Can Magnetic Resonance Enterocolonography Scoring System derived from Simplified Endoscopic Activity Score for Crohn' Disease be alternative to MaRIA score?

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Aims and objectives

Magnetic resonance (MR) enterography or enteroclysis for CD is recommended because it has highest diagnostic accuracy for inflammatory lesion of large and small bowel (5). Magnetic resonance index of activity (MaRIA) is known as validated score for assessing the activity of ileocolonic segments in CD (6, 7). However, the measurement of signal intensities and mural thickness for calculating MaRIA is time-consuming and difficult to use in daily clinical practice. In another study, magnetic resonance enterocolonography (MREC) scoring system derived from simplified endoscopic activity score for Crohn’s disease (SES-CD) had been proposed (8, 9). This system is simple and requires only visual assessments although validation study had not been conducted.

The purpose of this study is to assess the MREC derived from SES-CD score in evaluating the activity in CD, and to compare the MREC scoring system and MaRIA score.

Methods and materials

This study was approved by the Ethics Committee, and the requirement for informed consent was waived for this retrospective study

Patients

MREC imaging and Endoscopy

MREC was performed initially, with endoscopy subsequently performed. MREC and endoscopy were performed on the same day in 42 patients (84%). In cases that underwent MREC and endoscopy on different days, the mean duration between MREC and endoscopy was 23.5 days.

On the day before MR imaging, bowel cleansing was performed by oral ingestion of 50 g of magnesium citrate with 200 mL of water at 7 PM. Within 60 minutes before MR imaging, all patients were instructed to drink 1000 mL of polyethylene glycol. MR imaging was performed using a 1.5-T scanner (Excelart Vantage powered by Atlas; Toshiba Medical Systems, Tokyo, Japan). All MR images were acquired with the patient in the supine position. After intravenous injection of 20 mg of scopolamine butylbromide, coronal and axial single-shot fast-spin echo sequences, a coronal True Steady State Free Precession (True SSFP) and a coronal 3-dimensional T1-weighted gradient echo sequence, termed quick dimensional dynamic diagnostic scan (Quik3Ds) were acquired. After 60 seconds
of manual intravenous administration of gadolinium chelate at a dose of 0.2 mL/kg body weight, a Quick3Ds was performed in axial and coronal orientations. Finally, transverse diffusion-weighted imaging (spin-echo echo planar imaging) with b-value 800 sec/mm² was performed. All imaging covered the entire small and large intestines.

Single balloon-assisted enteroscopy (SBE) in 37 patients and ileocolonoscopy (ICS) in 13 patients were subsequently performed by experienced endoscopists. In cases that underwent endoscopy on another day of MREC, bowel cleaning was performed according to the same method as MREC. They used a retrograde approach and advanced the endoscopy as deep as possible. They limited the total insertion time to 90 minutes.

**Segmentation of the bowel and characterization of CD lesions for MREC and Endoscopies**

For comparison of MREC and endoscopic findings, the large bowel was divided into 5 segments instead of 4 used in conventional SES-CD: rectum, sigmoid colon, descending colon, transverse colon, and ascending colon, and the small bowel was divided into 3 segments: terminal ileum, proximal ileum and jejunum. In MREC analyses, ileum and jejunum were determined following the feature: the ileum generally occupies the right middle and lower portions of the abdominal cavity and the jejunum the left upper and middle portions (10). In endoscopic analyses, the ileum was defined as the distal part of the small bowel extending 300 cm or less from the ileocecal valve, and the jejunum was defined as the proximal part of the small bowel. (4). In MREC and endoscopic analyses, the terminal ileum was defined as the distal part of the ileum 10 cm or less from the ileocecal valve and proximal ileum was defined as the proximal part of the ileum. In addition, in case of an ileocolonic anastomosis, the terminal ileum included the distal part of the small bowel 10 cm or less from the anastomotic site.

Radiologists and Physicians blinded to result of another study, evaluated MREC and endoscopy.

For characterization of CD lesions with MREC, each segment was scored using MaRIA score (6, 7) and newly defined MREC activity (MREC-A) score derived from SES-CD.

In order to calculate MaRIA score, quantitative and qualitative variables were recorded in each segment. Pre- and postcontrast wall signal intensity (WSI) at 60 seconds in Quick3Ds were quantitatively analyzed for calculate relative contrast enhancement (RCE). WSI were quantitatively measured using the average of three regions of interest (ROIs) placed on the area within the wall presenting largest thickness. RCE was calculated according the following formula: \( RCE = \left( \frac{\text{WSI post gadolinium} - \text{WSI pre gadolinium}}{\text{WSI pre gadolinium}} \right) \times 100 \times \left( \frac{\text{SD noise pre gadolinium}}{\text{SD noise post gadolinium}} \right) \). The MaRIA was calculated with the following formula (6, 7) : \( \text{MaRIA} = 1.5 \times \text{wall thickening (mm)} + 0.02 \times \text{RCD} + 5 \times \text{edema} + 10 \times \text{ulceration} \).
We defined MREC-A score by revising MREC score previously reported (9) (table 1). Stenosis of the bowel was excluded from assessments in order to compare MREC-A with MaRIA that does not include stenosis. All variables are scored by qualitative assessments: morphologic change of the bowel, proportion of deep mucosal lesion, and proportion of superficial and deep mucosal lesions. Morphologic changes were classified in the following manner: no pathologic changes (NPC, score = 0), superficial mucosal lesion (SML, score = 1) and deep mucosal lesion (DML, score = 3). Imaging findings of each change were defined in table 2. In the small bowel, asymmetric involvement, that is, the mesenteric border appearing straight, and antimesenteric border appearing spared or partly spared, causing redundancy of the wall sacculation, or scalloping, was defined as DML when mesenteric border showed hyper-enhancement regardless of other findings. It has been known that the asymmetric involvement is related to longitudinal ulcer of the small bowel in contrast radiography (11) although this findings is described on MR images previously in a report(12). In addition, small bowel showing restriction of diffusion with hyper-enhancement was considered to be deep mucosal lesion regardless of other findings. Proportion of deep mucosal lesion surface (no lesion, score =0; > 0 and < 15 %, score = 1; # 15 and #30 %, score =2; > 30 %, score = 3) and proportion of superficial and deep mucosal lesion surface (no lesion, score = 0; >0 and < 50 %, score = 1; #50 and #75 %, score = 2; >75 %, score = 3) were classified visually in each segment. To evaluate each segment, we summed these three variables. In addition, the presence of asymmetric involvement with hyper-enhancement on the mesenteric border and restriction of diffusion with hyper-enhancement and was recorded in each segment of the large and small bowels.

We considered that endoscopy is the reference standard. The severity and extent of active lesions were evaluated using SES-CD in each segment(8). To compare SES-CD with MR scores, stenosis was excluded in this study, and we re-defined SES-CD activity score (SES-CD-A) (table 2). Sum of SES-CD-A variables # 4, # 3 and # 1, and 0 was defined as ulcerative lesions, non-ulcerative lesions and no lesions, respectively.

Statistical analysis

We performed statistical analysis with the R software (version 3.1.2, R Foundation for Statistical Computing, Vienna, Austria). Correlations between the SES-CD-A, MaRIA and MREC-A were measured by the Spearman rank coefficient.

We calculated sensitivity and specificity of MR findings related to MREC-A score as following parameters: deep mucosal lesion (score 3), asymmetric involvement with hyper-enhancement, and restriction of diffusion with hyper-enhancement, for diagnosing ulcerative lesion.

Area under the receiver operating characteristic (ROC) curves (AUCs) were obtained using pROC package to compare the accuracy of MR scores in discriminating ulcerative lesion (SES-CD-A per segment # 4).
**Table 1: Definition of MREC activity score for Crohn’s disease**

<table>
<thead>
<tr>
<th>Variable</th>
<th>MREC-A score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Severity of ulcers</td>
<td></td>
</tr>
<tr>
<td>No lesion</td>
<td>Superficial mucosal lesion</td>
</tr>
<tr>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Subtly increased contrast enhancemnt</td>
</tr>
<tr>
<td></td>
<td>Subtle irregularity of the fold pattern</td>
</tr>
<tr>
<td></td>
<td>No wall thickening</td>
</tr>
<tr>
<td></td>
<td>No submucosal edema</td>
</tr>
<tr>
<td></td>
<td>No extra-mural hypervascularity</td>
</tr>
<tr>
<td>deep mucosal lesion surface</td>
<td>None</td>
</tr>
<tr>
<td>superficial and deep mucosal lesion surface</td>
<td>None</td>
</tr>
<tr>
<td>Variable</td>
<td>SES-CD activity score</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Size of ulcers</td>
<td>No lesion</td>
</tr>
<tr>
<td>Ulcerated surface</td>
<td>None</td>
</tr>
<tr>
<td>Affected surface</td>
<td>None</td>
</tr>
</tbody>
</table>

**Table 2:** Definition of SES-CD activity score
Results

There were significant correlations of SES-CD-A with MaRIA ($Rs = 0.44$, $p<0.0001$) and MREC-A ($Rs = 0.59$, $p<0.0001$). There was a significant correlation between MREC-A and MaRIA ($Rs = 0.61$, $p<0.0001$).

AUCs of MaRIA score for discriminating ulcerative lesions in all segments, large bowel segments and small bowel segment were 81% (95% CI, 75 - 87 %), 79% (95% CI, 69 - 88%), and 81% (95% CI, 72 - 90%), respectively.

AUCs of MREC-A score for discriminating ulcerative lesions in all segments, large bowel segments and small bowel segment were 82% (95% CI, 77 - 87 %), 77% (95% CI, 69 - 85%), and 83% (95% CI, 75 - 91%), respectively.

Comparisons of AUCs between MaRIA and MREC-A in the large bowel segment and the small bowel segments were shown in Fig 1. There were no significant differences between MaRIA and MREC-A in the large bowel and the small bowel.

**Sensitivity and specificity of MR findings related to MREC-A for detecting endoscopic ulcerative lesions**

Relationships of MR findings to endoscopic findings were shown in Table 3. We added relationships of these findings to submucosal edema or ulcerations because MaRIA score is significantly affected by edema and ulcerations. Sensitivity and specificity were as follows: for "Deep mucosal lesions" defined in MREC-A score, 56% and 95% in the large bowel, and 83% and 84% in small bowel; for asymmetric involvement with hyper-enhancement, 3% and 99% in large bowel and 29% and 95% in small bowel; for restriction of diffusion with hyper-enhancement, 51% and 95% in large bowel and 75% and 84% in small bowel, respectively. Endoscopic ulcerative lesions not positive for submucosal edema or ulceration were seen in 18 large bowel segments and 14 small bowel segments. Of the 18 large bowel segments, 1 segment was diagnosed as deep mucosal lesion whereas of the 14 small bowel segments, 7 segments were diagnosed as deep mucosal segment by MREC-A score. These 8 segment presented hyper-enhancement in addition to asymmetric involvement or restriction of diffusion. Typical case showing these findings is shown in Fig 2.

**Images for this section:**
**Fig. 1:** Comparisons of AUCs between MaRIA and MREC-A in all segments(A), large bowel segments(B) and small bowel segments(C)
<table>
<thead>
<tr>
<th>MR findings related to MREC-A scoring</th>
<th>Endoscopic findings from SES-CD-A score</th>
<th>Large bowel</th>
<th>Small bowel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ulcerative (n=39)</td>
<td>Non-ulcerative (n=21)</td>
<td>No lesion (n=188)</td>
</tr>
<tr>
<td>Deep mucosal lesion</td>
<td>22 (56%, 21/1)</td>
<td>2 (10%, 2/0)</td>
<td>9 (4.8%, 8/1)</td>
</tr>
<tr>
<td>Superficial mucosal lesion</td>
<td>1 (3%, 0/1)</td>
<td>0</td>
<td>1 (0.5%, 0/1)</td>
</tr>
<tr>
<td>No lesion</td>
<td>16 (41%, 0/16)</td>
<td>19 (90%, 0/19)</td>
<td>178 (94.7%, 0/178)</td>
</tr>
<tr>
<td>Asymmetric involvement with hyper-enhancement</td>
<td>1 (3%, 1/0)</td>
<td>0</td>
<td>2 (1%, 2/0)</td>
</tr>
<tr>
<td>Restriction of diffusion with hyper-enhancement</td>
<td>20 (51%, 19/1)</td>
<td>3 (14%, 2/1)</td>
<td>7 (4%, 6/1)</td>
</tr>
</tbody>
</table>

Numbers following % in parenthesis are positive/ not positive for Edema or Ulceration on MR images. Ulcerative, non-ulcerative and no lesion correspond to SES-CD-A score ≥ 4, ≤3 and ≥1, and 0, respectively.

Table 3: Relationships of MR findings to endoscopic findings
Fig. 2: MR images and photograph of enteroscopy of 31 year-old man with Crohn disease exhibiting asymmetric involvement (a, b) in the proximal ileum, and hyper-enhancement(c), no edema (d) slight wall thickening and restriction of diffusion in the terminal ileum (e). Enteroscopy revealed small ulcers in ileum(e).
Conclusion

This newly defined MREC activity score might be alternative to MaRIA score in assessing activity of CD. Hyper-enhancement of the bowel wall in addition to asymmetric involvement or restriction of diffusion may be important for detecting ulcerative lesions when using MREC activity score.

Personal information

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References


