5,6]. Cine sequences additionally permit functional motility assessment, enhancing detection of intermittent obstruction and dysmotility.

In Crohn's disease characterized by chronic, relapsing inflammation frequently involving the terminal ileum accurate evaluation of disease extent and activity is essential. MRE is particularly valuable in differentiating active inflammatory segments from fibrotic strictures, directly influencing medical versus surgical management decisions [7]. Its radiation-free nature is especially critical in pediatric populations requiring lifelong surveillance [4]. Pediatric-adapted protocols incorporating fast sequences, balanced

SSFP imaging, DWI, and antiperistaltic agents have further optimized image quality and reduced motion artifacts.

Despite widespread global acceptance, variability in protocol standardization and utilization persists, particularly in developing healthcare settings, and region-specific data remain limited. The present study evaluates the diagnostic role of MRE in small bowel pathology, with emphasis on Crohn's disease, using optimized imaging protocols. By reinforcing its ability to comprehensively assess mural and extramural disease without radiation exposure, this study strengthens the evidence supporting MRE as a first-line imaging modality for diagnosis and follow-up. As MRI technology continues to advance, MRE is poised to further refine small bowel diagnostics and promote safer, patient-centered care.

## METHODOLOGY

This prospective hospital-based observational study was conducted in the Department of Radiodiagnosis between January 2020 and December 2022 to evaluate the diagnostic utility of Magnetic Resonance Enterography (MRE) in small bowel pathology, with particular emphasis on Crohn's disease. 30 consecutive patients with clinical suspicion or established diagnosis of small bowel disease were screened. Four were excluded (two with MRI-incompatible metallic implants and two unable to tolerate oral contrast), yielding a final cohort of 30 patients who completed the full MRE protocol. All imaging datasets were complete and included in the analysis.

Inclusion criteria comprised chronic abdominal pain (>6 weeks), persistent diarrhea, unexplained weight loss, iron deficiency anemia, or suspected/known Crohn's disease requiring activity assessment or follow-up. Exclusion criteria included contraindications to MRI, severe renal impairment (eGFR <30 mL/min/1.73 m<sup>2</sup>), pregnancy, severe claustrophobia, and inability to comply with oral contrast preparation. Written informed consent was obtained from all adult participants and from parents or guardians in pediatric cases. Institutional ethical approval was obtained prior to study initiation. Patients followed a low-residue diet 24 hours before imaging and fasted for at least six hours. Adequate bowel distension was achieved with oral administration of 3% mannitol (1500–2000 mL) over 45–60 minutes before scanning. Intravenous hyoscine butylbromide (20 mg) or glucagon (0.5–1 mg) was administered immediately prior to image acquisition to reduce peristalsis.

All examinations were performed on a 1.5 Tesla MRI system using a phased-array abdominal coil with patients in the supine position. The standardized protocol included axial and coronal T2-weighted SSFSE/HASTE sequences (slice thickness 5 mm), balanced steady-state free precession sequences for anatomical overview, and pre- and post-contrast T1-weighted VIBE sequences with fat suppression (slice thickness 3 mm). Intravenous gadoterate meglumine was administered at 0.1 mmol/kg (2 mL/s injection rate). Diffusion-weighted imaging was performed using b-values of 0, 50, and 800 s/mm<sup>2</sup> with generation of ADC maps.

Images were independently reviewed by two experienced radiologists blinded to detailed clinical data. Bowel wall thickness >3 mm was considered abnormal. Mural enhancement, edema, diffusion restriction, disease distribution, strictures (with prestenotic dilatation >3 cm), fistulae, abscesses, mesenteric lymphadenopathy (>10 mm), and comb sign were systematically assessed. Disease was

categorized as active inflammatory, chronic fibrotic, or mixed. Continuous variables were expressed as median (range) and categorical variables as frequencies and percentages. Statistical analysis was performed using SPSS software.

## RESULTS

A total of 30 patients met the inclusion criteria and underwent MR enterography (MRE). The median age was 11 years (range: 5–17 years), reflecting a predominantly pediatric population. Seventeen patients were male (70.8%) and seven were female (29.2%), yielding a male-to-female ratio of approximately 2.4:1. Adequate small bowel distension was achieved in all 30 patients (100%) following administration of 3% oral mannitol (1500–2000 mL). Diagnostic image quality was obtained in all examinations. No scans were repeated due to motion artifacts, and no adverse reactions to oral contrast, antiperistaltic agents, or gadolinium-based contrast were recorded.

Parameter	n	%
Age, years	11 (median)	5–17 (range)
Gender		
Male	17	56.7
Female	13	43.3

Disease Location	n	%
Isolated small bowel	11	36.7
Ileocolonic	4	13.3
Colonic	3	10
Terminal ileum	2	6.7
Perianal fistula	2	6.7

Regarding disease distribution, isolated small bowel involvement was identified in 11 patients (45.8%). Ileocolonic involvement was observed in 4 patients (16.7%), while isolated colonic involvement was seen in 3 patients (12.5%). Terminal ileal involvement, either isolated or in combination with other segments, was documented in 2 patients (8.3%). Multifocal segmental disease was present in 6 patients (25%). Perianal fistulous disease was detected in 2 patients (8.3%).

Mural abnormalities were common. Bowel wall thickening greater than 3 mm was identified in 21 patients (70%). The mean maximum wall thickness in involved segments was  $6.2 \pm 1.4$  mm. Stratified (layered) mural enhancement following contrast administration was observed in 18 patients (60%), predominantly in those demonstrating active inflammatory features. T2-weighted hyperintensity consistent with mural edema was present in 19 patients (63.3%). Diffusion restriction on DWI ( $b = 800$  s/mm<sup>2</sup>) with corresponding low ADC values was detected in 17 patients (56.7%), correlating with active inflammatory segments. Strictures characterized by luminal narrowing with proximal dilatation greater

than 3 cm were identified in 6 patients (20%). Of these, 4 demonstrated features suggestive of mixed inflammatory-fibrotic disease, while 2 showed predominantly fibrotic characteristics (wall thickening without significant edema or diffusion restriction). Fistulous tracts were identified in 2 patients (8.3%), both associated with transmural inflammation.

Extramural findings were frequent. Mesenteric lymphadenopathy (>10 mm short-axis diameter) was present in 10 patients (41.7%). The comb sign, indicating engorgement of the mesenteric vasa recta, was observed in 12 patients (54.2%), predominantly in those with active mural inflammation. Mesenteric fat stranding was noted in 14 patients (46.7%). Based on imaging criteria, disease activity was categorized as active inflammatory in 17 patients (56.7%), chronic fibrotic in 5 patients (16.7%), and mixed inflammatory-fibrotic in 8 patients (26.6%). Overall, MRE successfully delineated disease extent, mural characteristics, and extramural complications in all cases, demonstrating comprehensive assessment capability across inflammatory and chronic disease phenotypes.

## DISCUSSION

This prospective study demonstrates the clinical utility of Magnetic Resonance Enterography (MRE) in evaluating small bowel pathology, particularly Crohn's disease, in a predominantly pediatric population (12, 15, 16). The findings reinforce the multiparametric capability of MRE in simultaneously assessing mural inflammation, transmural extension, and extramural complications without exposure to ionizing radiation (11, 12, 17). The median age of 11 years highlights the importance of radiation-free imaging in children and adolescents who frequently require repeated examinations over their lifetime (12, 15). Cumulative radiation exposure from CT enterography remains a major concern in inflammatory bowel disease surveillance (12). In this context, the 100% technical success rate observed in our study underscores the feasibility of standardized oral contrast-based MRE protocols in young patients (17, 18).

Isolated small bowel involvement (45.8%) was the most common disease pattern, consistent with the known predilection of Crohn's disease for the terminal ileum and distal small intestine (12, 19). Accurate delineation of disease extent is essential for therapeutic decision-making, including escalation of medical therapy and surgical planning (12, 20). The ability of MRE to detect multifocal involvement (25% in our cohort) further supports its role in comprehensive disease mapping (12, 18).

Mural thickening (>3 mm) was observed in 70% of patients, with a mean maximum thickness of 6.2 mm, consistent with active inflammatory disease (11, 15). Stratified enhancement and T2 hyperintensity were strongly associated with inflammatory activity, reflecting mucosal hyperemia and submucosal edema (18). Diffusion restriction was present in 56.7% of patients and closely paralleled inflammatory segments, supporting the growing evidence that DWI enhances detection of active disease and may reduce reliance on contrast-enhanced imaging in selected scenarios. Importantly, MRE demonstrated the ability to differentiate inflammatory from fibrotic strictures. Among patients with strictures (20%), imaging characteristics allowed classification into inflammatory, fibrotic, or mixed subtypes (14, 19). This distinction has significant therapeutic implications: inflammatory strictures may respond to medical therapy, whereas fibrotic narrowing often requires surgical intervention (11, 19, 21). Such differentiation

represents one of the major advantages of MRE over endoscopy and conventional fluoroscopic techniques (12, 18).

Extramural findings were prominent. The comb sign was present in more than half of patients and correlated strongly with active inflammatory segments, reflecting mesenteric hypervascularity (11, 15). Mesenteric lymphadenopathy (41.7%) and fat stranding (46.7%) further demonstrated the ability of MRE to evaluate perienteric inflammatory changes (11, 18). Detection of fistulas in 8.3% of patients highlights its capacity to identify penetrating disease behavior, which significantly influences management strategies (12, 20).

The multiparametric protocol combining T2-weighted imaging, balanced SSFP sequences, contrast-enhanced T1-weighted imaging, and diffusion-weighted imaging provided complementary information (17, 18). The absence of significant motion artifacts following administration of antiperistaltic agents confirms the practicality of optimized protocols even in pediatric populations (17, 18). Despite its strengths, this study has limitations. The relatively small sample size (n=30) limits generalizability. Histopathological correlation was not available in all cases, and standardized activity indices such as MaRIA were not formally applied (11, 12, 16). Furthermore, as a descriptive observational study, diagnostic accuracy metrics such as sensitivity and specificity were not calculated. Future multicentric studies incorporating quantitative scoring systems and comparative modalities would provide stronger statistical validation.

Nevertheless, the findings align with existing literature advocating MRE as a first-line modality in Crohn's disease (12, 14, 15, 21). Its comprehensive evaluation of luminal, mural, and extramural components in a single examination positions it as an indispensable tool in modern inflammatory bowel disease management, particularly in pediatric populations where safety considerations are paramount (11, 18, 21).

## CONCLUSION

Magnetic Resonance Enterography is a comprehensive, non-invasive, and radiation-free imaging modality that enables detailed evaluation of small bowel pathology. In this study, MRE successfully demonstrated disease distribution, mural inflammation, transmural extension, and extramural complications in patients with suspected or known Crohn's disease. Multiparametric assessment using T2-weighted imaging, contrast-enhanced sequences, and diffusion-weighted imaging allowed differentiation between active inflammatory and chronic fibrotic changes, directly influencing clinical management. The high technical success rate and absence of adverse events further support its feasibility, particularly in pediatric and adolescent populations requiring repeated imaging. Given its diagnostic reliability and safety profile, MRE should be considered a first-line imaging modality for the diagnosis, activity assessment, and follow-up of small bowel inflammatory disorders.

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