Radiology

ORIGINAL RESEARCH • GASTROINTESTINAL IMAGING

Comparison of Conventional versus Abbreviated MR Enterography: Assessing Disease Activity and Complications in Crohn Disease

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Background: MR enterography (MRE) is increasingly used to guide treatment and improve outcomes in Crohn disease (CD). An abbreviated MRE (A-MRE) protocol—omitting contrast and antiperistaltic agents—may reduce scanning time and cost and improve compliance.

Purpose: To compare intrareader concordance and interreader agreement in detecting disease activity and disease-related complications using contrast-enhanced MRE (CE-MRE) versus an A-MRE protocol in participants with CD.

Materials and Methods: In this secondary analysis of a prospective study, 10 abdominal radiologists independently reviewed MRE examinations from a prospective study of participants with CD before and after treatment with biologics, using both A-MRE and CE-MRE protocols, at least 1 month apart. Interreader agreement and intrareader concordance were assessed using Gwet first agreement coefficient (AC1) at both the segment and participant levels for the presence of active inflammation, associated indicative features, and complications. Diagnostic accuracy of the simplified MR index of activity (sMaRIA) was evaluated against ileocolonoscopy when available.

Results: This study included 60 participants (median age, 36 years [IQR, 28–44 years]; 40 female; 80 examinations). Interreader agreement for detecting intestinal active disease was high and comparable between A-MRE and CE-MRE at the participant level (AC1, 0.87 [95% CI: 0.79, 0.95] vs 0.91 [95% CI: 0.85, 0.97]). For strictures, similar interreader agreement was observed between protocols (AC1: A-MRE, 0.61 [95% CI: 0.47, 0.74] vs CE-MRE, 0.50 [95% CI: 0.35, 0.65]). For penetrating complications, the interreader agreement was also similar between protocols (A-MRE, 0.71 [95% CI: 0.56, 0.86] vs CE-MRE, 0.76 [95% CI: 0.63, 0.90]). The intrareader concordance between protocols for detecting active inflammation and CD complications was almost perfect for all readers (AC1 range, 0.86–1.00). In the terminal ileum, sMaRIA showed high sensitivity (A-MRE, 96.4%; CE-MRE, 98.4%) and specificity (A-MRE, 68.1%; CE-MRE, 71.4%) for detecting inflammation.

Conclusion: An A-MRE protocol demonstrated comparable interreader agreement to conventional CE-MRE and high intrareader concordance for detecting active CD and related complications in participants with CD.

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MR enterography (MRE) is increasingly used to diagnose and monitor Crohn disease (CD) because it can be used to noninvasively evaluate the entire intestine and accurately detect complications such as strictures, fistulas, and abscesses (1,2). As clinical symptoms often poorly reflect intestinal activity (3–5), CD management is shifting toward more objective imaging measures to guide treatment.

Standard MRE for assessing CD uses intravenous contrast and antiperistaltic agents to help detect inflammation and minimize motion artifacts, respectively. Unenhanced abbreviated MRE (A-MRE) offers a faster, simplified alternative to contrast-enhanced MRE (CE-MRE) for assessing inflammatory lesions in the bowel. These protocols usually focus on T2-weighted sequences with and without fat saturation, as they are both fast and motion robust.

Omitting gadolinium contrast and antiperistaltic agents can improve comfort, simplify MRE, and reduce costs, environmental impact, and barriers to routine use. Evidence also shows that omitting gadolinium does not reduce MRE accuracy for detecting inflammation (6–8). However, further evaluation of the performance of A-MRE is needed to establish its utility for serial assessments in clinical practice and its broader adoption in clinical research by means of scoring systems. Moreover, routine clinical practice may benefit from scoring systems that are becoming simpler (9). Among the different validated scoring systems, the simplified MR index of activity (sMaRIA) potentially allows grading activity using T2-weighted sequences with and without fat saturation (10).

This study aimed to compare intra- and interreader agreement in detecting disease activity and disease-related complications using CE-MRE versus an A-MRE protocol in participants with CD. In this collaborative study, radiologists from the Small Bowel and Crohn's Disease-Focused Panel of the Society of Abdominal Radiology and an international panel of European and Iranian radiologists with expertise in small bowel imaging were included, based on prior publications and affiliation with international abdominal radiology societies. Interreader agreement and intrareader concordance for imaging features indicative of active

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Abbreviations

AC1 = Gwet first agreement coefficient, A-MRE = abbreviated MRE, CD = Crohn disease, CE-MRE = contrast-enhanced MRE, ICC = intraclass correlation coefficient, MRE = MR enterography, sMaRIA = simplified MR index of activity

Summary

In participants with Crohn disease (CD), an abbreviated MR enterography (MRE) protocol demonstrated similar interreader agreement to contrast-enhanced MRE and high intrareader concordance for detecting active CD and related complications.

Key Results

- In this secondary analysis of a prospective study of 60 participants with Crohn disease, interreader agreement for the detection of intestinal active inflammation was high and comparable between contrast-enhanced MR enterography (CE-MRE) and abbreviated MR enterography (A-MRE) protocols (Gwet first agreement coefficient [AC1]: 0.91 [95% CI: 0.85, 0.97] vs 0.87 [95% CI: 0.79, 0.95]).
- Interreader agreement was similar between protocols for strictures (AC1: A-MRE, 0.61 [95% CI: 0.47, 0.74] vs CE-MRE, 0.50 [95% CI: 0.35, 0.65]) and penetrating complications (0.71 [95% CI: 0.56, 0.86] vs 0.76 [95% CI: 0.63, 0.90]).
- In the terminal ileum, for both A-MRE and CE-MRE, the simplified MR index of activity demonstrated high sensitivity (96% and 98%, respectively) and specificity (68% and 71%, respectively) for detecting inflammation.

CD and related complications were evaluated using standard CE-MRE and A-MRE protocols. Additionally, the agreement of the sMaRIA across both protocols, as well as its diagnostic accuracy compared with ileocolonoscopy, were evaluated.

Materials and Methods

Study Design

This international multireader multicenter secondary analysis of a prospective study was approved by the local institutional review board with a waiver of informed consent (HCB/2021/0629). Study procedures were performed in compliance with the principles contained in the Declaration of Helsinki.

All MRE examinations used in the present study were obtained from a prospective cohort at a single tertiary care institution (Hospital Clinic of Barcelona) from March 2013 to April 2021, including participants with active CD who underwent MRE assessments and required biologic therapy due to the severity of their lesions. The dataset included both pre- and posttreatment MRE assessments, performed 46 weeks after initiation of biologic therapy. The main study aimed to identify imaging biomarkers predictive of treatment response in participants with CD receiving biologic therapies (11). The aims of the current and previous cohort-related studies are nonoverlapping.

Inclusion criteria for participants were adult patients (age ≥18 years) with active CD who were candidates for treatment with biologic drugs, having pretreatment MRE and additional MRE examination at week 46 after treatment initiation (Fig 1). One investigator (J.R., with 18 years of experience in bowel imaging), not involved in the image interpretation process, reviewed the phenotype and inflammation status of participants included in the original database. Participants in the current study were selected in reverse chronologic order of MRE examinations, from the most recent to the oldest, with consideration given to the frequencies of participant phenotypes (ie, active inflammatory, stricturing, and internal penetrating disease), simulating the expected percentages in a cross-section of patients with CD (12,13). On the basis of this consideration, a study sample containing approximately 55% inflammatory disease, 20% stricturing disease, 15% internal penetrating disease, and 10% inactive disease was targeted. After the initial selection, the investigator reviewed all MRE examinations of participants and confirmed adequate diagnostic quality standards (ie, free of breath motion artifacts causing nondiagnostic image quality) before inclusion in the final dataset. Activity in the colon was confirmed endoscopically when available, whereas the small intestinal activity was assessed using ileocolonoscopy when available, investigator evaluation, and clinical or radiologic findings. Examinations were excluded if the investigator deemed the image quality to be nondiagnostic.

The final study sample included participants with examinations performed both immediately before biologic treatment initiation and 46 weeks after treatment initiation. These examinations represented approximately two-thirds and one-third, respectively, of the total MRE examinations. The posttreatment MRE examinations included in the study were assumed to have a radiologic response rate of approximately 45% (3,14).

Conventional CE-MRE Protocol

All participants underwent standardized CE-MRE. Participants ingested 1000–1500 mL of 2.5% mannitol for small bowel distension. Imaging was performed on 1.5-T (Magnetom Aera, Siemens) or 3.0-T (Magnetom Vida, Siemens) MRI scanners using a standard protocol: coronal balanced steady-state free precession sequences, axial and coronal T2-weighted single-shot

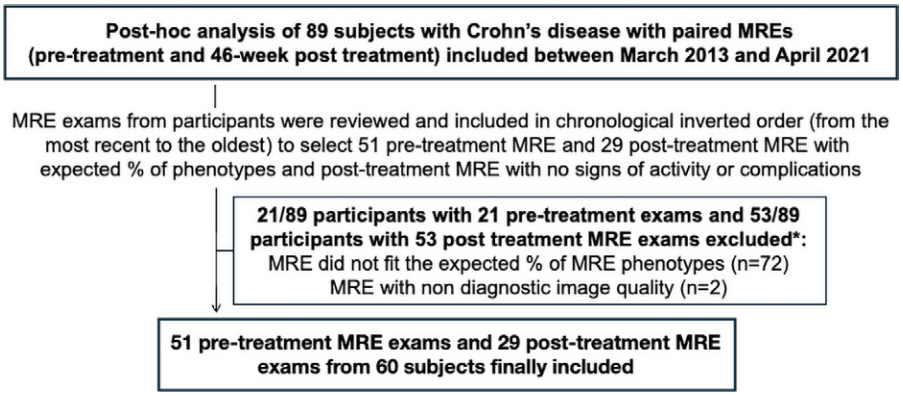


Figure 1: Flowchart of participants selected for this study. From the original cohort of 89 participants who underwent both pre- and posttreatment MR enterography (MRE), a total of 80 MRE examinations (51 pretreatment and 29 posttreatment) in 60 participants were selected to meet the predefined phenotype and outcome distribution. * = Once the target phenotype percentage was achieved, the review and selection of the remaining MRE examinations was discontinued.

Table 1: Baseline Characteristics of Participants

Characteristic	Value (*N* = 60)
Age (y)*	36 (28–44) [18–76]
Disease duration (y)*	7 (2–17)
Sex	
F	40 (67)
M	20 (33)
Previous intestinal resection	16 (27)
Disease location at diagnosis (Montreal classification)	
L1	37 (62)
L2	1 (1.7)
L3	21 (35)
L3 and L4	1 (1.7)
Disease behavior at diagnosis	
Inflammatory	31 (52)
Stricturing	21 (35)
Penetrating	8 (13)

Note.—Unless otherwise specified, data are numbers of participants, with percentages in parentheses. This table reports the demographic characteristics of the 60 participants with Crohn disease included in the study. Among them, 40 (67%) were female, the median age was 36 years (IQR, 28–44 years), and most participants had ileal disease involvement (62%) and an inflammatory phenotype at diagnosis (52%).

* Data are medians, with IQRs in parentheses and range in brackets.

fast spin-echo sequences with and without fat suppression, and fat-suppressed three-dimensional T1-weighted gradient-echo sequences obtained before and after gadolinium chelate administration. An antiperistaltic agent (10 mg, hyoscine butylbromide) was injected intravenously before T1-weighted sequences. From the standard CE-MRE examinations, axial T2-weighted images (with and without fat saturation), coronal T2-weighted single-shot images, and coronal balanced steady-state free precession images were extracted to create the A-MRE examinations (Table S1). Diffusion-weighted imaging was not included as part of the study.

Image Analysis

Study radiologists

Ten abdominal radiologists (S.A., N.C., B.D., K.T.F., J.R.G., C.H., T.J., I.D.K., A.R.R., and M.S.), with varying levels of expertise (mean, 9.5 years ± 4.7 [SD]), served as readers for the current investigation, including five radiologists classified as novices, with 8 or fewer years of experience after residency training, and five radiologists classified as experienced, with more than 8 years of experience after residency training (Table S2). There was no specific MRE training of radiologists before or during the MRE interpretation. Radiologists were blinded to clinical data, the spectrum of disease, and previous treatments.

Table 2: Interreader Agreement and Intrareader Concordance for Assessing MRE Findings at the Participant Level, in the Small Bowel, and in Colorectal Tissue Related to Crohn Disease Activity and Related Complications

	Interreader Agreement		
Analysis Level and MRE Finding	CE-MRE	A-MRE	Intrareader Concordance
Participant-level analysis (*N* = 80)*			
Wall thickness >3 mm	0.91 (0.84, 0.97)	0.88 (0.80, 0.95)	0.86 (0.85, 0.88)
Edema	0.79 (0.67, 0.90)	0.76 (0.64, 0.88)	0.88 (0.87, 0.89)
Ulcers	0.26 (0.10, 0.42)	0.24 (0.08, 0.41)	0.92 (0.91, 0.93)
Fat stranding	0.50 (0.33, 0.67)	0.38 (0.19, 0.56)	0.87 (0.86, 0.88)
Stricturing disease	0.50 (0.35, 0.65)	0.61 (0.47, 0.74)	1.00 (1.00, 1.00)
Penetrating disease	0.76 (0.63, 0.90)	0.71 (0.56, 0.86)	0.96 (0.96, 0.97)
Small bowel (*N* = 80)			
Wall thickness >3 mm	0.89 (0.83, 0.96)	0.87 (0.79, 0.94)	0.79 (0.77, 0.82)
Edema	0.76 (0.63, 0.89)	0.74 (0.61, 0.86)	0.77 (0.75, 0.80)
Ulcers	0.29 (0.14, 0.44)	0.27 (0.11, 0.44)	0.82 (0.80, 0.84)
Fat stranding	0.48 (0.31, 0.64)	0.36 (0.21, 0.51)	0.74 (0.71, 0.77)
Stricturing disease	0.52 (0.38, 0.66)	0.61 (0.47, 0.75)	0.73 (0.70, 0.76)
Penetrating disease	0.78 (0.65, 0.91)	0.75 (0.60, 0.89)	0.92 (0.91, 0.93)
Colorectal (*N* = 80)			
Wall thickness >3 mm	0.60 (0.42, 0.78)	0.56 (0.37, 0.75)	0.90 (0.89, 0.92)
Edema	0.67 (0.52, 0.82)	0.65 (0.50, 0.80)	0.93 (0.92, 0.94)
Ulcers	0.85 (0.74, 0.96)	0.82 (0.68, 0.96)	0.97 (0.96, 0.97)
Fat stranding	0.73 (0.60, 0.85)	0.65 (0.49, 0.81)	0.93 (0.92, 0.94)
Stricturing disease	0.91 (0.86, 0.97)	0.87 (0.80, 0.95)	0.98 (0.97, 0.98)
Penetrating disease	0.89 (0.84, 0.94)	0.88 (0.82, 0.94)	0.98 (0.98, 0.99)

Note.—Data are Gwet first agreement coefficients, with 95% CIs in parentheses. For both abbreviated MR enterography (A-MRE) and contrast-enhanced MR enterography (CE-MRE), agreement in detecting active inflammation and Crohn disease (CD)–related complications was comparable (based on the overlap of the 95% CIs) at both the participant level and the organ level (small bowel or colorectal). The intrareader concordance between A-MRE and CE-MRE for detecting signs of active inflammation and CD-related complications was almost perfect. MRE = MR enterography.

* Key features were considered present if the reader categorized them as present in any intestinal segment.

MRE interpretation

All A-MRE and CE-MRE studies were deidentified, assigned unique numeric identifiers, randomly reordered, and uploaded to a secure image-reading platform (Entrolytics, Motilent). Reader assessments were recorded in REDCap (Research Electronic Data Capture; nPhase).

MRE examinations were interpreted in two rounds separated by 1 month. In the first round, readers evaluated disease activity and complications using A-MRE examinations only; in the second, identical assessments were performed using CE-MRE examinations. For the second round, the order of MRE examinations was rerandomized, and readers were blinded to their previous interpretations.

For assessment, the bowel was divided into eight segments: three small bowel (jejunum, proximal/mid ileum, and terminal ileum) and five colon segments (rectum, sigmoid, descending, transverse, and cecum/ascending). Each segment was scored for maximum wall thickness, mural edema, ulcerations, and perienteric or pericolic fat inflammation. Wall thickness was classified as normal (≤3 mm) or abnormal (>3 mm). Readers also recorded CD-related complications—strictures and internal penetrating complications (sinus tract or fistula, abscess, and inflammatory mass)—according to consensus definitions (15,16) (Table S3).

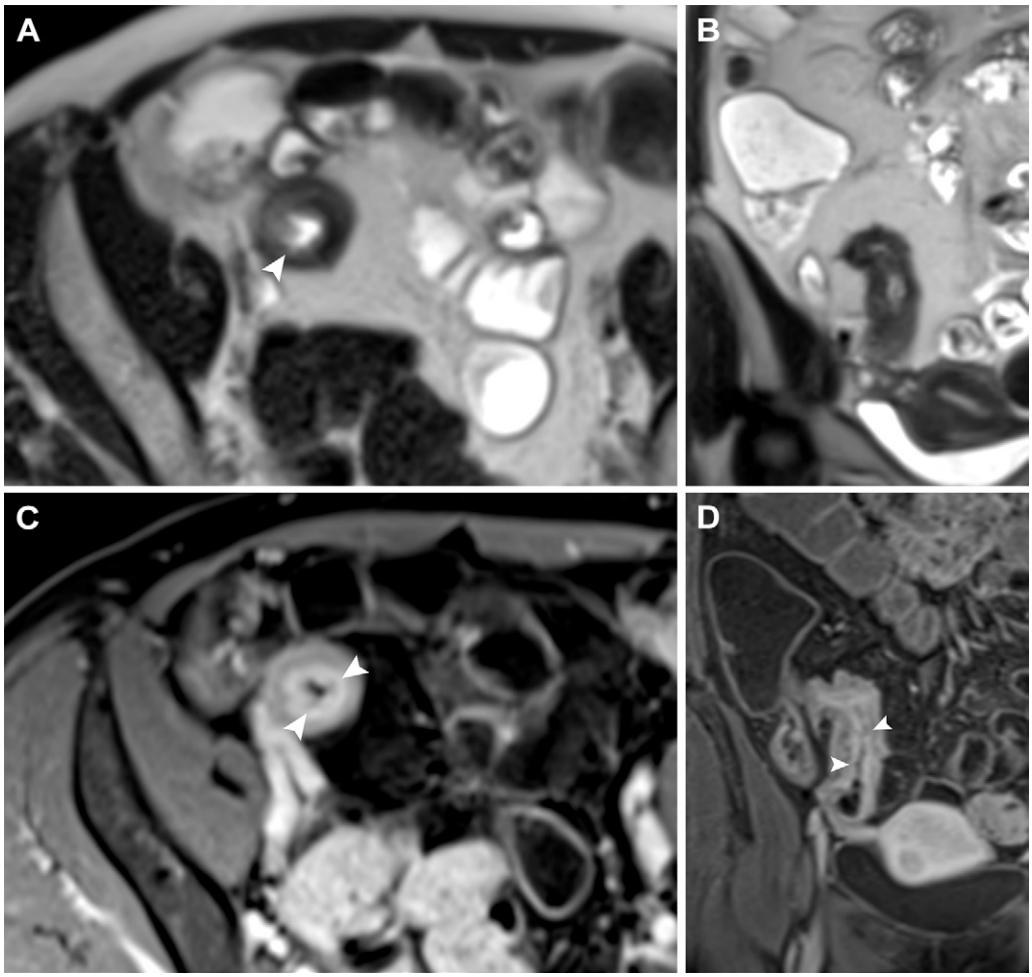


Figure 2: Example images in a 33-year-old female participant with Crohn disease. **(A)** Axial and **(B)** coronal single-shot fast spin-echo T2-weighted MR enterography (MRE) images without fat saturation and **(C)** axial and **(D)** coronal contrast-enhanced T1-weighted images with fat saturation. The T2-weighted images demonstrate wall thickening of the terminal ileum. In the axial plane **(A)**, a subtle mucosal irregularity of the ileum (arrowhead) is evident, although it is less conspicuous in the coronal plane **(B)**. On contrast-enhanced T1-weighted images, similar irregularities are visible in both the axial and coronal planes (arrowheads in **C** and **D**). These findings were interpreted as ulcers by 40% of readers (four of 10) in the abbreviated MRE protocol, with the proportion increasing to 60% (six of 10) in the contrast-enhanced MRE protocol.

Additionally, using the reader assessments for all MRE examinations, the sMaRIA score (0–5) was automatically calculated from spreadsheet results for each intestinal segment and categorized as inactive (sMaRIA = 0), active (sMaRIA ≥1), or with severe inflammatory lesions (sMaRIA ≥2), according to validated cutoff values (10,17,18). Detailed components of the sMaRIA index and corresponding cutoff values to define disease status are described in Table S4.

The mean acquisition time for T2-weighted and balanced steady-state free precession sequences, as well as for T1-weighted images (including the injection of antiperistaltic and intravenous contrast agents), was calculated according to data extracted from the Digital Imaging and Communications in Medicine header.

Ileocolonoscopy

Ileocolonoscopy, when available, was performed by one of two endoscopists involved in the original study, each with over 10 years of experience, within 1 month of MRE. Segmental disease activity was assessed using the Simple Endoscopic Score for Crohn's Disease (SES-CD) (19). Segmental SES-CD of 3 or higher in the ileum or colon was considered indicative of active disease, and severity was defined by the presence of superficial or deep ulcers larger than 5 mm at endoscopy.

Statistical Analysis

Continuous variables were summarized as medians with IQRs, and categorical variables as counts and percentages. Interreader agreement and intrareader concordance were evaluated to assess consistency between and within readers, respectively. Agreement for binary variables was quantified using the Gwet first agreement coefficient (AC1), which adjusts for prevalence effects, with corresponding two-sided 95% CIs (20,21). For quantitative variables, interreader agreement was assessed using the intraclass correlation coefficient (ICC) and intrareader

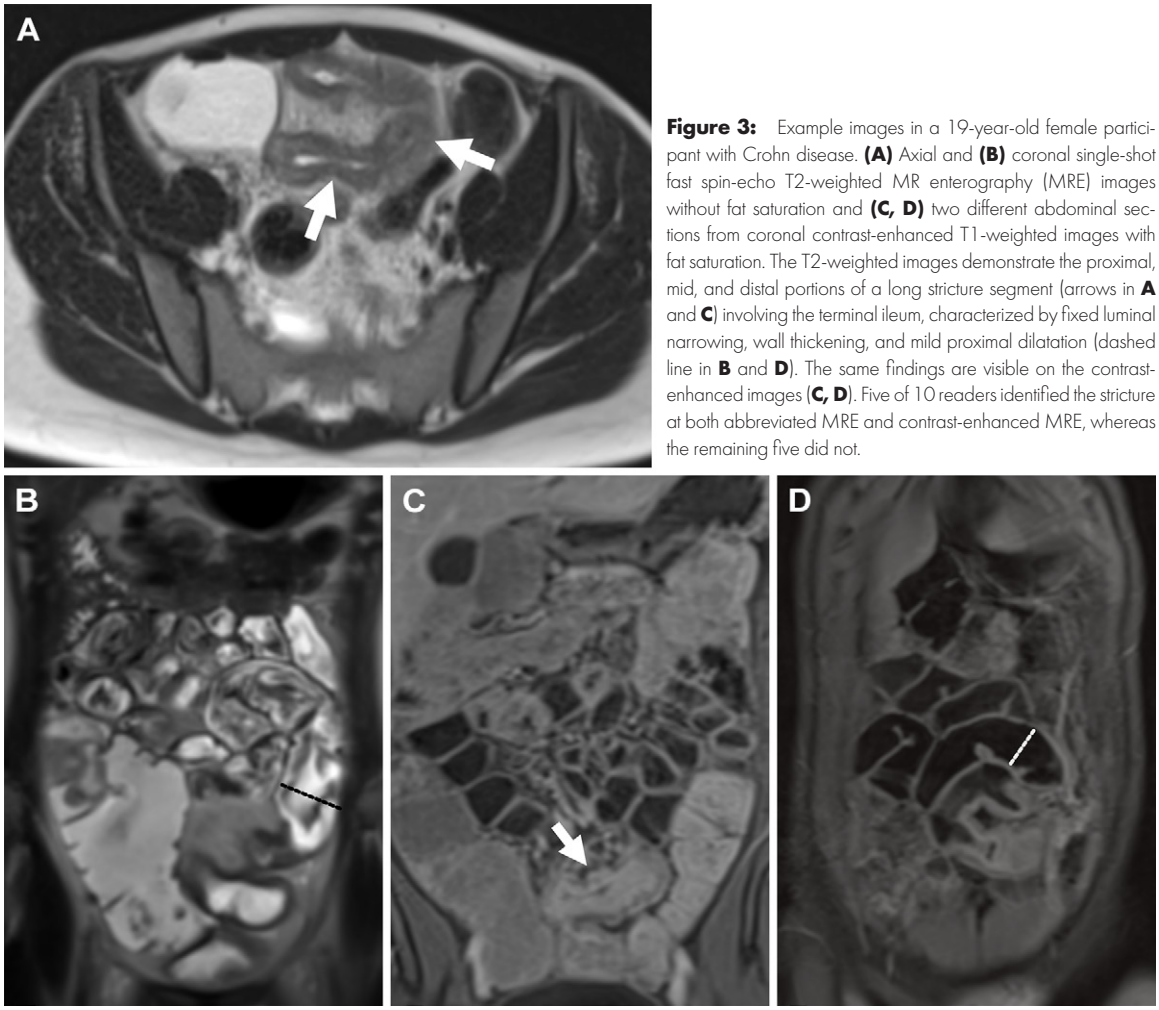


Figure 3: Example images in a 19-year-old female participant with Crohn disease. **(A)** Axial and **(B)** coronal single-shot fast spin-echo T2-weighted MR enterography (MRE) images without fat saturation and **(C, D)** two different abdominal sections from coronal contrast-enhanced T1-weighted images with fat saturation. The T2-weighted images demonstrate the proximal, mid, and distal portions of a long stricture segment (arrows in **A** and **C**) involving the terminal ileum, characterized by fixed luminal narrowing, wall thickening, and mild proximal dilatation (dashed line in **B** and **D**). The same findings are visible on the contrast-enhanced images (**C, D**). Five of 10 readers identified the stricture at both abbreviated MRE and contrast-enhanced MRE, whereas the remaining five did not.

concordance using the Lin concordance coefficient, both with two-sided 95% CIs (22,23).

Agreement was assessed using Landis and Koch benchmarks, whereby AC1s, ICCs, or Lin concordance coefficients of 0.20, 0.21–0.40, 0.41–0.60, 0.61–0.80, and greater than 0.80 constitute "slight," "fair," "moderate," "substantial," and "almost perfect" reliability, respectively (24). Estimates of interreader agreement were compared by analyzing whether 95% CIs overlapped.

Agreements were assessed primarily at the bowel segment level and subsequently at the participant level, with findings considered present if identified in any segment. Sensitivity analyses evaluated the impact of *(a)* therapeutic intervention, *(b)* disease location by combining small intestinal and colorectal assessments, and *(c)* reader experience.

Diagnostic accuracies of the sMaRIA for the terminal ileum and colon were assessed using sensitivity, specificity, and positive and negative predictive values, with ileocolonoscopy as the reference standard.

The influence of MR protocol, organ, and their interaction on organ-level comparisons and diagnostic summaries was evaluated using mixed-effects regression models, with these factors entered as fixed effects and participant and reader specified as random intercepts. Overall effects were assessed with type III tests, and adjusted probabilities were obtained from least-squares means. A repeated-measures mixed model was also applied to account for multiple measurements within each participant-organ structure.

A sample size calculation of a minimum of 77 MR examinations was based on a minimum acceptable ICC of 0.7, as suggested by prior studies (25), with a minimum expected ICC of 0.6. The calculation also assumed 10 readers, a power of 80%, and an α error of .05 (26).

All statistical analyses were performed by board-certified statisticians (A.R. and C.S.) using SAS 9.4 software (SAS Institute).

Results

Participant Characteristics

This study included 60 participants with CD (median age, 36 years [IQR, 28–44 years]; age range, 18–76 years; 40 female; 80 MRE examinations). Among the pool of MRE examinations from the original cohort of 89 participants, each with a pre- and posttreatment MRE examination, 60 participants (51 pretreatment and 29 posttreatment MRE examinations) were selected to achieve the target phenotype percentages (Table 1). Once this proportion was reached, the review and selection process for the remaining MRE examinations was discontinued. Following the selection process, a total of 74 MRE examinations from 53 participants were excluded due to a lack of the expected percentage of MRE phenotypes

Table 3: Interreader Agreement and Intrareader Concordance for Assessing MRE Findings Related to Crohn Disease Activity and Related Complications When Considering the Effect of Biologic Medical Therapy and Reader Experience

Variable and MRE Finding	Interreader Agreement		Intrareader Concordance
	CE-MRE	A-MRE	
Baseline (before treatment) (*n* = 51)			
Wall thickness >3 mm	0.95 (0.91, 1.00)	0.91 (0.83, 0.98)	0.85 (0.83, 0.86)
Edema	0.84 (0.72, 0.96)	0.82 (0.71, 0.94)	0.87 (0.85, 0.88)
Ulcers	0.24 (0.01, 0.48)	0.20 (0.00, 0.41)	0.91 (0.90, 0.92)
Fat stranding	0.60 (0.41, 0.79)	0.50 (0.27, 0.72)	0.86 (0.84, 0.87)
Stricturing disease	0.53 (0.34, 0.73)	0.67 (0.51, 0.84)	0.91 (0.89, 0.92)
Penetrating disease	0.72 (0.54, 0.90)	0.65 (0.46, 0.83)	0.95 (0.95, 0.96)
After treatment (*n* = 29)			
Wall thickness >3 mm	0.81 (0.65, 0.97)	0.82 (0.67, 0.96)	0.88 (0.87, 0.91)
Edema	0.67 (0.47, 0.87)	0.63 (0.39, 0.86)	0.89 (0.88, 0.91)
Ulcers	0.32 (0.09, 0.56)	0.36 (0.08, 0.64)	0.93 (0.92, 0.95)
Fat stranding	0.34 (0.15, 0.54)	0.20 (0.04, 0.36)	0.89 (0.88, 0.91)
Stricturing disease	0.47 (0.27, 0.66)	0.48 (0.28, 0.68)	0.92 (0.91, 0.94)
Penetrating disease	0.83 (0.70, 0.96)	0.81 (0.65, 0.96)	0.97 (0.97, 0.98)
Novice readers (*N* = 80)*			
Wall thickness >3 mm	0.84 (0.74, 0.94)	0.89 (0.78, 1.00)	0.87 (0.85, 0.88)
Edema	0.78 (0.65, 0.92)	0.80 (0.66, 0.94)	0.87 (0.85, 0.89)
Ulcers	0.21 (−0.19, 0.62)	0.17 (−0.07, 0.42)	0.93 (0.92, 0.94)
Fat stranding	0.25 (0.07, 0.42)	0.44 (0.22, 0.66)	0.87 (0.85, 0.89)
Stricturing disease	0.54 (0.36, 0.71)	0.47 (0.30, 0.64)	0.91 (0.89, 0.92)
Penetrating disease	0.71 (0.56, 0.85)	0.74 (0.54, 0.94)	0.96 (0.96, 0.97)
Experienced readers (*N* = 80)*			
Wall thickness >3 mm	0.92 (0.86, 0.99)	0.92 (0.85, 0.99)	0.86 (0.81, 0.88)
Edema	0.76 (0.57, 0.94)	0.74 (0.56, 0.92)	0.88 (0.87, 0.90)
Ulcers	0.32 (−0.03, 0.66)	0.30 (−0.03, 0.63)	0.91 (0.90, 0.93)
Fat stranding	0.54 (0.27, 0.81)	0.50 (0.19, 0.81)	0.87 (0.85, 0.89)
Stricturing disease	0.51 (0.26, 0.75)	0.64 (0.46, 0.82)	0.92 (0.91, 0.93)
Penetrating disease	0.77 (0.57, 0.97)	0.69 (0.38, 0.99)	0.95 (0.95, 0.97)

Note.—Data are Gwet first agreement coefficients, with 95% CIs in parentheses. Overall, interreader agreement for assessments at both baseline and after treatment was consistent, with almost perfect agreement for wall thickening and substantial to almost perfect agreement for edema. Agreement for fat stranding and ulcers was fair. Intrareader concordance was almost perfect for all activity and complication features at both timepoints. There was no evidence of any difference in interreader agreement between novice and experienced readers across the abbreviated MR enterography (A-MRE) and contrast-enhanced MR enterography (CE-MRE) protocols in determining the presence of intestinal active inflammation and Crohn disease–related complications. MRE = MR enterography.

* *Experienced* was defined as more than 8 years of posttraining experience, whereas *novice* was defined as 8 or fewer years of posttraining experience.

(*n* = 21 pretreatment and 51 posttreatment MRE examinations) or nondiagnostic quality (*n* = 2) (Fig 1).

Of the 80 MRE examinations, 42 (53%) showed active inflammatory disease, 17 (21%) showed stricturing disease, 13 (16%) showed internal penetrating disease, and eight (10%) showed inactive disease.

Reliability of MRE Findings

Table 2 shows intrareader concordance and interreader agreement (AC1) for each MRE finding across CE-MRE and A-MRE protocols. Overall, agreement for detecting active inflammation and CD-related complications was comparable between protocols.

For both protocols, interreader agreement at the participant level was almost perfect for abnormal bowel wall thickness (AC1: CE-MRE, 0.91 [95% CI: 0.84, 0.97] vs A-MRE, 0.88 [95% CI: 0.80, 0.95]) and substantial for edema (AC1: CE-MRE, 0.79 [95% CI: 0.67, 0.90] vs A-MRE, 0.76 [95% CI: 0.64, 0.88]) (Fig 2). For fat stranding, interreader agreement was moderate in CE-MRE (AC1: 0.50 [95% CI: 0.33, 0.67]) and fair in A-MRE (0.38 [95% CI: 0.19, 0.56]). Agreement for ulcer detection was fair in both protocols (AC1: CE-MRE, 0.26 [95% CI: 0.10, 0.42] vs A-MRE, 0.24 [95% CI: 0.08, 0.41]).

Regarding CD-related complications, agreement for identifying strictures was moderate in CE-MRE (AC1: 0.50 [95% CI: 0.35, 0.65]) and substantial in A-MRE (0.61 [95% CI: 0.47, 0.74]) (Fig 3). For internal penetrating complications, interreader agreement was substantial in both protocols (AC1: CE-MRE, 0.76 [95% CI: 0.63, 0.90] vs A-MRE, 0.71 [95% CI: 0.56, 0.86]).

The intrareader concordance between A-MRE and CE-MRE for detecting signs of active inflammation and CD-related complications was almost perfect, ranging from an AC1 of 0.86 (95% CI: 0.85, 0.88) for abnormal wall thickness to 1.00 (95% CI: 1.00, 1.00) for strictures (Table 2).

Table 4: Interreader Agreement and Intrareader Concordance of the sMaRIA for Categorizing Participants Having at Least One Bowel Segment with Active Disease or Severe Active Inflammation and the Concordance Correlation Coefficient for Overall sMaRIA

	Interreader Agreement		
Variable and Group	CE-MRE	A-MRE	Intrareader Concordance
Active disease			
Full study sample (*N* = 80)	0.91 (0.85, 0.97)	0.87 (0.79, 0.95)	0.92 (0.90, 0.94)
Baseline (*n* = 51)	0.95 (0.89, 1.00)	0.89 (0.81, 0.97)	0.89 (0.85, 0.92)
Posttreatment (*n* = 29)	0.83 (0.68, 0.97)	0.83 (0.69, 0.96)	0.97 (0.95, 0.99)
Severe active inflammation			
Full study sample (*N* = 80)	0.79 (0.68, 0.90)	0.74 (0.61, 0.88)	0.93 (0.90, 0.95)
Baseline (*n* = 51)	0.84 (0.73, 0.95)	0.80 (0.68, 0.92)	0.90 (0.87, 0.93)
Posttreatment (*n* = 29)	0.70 (0.50, 0.89)	0.63 (0.37, 0.89)	0.97 (0.94, 0.99)
sMaRIA*			
Full study sample (*N* = 80)	0.51 (0.42, 0.59)	0.43 (0.33, 0.52)	0.74 (0.71, 0.77)†
Baseline (*n* = 51)	0.47 (0.36, 0.59)	0.41 (0.31, 0.53)	0.72 (0.68, 0.76)†
Posttreatment (*n* = 29)	0.52 (0.38, 0.66)	0.41 (0.29, 0.57)	0.75 (0.70, 0.80)†

Note.—Unless otherwise specified, data are Gwet first agreement coefficients, with 95% CIs in parentheses. When considering global simplified MR index of activity (sMaRIA) scores across all bowel segments, both MRE techniques showed moderate and similar intraclass correlation coefficients (ICCs). Contrast-enhanced MR enterography (CE-MRE) achieved an ICC of 0.51 (95% CI: 0.42, 0.59), whereas abbreviated MR enterography (A-MRE) showed an ICC of 0.43 (95% CI: 0.33, 0.52). For the classification of disease activity, the two protocols demonstrated near-perfect interreader agreement in identifying active disease (defined as sMaRIA score ≥1 in at least one segment); severe active inflammation was defined as segmental sMaRIA score of 2 or higher. Gwet first agreement coefficients were 0.91 (95% CI: 0.85, 0.97) for CE-MRE and 0.87 (95% CI: 0.79, 0.95) for A-MRE, with overlapping CIs indicating comparable agreement. Data are presented for the entire study sample (*N* = 80), baseline MR enterography (MRE) examinations (*n* = 51), and 46-week posttreatment MRE examinations (*n* = 29).

* Sum of all segmental sMaRIA scores. Unless otherwise specified, data are ICCs, with 95% CIs in parentheses.

† Data are Lin concordance coefficients, with 95% CIs in parentheses.

The interreader agreement and intrareader concordance for each individual bowel segment are presented in Table S5.

Effect of Disease Location

Of the 80 MRE examinations, 16 (20%) showed signs of active disease in at least one colorectal segment, whereas 64 (80%) showed inflammation in at least one small bowel segment. In analyses of small bowel and colorectal segments separately, A-MRE and CE-MRE showed similar agreement in detecting active disease features and CD-related complications (Table 2). Intrareader concordance remained substantial to nearly perfect across disease locations (AC1 ranging from 0.73 [95% CI: 0.70, 0.76] to 0.98 [95% CI: 0.97, 0.98]).

Effect of Treatment

Overall, readers showed consistency in identifying MRE signs of disease activity at both baseline and after treatment, with wall thickening demonstrating high agreement across timepoints (AC1: baseline CE-MRE, 0.95 [95% CI: 0.91, 1.00] vs posttreatment examination, 0.81 [95% CI: 0.65, 0.97]; baseline A-MRE, 0.91 [95% CI: 0.83, 0.98] vs posttreatment examination, 0.82 [95% CI: 0.67, 0.96]). The intrareader concordance was almost perfect at both timepoints (Table 3).

Effect of Reader Experience

There was no evidence of a difference in interreader agreement between novice and experienced readers across the A-MRE and CE-MRE protocols for determining the presence of intestinal active inflammation and CD-related complications (Table 3). The intrareader concordance was almost perfect for all features of activity and complications for both novice (AC1 ranging from 0.87 [95% CI: 0.85, 0.89] to 0.96 [95% CI: 0.96, 0.97]) and expert readers (AC1 ranging from 0.86 [95% CI: 0.81, 0.88] to 0.95 [95% CI: 0.95, 0.97]).

sMaRIA Reliability

Table 4 presents the ICCs for global sMaRIA scores using both the CE-MRE and A-MRE protocols, along with agreement levels for disease severity classifications, whereas the agreement of sMaRIA at the segment level is presented in Table S6.

For global sMaRIA scores, when all bowel segments were pooled, both MRE protocols demonstrated moderate and comparable ICCs (CE-MRE, 0.51 [95% CI: 0.42, 0.59] vs A-MRE, 0.43 [95% CI: 0.33, 0.52]) (Table 4).

For disease status classification, both protocols showed almost perfect interreader agreement for identifying active disease (sMaRIA ≥1 in at least one intestinal segment) in the full study sample, with AC1 values of 0.91 (95% CI: 0.85, 0.97) for CE-MRE and 0.87 (95% CI: 0.79, 0.95) for A-MRE.

sMaRIA Accuracy

Ileocolonoscopy data were available for 52 of 80 (65%) MRE examinations. In the terminal ileum, sMaRIA demonstrated sensitivities of 96.4% (430 of 446; 95% CI: 94.2, 97.9) and 98.4% (442 of 449; 95% CI: 96.8, 99.4) and specificities of 68.1% (47 of 69; 95% CI: 55.8, 78.8) and 71.4% (50 of 70; 95% CI: 59.4, 81.6) for A-MRE and CE-MRE, respectively, for detecting activity. In the colon, sensitivities were 51.7% (60 of 116;

95% CI: 42.3, 61.1) and 56.8% (71 of 125; 95% CI: 47.6, 65.6) and specificities were 73.9% (314 of 425; 95% CI: 69.4, 78.0) and 75.8% (335 of 442; 95% CI: 71.5, 79.7) for A-MRE and CE-MRE, respectively, for detecting activity. Diagnostic accuracy of sMaRIA for detecting activity and severity in both regions is shown in Figure 4 and Table S7.

Reduction of Scanning Time

The median time required to obtain T2-weighted and balanced steady-state free precession images was 11.5 minutes (IQR, 8.8–13.5 minutes; range, 8.8–17 minutes), whereas the median time for T1-weighted sequences, including the injection time, was 7.5 minutes (IQR, 6.3–7.8 minutes; range, 6.0–8.8 minutes). Therefore, using the simulated A-MRE protocol could reduce average CE-MRI scanning time, in which the participant remains inside the MR gantry, by 39.5% (7.5 minutes divided by 19 minutes).

Organ, Protocol, and Item Interaction Independence and Response Outcome Measures

The effects of the MR protocol, organ, and their interaction on organ-level comparisons and diagnostic summaries are presented in Tables S8 and S9. There was no evidence of an interaction between the MRE protocol and the bowel segment, indicating that the effect of the MRE protocol does not depend on the bowel segment. Model-based adjusted probabilities demonstrated similar outcome detection rates between protocols within each bowel segment.

The participant-level ICC was 0.19, indicating slight within-patient correlation, whereas the reader-level ICC was 0.03, confirming that dependence was present and appropriately addressed through random effects (Table S10). Model-based adjusted probabilities showed very similar diagnostic performance between organs (Table S11) and protocols (Table S12).

Discussion

This study compared agreement between abbreviated MR enterography (MRE) and contrast-enhanced MRE protocols for evaluating Crohn disease activity and complications. Ten radiologists reviewed 80 prospectively acquired MRE examinations. Interobserver agreement was moderate to substantial for most MRI features, with comparable results across protocols, whereas intraobserver concordance was generally almost perfect.

A key strength of our study is the comparable interreader agreement between noncontrast A-MRE and conventional CE-MRE in assessing CD activity. For CD-related complications, interreader agreement for detecting strictures was substantial with A-MRE and moderate with CE-MRE and substantial for internal penetrating complications with both protocols.

Only a few features, such as ulcers and fat stranding at A-MRE, showed fair interreader agreement, likely due to lack of training and difficulty distinguishing findings from other irregularities or defects on the bowel. The low agreement observed aligns with previous research in this field (25). To improve ulceration

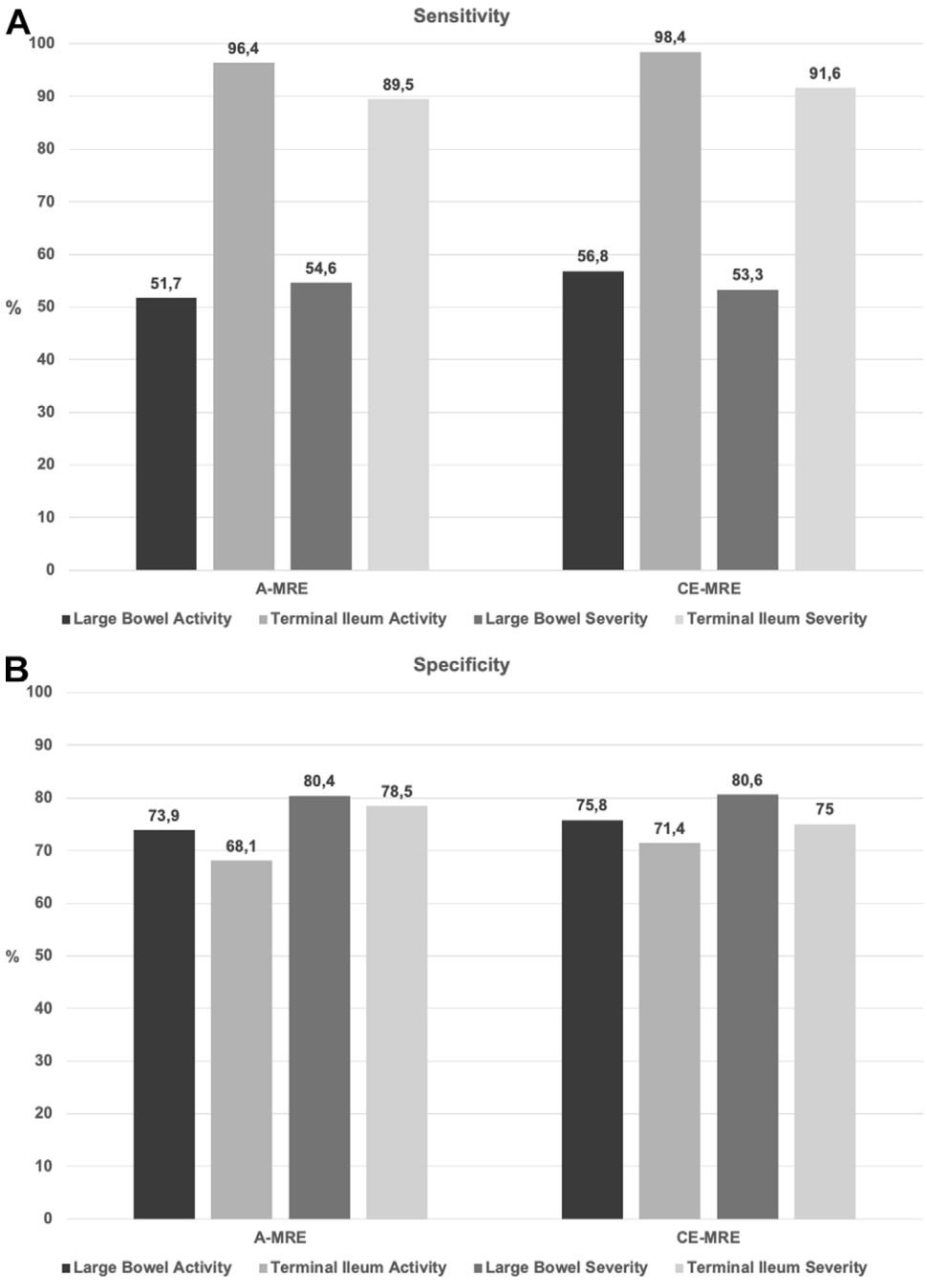


Figure 4: Clustered bar graphs show **(A)** sensitivity and **(B)** specificity, *(Fig 4 continues).*

assessment, more specific definitions and stricter imaging criteria are needed. Although ulcer detection shows lower agreement, limiting its clinical impact, other severity markers, such as edema, demonstrate high concordance. In research, however, ulcer misclassification can meaningfully affect severity scoring (10,27,28).

Previous studies showed that MRE is reproducible for assessing CD, but they mainly used single contrast-enhanced protocols without comparing conventional and abbreviated approaches (25,29,30). Our study fills this gap and strengthens generalizability by including radiologists from diverse regions and experience levels.

Finally, we evaluated the interreader agreement and intrareader concordance of the sMaRIA scoring system for CD, as its interreader reliability remains underexplored despite prior validation. Unlike the MR index of activity, sMaRIA does not require contrast-enhanced imaging (10,25,28,31,32). The comparable ICCs, Lin concordance coefficients, and accuracies observed across both protocols contribute to the robustness of sMaRIA and reinforce prior evidence that contrast-enhanced sequences do not substantially influence image interpretation.

The implementation of A-MRE protocols offers several potential advantages. In terms of efficiency, the abbreviated protocol can simplify workflow, enable a higher volume of studies, improve accessibility within radiology departments, and reduce waiting times for MRE scheduling (6). Because patients with CD often require repeated assessments, the length of MRE examinations and the need for multiple injections of gadolinium-based contrast and antiperistaltic agents can feel burdensome. The reasons why patients may dislike MRE vary between individuals. However, shortened protocols may improve patient experience and support better compliance with disease monitoring. In this context, assessing interreader agreement is essential to ensure reliable and consistent image interpretation. Additionally, omitting gadolinium can further reduce environmental impact by lowering the demand for rare-earth mining and decreasing the risk of water contamination (33,34).

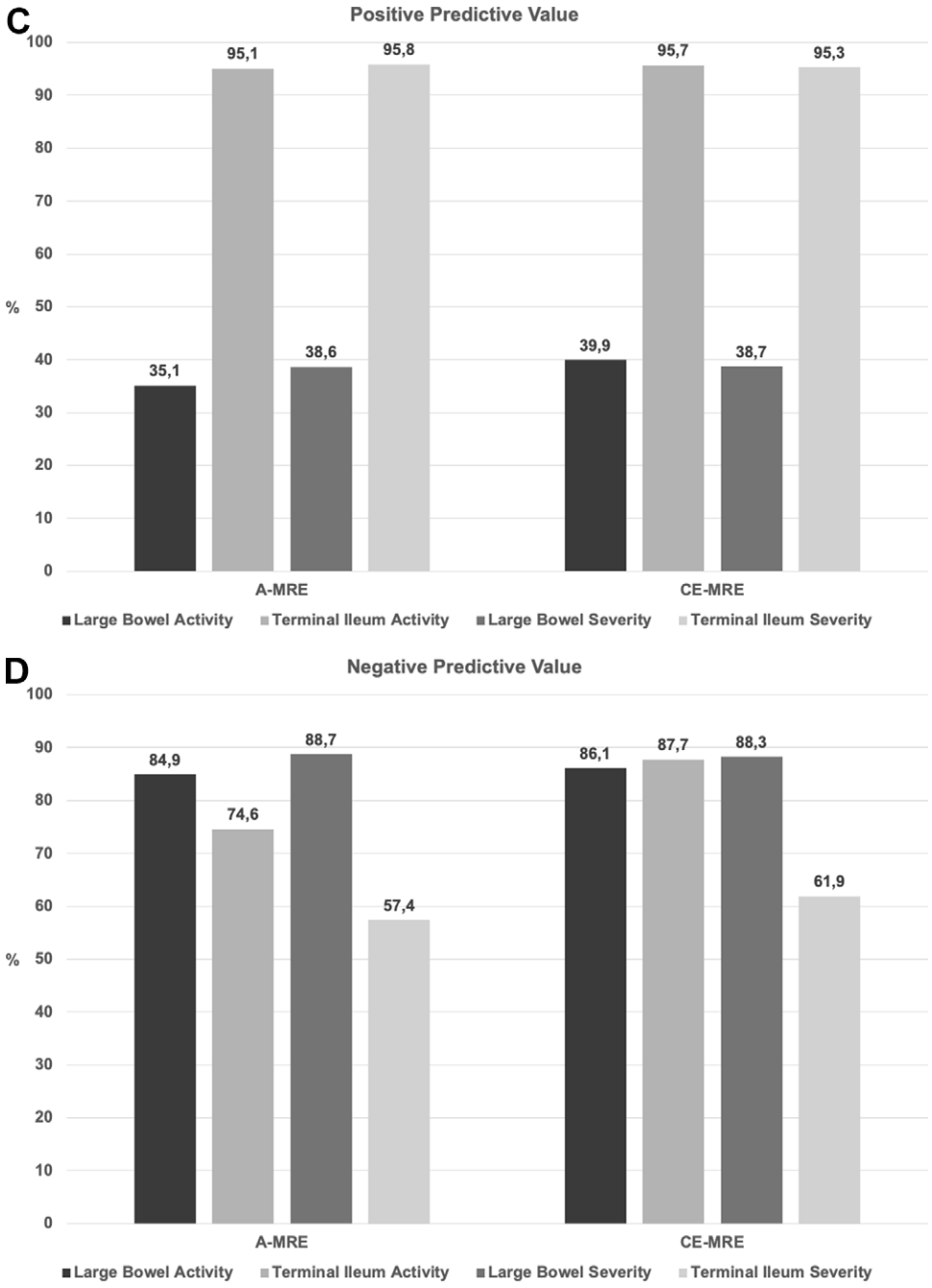


Figure 4 (continued). Clustered bar graphs show **(C)** positive predictive value and **(D)** negative predictive value of simplified MR index of activity scores for detecting active and severe inflammatory lesions in participants undergoing contrast-enhanced MR enterography (CE-MRE) and abbreviated MR enterography (A-MRE) of the terminal ileum and large bowel. Columns in light gray represent the terminal ileum, whereas those in dark gray represent the large bowel. The corresponding percentage values are shown at the top of each column. A-MRE and CE-MRE showed comparable diagnostic performance, with both protocols achieving very high sensitivity and positive predictive value and moderate specificity and negative predictive value for detecting terminal ileum activity. In the colon, both techniques demonstrated similarly lower sensitivities but maintained moderate specificities.

Different combinations of sequences may constitute A-MRE, and determining the best combination is still an open question (8). Dillman et al (35) proposed a brief protocol incorporating axial and coronal T2-weighted sequences with and without fat saturation. In contrast, Jhaveri et al (7) reported the feasibility of an A-MRE protocol consisting exclusively of balanced steady-state free precession sequences with over 95% sensitivity and

specificity for detecting active CD. Our A-MRE protocol emphasizes T2-weighted sequences, which are fast and reliable for detecting CD activity and complications. Diffusion-weighted imaging remains controversial because restricted diffusion is nonspecific (1,16). Due to its limited specificity and susceptibility artifacts, it was excluded to avoid confounding effects. Although evidence indicates that cinematic sequences may help predict the presence of activity, future investigations are needed to determine their applicability in large-scale studies (36,37).

Despite the notable strengths of our study, some limitations should be acknowledged. First, the analysis was based on a simulated A-MRE model; therefore, prospective studies including consecutive participants with CD are required to confirm its clinical applicability. Second, all imaging was performed at a single tertiary center, with participants selected based on expert radiologist interpretation, which may introduce specific biases. Nevertheless, the scanners, sequences, and protocols used reflect standard clinical practice and comply with current recommendations (1,38). Reported time savings pertain only to scanning time, and unmeasured factors such as participant positioning or postprocessing may have led to an overestimation of efficiency gains. Third, protocol comparisons were based on CI differences, although the optimal approach for assessing reader agreement remains undefined. Fourth, segment-level analyses may also have violated independence assumptions, potentially narrowing CIs. Finally, all MRE examinations underwent image quality screening to ensure consistency between A-MRE and CE-MRE. It is also worth noting that, despite the similarities between A-MRE and CE-MRE in detecting luminal disease and complications, A-MRE alone may be insufficient for characterizing complications (eg, distinguishing masses from collections), which may impact clinical management. Therefore, in CD-related complications, a personalized approach including contrast-enhanced sequences should be considered.

In summary, an abbreviated MR enterography (MRE) protocol demonstrated comparable interreader agreement to conventional contrast-enhanced MRE and high intrareader concordance for detecting active Crohn disease (CD) and related complications in participants with CD, supporting its adoption in clinical practice and research. These results suggest that noncontrast MRE, relying only on T2-weighted and balanced steady-state free precession sequences, could be a reliable alternative to conventional protocols, maintaining diagnostic accuracy and consistency among radiologists.

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