

Role of Ultrasound and Magnetic Resonance Enterography in the Assessment of Bowel Diseases

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Abstract:

Background: Ultrasonography (USG) and magnetic resonance enterography (MRE) are important non-invasive imaging modalities for the evaluation of bowel diseases. While USG is inexpensive, readily available, and suitable for real-time assessment, MRE provides superior visualization of transmural and extraintestinal disease. The present study compared the diagnostic role of USG with MRE in bowel disease assessment.

Methods: This hospital-based observational cross-sectional study was conducted in the Department of Radiodiagnosis, SMS Medical College, Jaipur, over one year. Fifty adults with bowel diseases underwent both transabdominal USG and MRE using standardized imaging protocols. Imaging findings, including bowel wall thickening, mesenteric lymphadenopathy, Doppler vascularity, stricture, fistula, and abscess, were recorded. MRE served as the reference imaging modality. Data were analysed using SPSS version 24.0, and associations were assessed using the Chi-square test, with $p < 0.05$ considered statistically significant.

Results: The mean age was 40.72 ± 14.15 years, with male predominance (60.0%). Crohn's disease was the commonest diagnosis (44.0%), followed by ulcerative colitis (32.0%) and intestinal tuberculosis (24.0%). USG detected bowel wall thickening in 64.0%, mesenteric lymphadenopathy in 56.0%, increased vascularity in 60.0%, stricture in 36.0%, fistula in 16.0%, and abscess in 20.0% of patients. MRE detected bowel wall thickening in 68.0%, stricture in 44.0%, fistula in 24.0%, and abscess in 18.0%. Significant agreement between USG and MRE was observed for bowel wall thickening ($\chi^2=20.911$), stricture ($\chi^2=23.000$), fistula ($\chi^2=13.581$), and abscess ($\chi^2=22.900$) (all $p < 0.001$).

Conclusion: Ultrasonography is an effective, accessible first-line imaging modality for bowel diseases, demonstrating good concordance with MRE. Magnetic resonance enterography provides additional diagnostic information, particularly for deep bowel segments and complex transmural complications. A stepwise imaging approach using USG for initial evaluation and MRE for comprehensive disease assessment is recommended.

Keywords: Ultrasonography, Magnetic resonance enterography, Crohn's disease, Inflammatory bowel disease, Bowel imaging.

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Introduction

Bowel diseases represent a significant cause of morbidity worldwide and encompass a wide spectrum of inflammatory, infectious, neoplastic, and functional disorders affecting the gastrointestinal tract. Imaging modalities play a fundamental role in the evaluation of bowel diseases, particularly in identifying structural abnormalities, inflammatory activity, and extraintestinal complications [1].

Traditionally, imaging techniques such as computed tomography enterography (CTE) have

been used for evaluating small bowel diseases. However, the use of ionizing radiation associated with CT raises concerns, especially in young patients and those requiring repeated imaging during long-term follow-up. [2] While endoscopy remains the gold standard for mucosal evaluation and biopsy, it is limited in its ability to assess the full thickness of the bowel wall and surrounding mesentery.[3]

Ultrasound is a widely used, non-invasive imaging modality for bowel disease evaluation owing to its

accessibility, cost-effectiveness, and real-time assessment. It enables detection of bowel wall thickening, altered peristalsis, mesenteric fat changes, lymphadenopathy, vascularity, and complications such as fistulas, abscesses, and strictures, with advanced techniques including contrast-enhanced ultrasound and elastography further improving diagnostic accuracy [4,5]. Magnetic resonance enterography (MRE) provides high-resolution multiplanar imaging with excellent soft-tissue contrast, allowing to provide important information about the extent and severity of bowel disease by assessing several imaging features such as bowel wall thickening, mural enhancement, oedema, ulceration, and mesenteric inflammation. It also enables the evaluation of transmural disease involvement, which is particularly relevant in Crohn's disease where inflammation often extends beyond the mucosal layer. [6,7] Another important advantage of magnetic resonance enterography is its ability to evaluate the entire small bowel, including segments that are difficult to access through endoscopy.[8]

Ultrasound and magnetic resonance enterography (MRE) are complementary imaging modalities for bowel disease evaluation. Ultrasound is inexpensive, readily available, and suitable for bedside assessment but is operator-dependent and limited by patient body habitus. In contrast, MRE provides superior anatomical and functional assessment but is more costly, time-consuming, and less accessible. Appropriate modality selection should therefore be guided by clinical indications and resource availability [9].

Given the growing prevalence of bowel diseases and the increasing reliance on imaging for diagnosis and monitoring, it is important to evaluate the effectiveness of different imaging modalities. Therefore, the present observational study aims to assess the role of ultrasound and magnetic resonance enterography in the evaluation of bowel diseases with particular emphasis on their diagnostic utility, advantages, and limitations in clinical practice.

Materials and Methods

The observational hospital-based cross-sectional study was conducted in the Department of Radiodiagnosis, Sawai Man Singh (SMS) Medical College, Jaipur, Rajasthan over a period of one year after receiving approval from the Institutional Ethics Committee and Research Review Board. 50 patients fulfilling the inclusion criteria were selected for the study by using a consecutive sampling technique.

Inclusion & Exclusion Criteria: Patients of both genders aged above 18 years, known patients of bowel diseases referred to the Department of

Radiodiagnosis for imaging evaluation were included.

Patients unfit to undergo Magnetic Resonance Imaging, including those with absolute contraindications such as metallic stents, clips, pacemakers, metallic vascular clamps, severe claustrophobia, deranged kidney function tests, or allergy to contrast agents, with a prior history of abdominal surgery, unwilling to provide informed written consent were excluded.

All participants underwent detailed history taking, clinical examination, laboratory investigations, and radiological evaluation.

Study Procedure: Following enrolment and informed consent, all participants underwent both transabdominal ultrasonography (USG) and magnetic resonance enterography (MRE) according to a standardized imaging protocol.

Transabdominal ultrasonography was performed after a minimum fasting period of 6 hours to minimize bowel gas interference. Imaging was conducted using a Samsung HS70A ultrasound system equipped with 2.5–4.5 MHz curved-array and 6.0–8.4 MHz linear-array transducers. The examination systematically evaluated bowel wall thickness, inflammatory mesenteric fat, mesenteric lymphadenopathy, bowel vascularity using colour Doppler imaging, and disease-related complications including stenosis, fistulae, and inflammatory masses.

MRE was performed on a 3-Tesla SIGMA Architect MRI scanner. Participants were instructed to follow a low-residue diet on the day preceding the examination and to fast for 6–8 hours before imaging. The standardized MRE protocol comprised coronal T2-weighted single-shot fast spin-echo (SSFSE), coronal steady-state free precession (SSFP), axial T2-weighted imaging (T2WI), axial diffusion-weighted imaging (DWI), three-dimensional (3D) THRIVE, and axial and coronal post-contrast fat-suppressed T1-weighted gradient-echo sequences. Images were evaluated for bowel wall thickening, mural enhancement, diffusion restriction, inflammatory activity, disease extent, mesenteric involvement, lymphadenopathy, and extraintestinal complications.

All imaging examinations were interpreted by experienced radiologists. The ultrasonographic findings were subsequently compared with the corresponding MRE findings, which served as the reference standard, to determine the diagnostic performance of ultrasonography in the evaluation of bowel diseases.

Data were collected using a pre-designed structured proforma compiled and analysed using the SPSS version 24.0. Qualitative variables were expressed

as frequency and percentages, while quantitative variables were presented as mean $\pm$ standard deviation (SD). The Chi-square test and unpaired t-test were used to assess statistical significance. A

p-value < 0.05 was considered statistically significant.

Result

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population (N = 50)

Variable	n (%) / Mean $\pm$ SD
Age (years)	40.72 $\pm$ 14.15
Age category (years)	
18–30	14 (28.0)
31–40	12 (24.0)
41–50	10 (20.0)
51–60	8 (16.0)
>60	6 (12.0)
Sex	
Male	30 (60.0)
Female	20 (40.0)
Duration of symptoms	
<3 months	10 (20.0)
3–6 months	18 (36.0)
6–12 months	14 (28.0)
>12 months	8 (16.0)
Clinical presentation*	
Abdominal pain	40 (80.0)
Diarrhoea	32 (64.0)
Weight loss	26 (52.0)
Fever	18 (36.0)
Rectal bleeding	14 (28.0)
Final diagnosis	
Crohn's disease	22 (44.0)
Ulcerative colitis	16 (32.0)
Intestinal tuberculosis	12 (24.0)

Data are presented as mean $\pm$ standard deviation or frequency (%): The study included 50 participants with a mean age of 40.72 $\pm$ 14.15 years. The largest proportion belonged to the 18–30 years age group (28.0%), followed by 31–40 years (24.0%), while participants aged >60 years constituted 12.0%. There was a male predominance (60.0%). Most participants belonged to the middle socioeconomic class (32.0%), followed by the upper middle class (24.0%). The most common

symptom at presentation was abdominal pain (80.0%), followed by diarrhoea (64.0%) and weight loss (52.0%), whereas rectal bleeding (28.0%) was the least frequent. The majority of patients had symptoms for 3–6 months (36.0%). Crohn's disease was the most common final diagnosis (44.0%), followed by ulcerative colitis (32.0%) and intestinal tuberculosis (24.0%), reflecting the spectrum of bowel diseases included in the study.

Table 2: Comparison of Imaging Findings on Ultrasonography and Magnetic Resonance Enterography (N = 50)

Imaging Finding	Ultrasonography n (%)	MRE n (%)	p-value
Bowel wall thickening	32 (64.0)	34 (68.0)	<0.001*
Mesenteric lymphadenopathy	28 (56.0)	28 (56.0) [†]	—
Increased vascularity (Colour Doppler hyperemia)	30 (60.0)	—	—
Stricture	18 (36.0)	22 (44.0)	<0.001*
Fistula	8 (16.0)	12 (24.0)	<0.001*
Abscess	10 (20.0)	9 (18.0)	<0.001*

Data are presented as frequency (%): *p-values are based on the association between ultrasonography and MRE findings (Chi-square test). MRE demonstrated a higher detection rate than

ultrasonography for bowel wall thickening (68.0% vs. 64.0%), strictures (44.0% vs. 36.0%), and fistulae (24.0% vs. 16.0%), whereas the detection of abscesses was comparable between the two modalities (18.0% vs. 20.0%). Ultrasonography

additionally identified mesenteric lymphadenopathy (56.0%) and increased vascularity on colour Doppler (60.0%), highlighting its utility in assessing inflammatory bowel activity. Significant agreement was observed between ultrasonography and MRE for bowel wall

thickening, stricture, fistula, and abscess detection (all $p < 0.001$), indicating that ultrasonography provides good diagnostic performance, although MRE remains superior for comprehensive evaluation of bowel pathology.

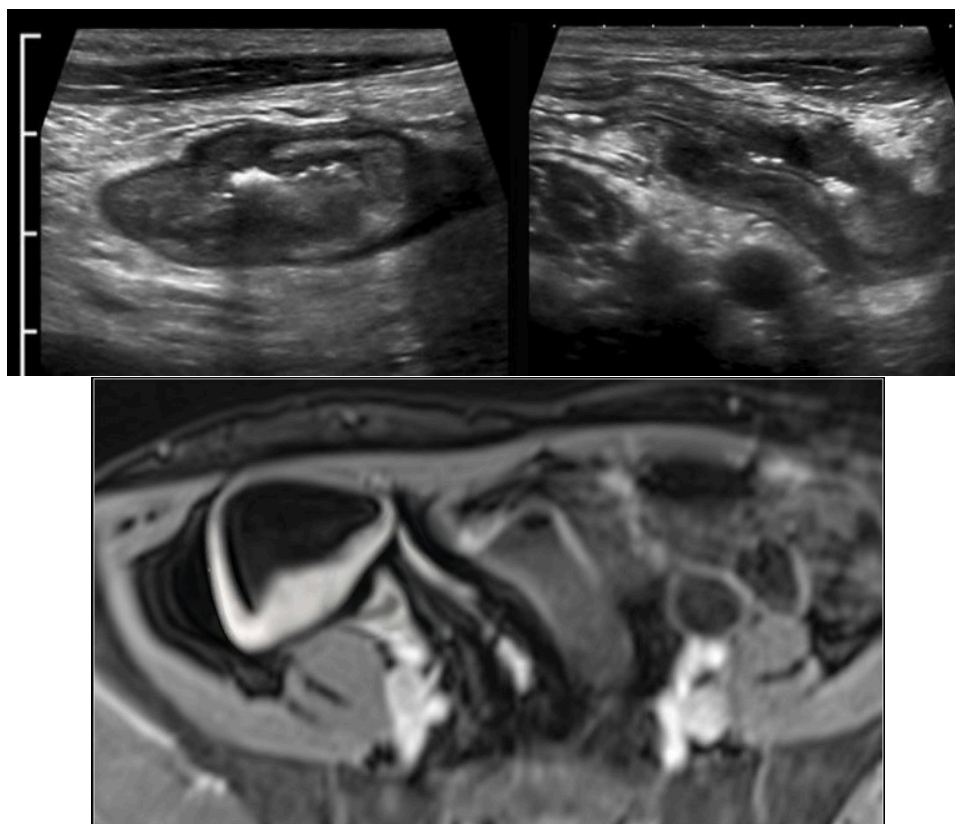
Table 3: Association Between Ultrasonography and Magnetic Resonance Enterography Findings in the Assessment of Bowel Diseases (N = 50)

Imaging Parameter	USG Positive/MRE Positive	USG Positive/MRE Negative	USG Negative/MRE Positive	USG Negative/MRE Negative	χ^2	p-value
Bowel wall thickening	29	3	5	13	20.911	<0.001
Stricture	16	2	6	26	23.000	<0.001
Fistula	6	2	6	36	13.581	<0.001
Abscess	7	3	2	38	22.900	<0.001

Data are presented as frequencies. MRE was considered the reference imaging modality. χ^2 : Chi-square test: Ultrasonography demonstrated a significant association with magnetic resonance enterography for the detection of all evaluated bowel abnormalities. Agreement between the two modalities was strongest for stricture ($\chi^2 = 23.000$, $p < 0.001$), followed by abscess ($\chi^2 = 22.900$, $p < 0.001$) and bowel wall thickening ($\chi^2 = 20.911$, $p <$

0.001). A significant association was also observed for fistula detection ($\chi^2 = 13.581$, $p < 0.001$). These findings indicate that ultrasonography shows good concordance with MRE in identifying major bowel pathologies and supports its role as a reliable first-line imaging modality in the evaluation of bowel diseases.

Representative Cases



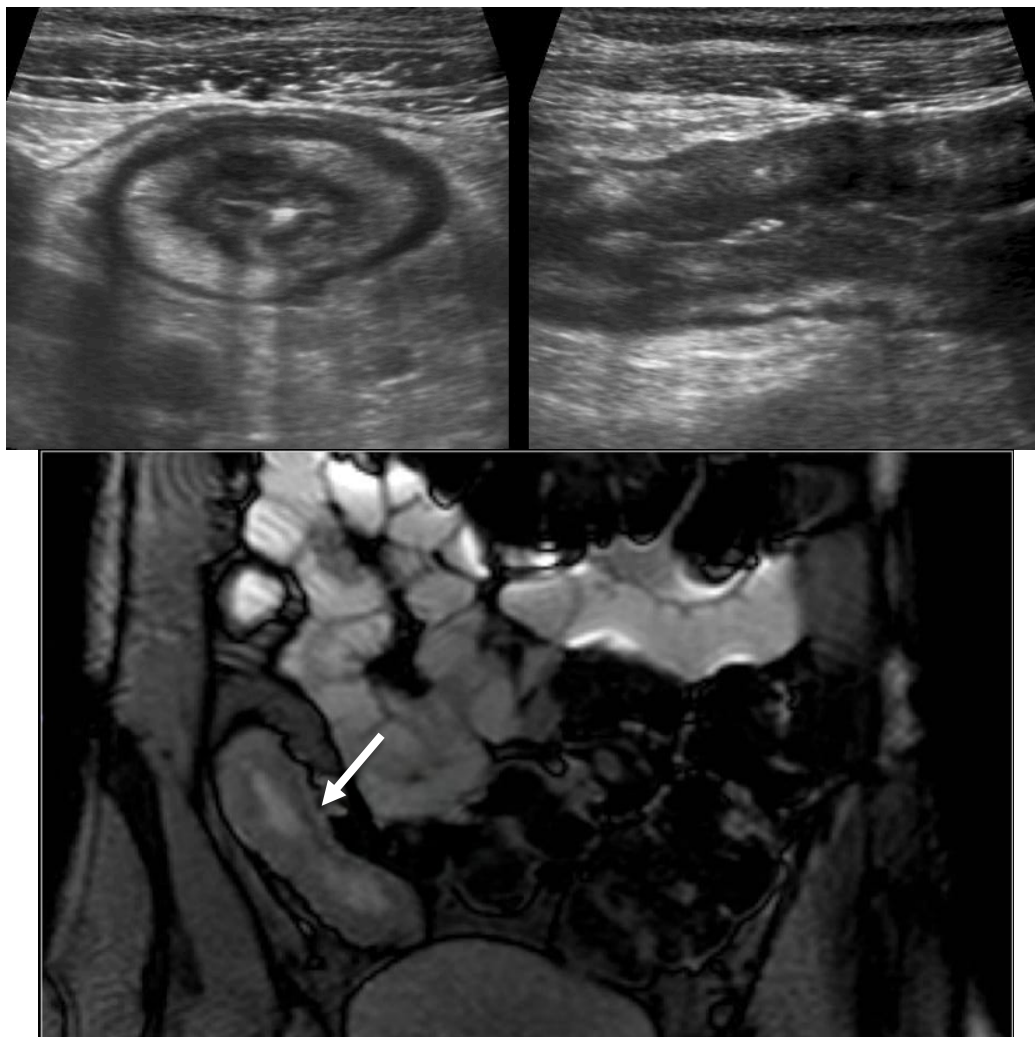
CASE 1

An 18 yrs old male patient presented with acute complaints of right lower quadrant pain mimicking appendicitis, on imaging appendix was normal (not

shown here), terminal ileum showed asymmetrical transmurial thickening, MRE showed diffuse homogenous enhancement of the involved small

bowel segment, diagnosis of acute Crohn's was assigned with proper clinical and laboratory

evaluation.



CASE 2

A 50 yrs old male diagnosed with Crohn's disease with complaints of abdominal pain and fever for a duration of 10 months presented to SMS for evaluation. USG shows transverse thickening involving terminal ileum, MRE shows the same, there were no necrotic lymph nodes noted. No ulceration, abscesses or fistula were seen.

Discussion

The aim of the present observational study was to assess the role of ultrasonography and magnetic resonance enterography in the evaluation of patients with bowel diseases at SMS Medical College, Jaipur, with particular emphasis on their ability to identify bowel wall abnormalities, disease extent, and associated complications.

Baseline Demographic and Clinical Characteristics: The present study included a relatively young cohort (mean age 40.72 ± 14.15 years), with 52.0% of participants aged ≤ 40 years and a moderate male predominance (60.0%).

Crohn's disease was the most frequent diagnosis (44.0%), followed by ulcerative colitis (32.0%) and intestinal tuberculosis (24.0%). Age, sex, socioeconomic status, and duration of symptoms showed no significant association with the final diagnosis (all $p > 0.05$), indicating that demographic characteristics alone could not reliably distinguish among bowel diseases. Similar demographic findings were reported by Miles et al. [10], who evaluated 159 patients with newly diagnosed or relapsing Crohn's disease (mean age 38 years) and demonstrated that inflammatory bowel disease predominantly affects young adults. Likewise, Kamel et al. [11], in a study of 40 patients with inflammatory bowel disease, reported a predominance of Crohn's disease (65%) over ulcerative colitis (35%), consistent with the higher frequency of Crohn's disease observed in the present study. Calavrezos et al. [12] also reported Crohn's disease as the predominant diagnosis (44/54 patients), supporting the disease distribution

observed in our cohort. The inclusion of intestinal tuberculosis (24.0%) in the present study reflects the regional disease spectrum and highlights the importance of differentiating inflammatory from infectious bowel disorders.

Comparison of Imaging Findings Between Ultrasonography and Magnetic Resonance Enterography: Both ultrasonography (USG) and magnetic resonance enterography (MRE) effectively detected bowel abnormalities, although MRE demonstrated slightly higher detection rates for bowel wall thickening (68.0% vs 64.0%), strictures (44.0% vs 36.0%), and fistulas (24.0% vs 16.0%), while abscess detection was comparable (18.0% vs 20.0%). The greater detection of transmural complications by MRE is attributable to its superior soft-tissue contrast and multiplanar capability. Similar findings were reported by Yuksel et al. [13], who demonstrated comparable overall accuracy of intestinal ultrasound and MRE for mural inflammation but significantly higher sensitivity of MRE for stenosis and loss of bowel wall stratification ($p < 0.001$). Castiglione et al. [14] evaluated 249 patients with suspected small-bowel Crohn's disease and reported that MRE showed superior delineation of disease extent and enteroenteric fistulas, whereas bowel sonography demonstrated high diagnostic accuracy for bowel wall abnormalities. Likewise, Allocca et al. [15], in 60 patients with ileocolonic Crohn's disease, reported ultrasound sensitivity of 92% and specificity of 100% for active disease, with excellent accuracy for detecting strictures, fistulas, and abscesses, supporting the role of USG as an effective first-line imaging modality. Calavrezos et al. [12] further demonstrated comparable sensitivity of MRE (90.5%) and ultrasound (88.1%) for detecting intestinal inflammation, emphasizing the complementary value of both techniques.

Association Between Ultrasonography and Magnetic Resonance Enterography Findings: A highly significant association was observed between USG and MRE for bowel wall thickening ($\chi^2 = 20.911$, $p < 0.001$), stricture ($\chi^2 = 23.000$, $p < 0.001$), fistula ($\chi^2 = 13.581$, $p < 0.001$), and abscess detection ($\chi^2 = 22.900$, $p < 0.001$), indicating good concordance between the two imaging modalities. However, MRE detected additional cases of bowel wall thickening, strictures, and fistulas that were not identified on ultrasonography, highlighting its greater ability to evaluate deep bowel segments and complex transmural disease. Similar observations were made by Castiglione et al. [14], who reported substantial agreement between bowel sonography and MRE for disease location ($\kappa = 0.81$), strictures ($\kappa = 0.82$), fistulas ($\kappa = 0.67$), and abscesses ($\kappa = 0.88$). Allocca et al. [15] also demonstrated excellent agreement between ultrasound- and MRE-guided therapeutic decisions ($\kappa = 0.768$ and κ

$= 0.767$, respectively), indicating comparable clinical utility of both modalities. Furthermore, Miles et al. [10] found that patients preferred ultrasound over MRE (99% vs 88% satisfaction), while diagnostic accuracy remained comparable, supporting the use of ultrasonography as the initial imaging investigation with MRE reserved for comprehensive disease mapping and evaluation of complex complications. Overall, the present findings reinforce that USG and MRE are complementary rather than competing modalities in the assessment of bowel diseases.

The study directly compared ultrasonography (USG) and magnetic resonance enterography (MRE) in the same 50 patients, enabling objective evaluation of their complementary role in bowel diseases. Assessment of mural abnormalities and complications, including bowel wall thickening, stricture, fistula, and abscess, with significant intermodality agreement (all $p < 0.001$), enhances the clinical relevance of the findings. However, the study was limited by its small sample size, single-centre design, heterogeneous disease spectrum, and lack of a uniform reference standard for calculating diagnostic accuracy. The operator-dependent nature of USG and the absence of interobserver variability, endoscopic/histopathological correlation, and cost-effectiveness analysis are additional limitations. Despite these limitations, the findings support USG as an effective first-line investigation, with MRE serving as a complementary modality for comprehensive assessment of bowel diseases.

Conclusion

The present observational study concluded that ultrasonography and magnetic resonance enterography are valuable, non-invasive, and complementary imaging modalities for evaluating patients with bowel diseases.

Ultrasonography emerged as a practical first-line investigation because it is widely available, relatively inexpensive, repeatable, radiation-free, and capable of real-time evaluation of bowel wall abnormalities and related complications. Its significant agreement with MRE for bowel wall thickening, stricture, fistula, and abscess supports its routine use for initial evaluation and follow-up. However, a negative ultrasound examination could not completely exclude bowel pathology, as MRE detected additional abnormalities in some ultrasound-negative patients. MRE therefore serves as an important complementary modality, particularly when ultrasound findings are negative or inconclusive, complete small-bowel assessment is required, or complex stricturing and penetrating disease is suspected. The findings support a stepwise imaging strategy in which ultrasonography is used for initial evaluation and

MRE for comprehensive disease mapping, confirmation of uncertain findings, and detailed assessment of complications. Thus, ultrasonography functions as an effective screening and monitoring tool, whereas MRE remains essential for complete transmural and extramural assessment of bowel diseases.

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