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Ileal Crohn's disease: MRI with endoscopic correlation

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ABSTRACT

Purpose: To evaluate activity staging of Crohn's disease (CD) measured with MR-enterography using ileoscopy as reference standard.
Materials and methods: A prospective study was made of 61 patients with CD. All patients underwent MR-enterography and ileoscopy. MRI activity was measured by means of an ad hoc developed score, as well as by analysis of the imaging findings, and was compared with the SES-CD score obtained via ileoscopy. Examinations were performed using a 1.0 T scanner.
Results: MRI score discriminates between active and inactive disease with an area under the ROC curve of 0.941. Overall correlation with the standard reference SES-CD score was moderate to strong (Spearman's $r = 0.62$ $p < 0.001$).

Agreement between both methods in staging patients with ileal CD as inactive, mild or moderate to severe was good (Cohen's $\kappa = 0.60$). Differences in means of the MRI activity scores of the three groups showed statistical significance ($p < 0.01$).
Conclusions: The MRI score is a reliable predictor of activity in ileal CD and can stage patients in a way comparable to endoscopy. 1.0 T scans are valid for performing radiological evaluation of ileal Crohn's disease.

1. Introduction

Magnetic resonance imaging (MRI) is becoming a "first line" tool in both the detection of disease and in the assessment of activity in Crohn's disease (CD). The accuracy of imaging methods in diagnosing CD is very similar [1]. At present, the role of imaging is centred on the assessment of disease extent and severity, and response to therapy [2]. MRI is a noninvasive bowel imaging technique without any ionizing radiation, capable of demonstrating most of the classical radiological signs of the disease as well as other enteric and extraenteric manifestations. Thus, small bowel MRI can complement the endoscopic findings in the evaluation of CD.

Typical signs of CD in MRI were well-described by Koh et al. [3]. These authors also correlated quantitative and qualitative criteria with activity indexes. Several later studies emphasized the usefulness of MR in distinguishing patients with active disease from those with inactive disease [4–10]. However, the current issue is whether MRI is able to grade the severity of the disease in the same way as other techniques. To answer this question, MRI or any other imaging technique must be correlated to an acceptable reference standard such as endoscopy, the histological findings or surgery. Even in such cases, however, the absence of a "gold standard" for detecting activity in this disease is a handicap for the obtainment of results.

Studies that used MRI to evaluate and to stage disease activity in the ileum using a valid reference standard are few and involve small patient samples [11–14]. For this reason, we started a prospective study of 70 patients with ileal CD in order to evaluate activity staging measured with MR-enterography, using ileoscopy as reference standard. In contrast to almost all previous authors who have used 1.5 T or 3.0 T scanners, our study was carried out using an intermediate-high field machine with a tesla rating of 1.0 T.

2. Materials and methods

Between November 2008 and December 2009, a total of 70 consecutive patients with known or suspected Crohn's disease underwent MR-enterography and ileocolonoscopy. During this period 9 patients were excluded because of incomplete endoscopy ($n = 4$), impossible MR-enterography ($n = 1$), or a final diagnosis other than CD ($n = 4$). A total of 61 patients with biopsy-proven ileal CD were finally enrolled in the study. In 12 patients subjected to previous ileal resection, the neoterminal ileum was scored as terminal ileum.

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The study was conducted following the recommendations of the Declaration of Helsinki, and approved by the local ethics committee. Informed consent was obtained from all patients.

2.1. Reference standard

Ileocolonoscopy was planned for all patients within 15 days of MRI, and was performed by two gastroenterologists with experience in inflammatory bowel disease, blinded to the imaging findings. Terminal or neoterminal ileum, in the case of previous surgical resection, was reached in all of the 61 patients finally selected. Findings in the ileum were scored according to the Simple Endoscopic Score for Crohn's disease (SES-CD) [15]. Four endoscopic variables were scored from 0 to 3: presence and size of ulcers, extent of ulcerated surface, extent of affected surface and presence and type of narrowing, yielding values for the index of between 0 and 12. Based on the SES-CD results, ileal disease for each patient was classified as inactive (0–2), mild (3–6) or moderate-severe (≥7).

2.2. MRI

MR imaging was performed with a 1.0 T machine, with gradient amplitude 15 mT/m (Intera, Philips, Best, The Netherlands) using a multichannel-body coil covering from the xiphoid process to the pubis.

Patients fasted for almost 8 h and ingested 1.5 l of a polyethyleneglycol and mineral salts solution over 45 min before the MRI without any particular preparation of the colon. Images were acquired in the prone position and the fields of view were determined by the size of the patient, in order to avoid phase-encoding aliasing artefacts.

First, thick-slab coronal dynamic single-shot turbo spin-echo with fat saturation was performed to monitor fluid saturation of the small bowel, and to evaluate motility and distensibility of the affected segments.

After 20–40 mg of intravenous hyoscine bromide (Buscapina®, Boehringer Ingelheim), axial and coronal T2-weighted single-shot turbo spin-echo (SSTSE) (TR 2500 ms/TE 240 ms, slice thickness 6 mm, gap 1 mm, matrix 512 × 205), axial and coronal true fast imaging with steady-state precession (B-FFE) (TR 7.5 ms/TE 3.7 ms, 60° flip angle, slice thickness 5 mm, gap 1 mm, matrix 560 × 272) and coronal fat-suppressed THRIVE (T1-weighted high resolution isotropic volume examination), (TR 6.2 ms/TE 3.2 ms, 10° flip angle, slice thickness 4.2 mm, matrix 256 × 141, fat-saturation SPIR), were performed, all them in breath-hold mode. This last sequence was acquired before and after intravenous bolus dose injection of gadopentetate dimeglumine (Magnevist®, Bayer) (0.1 mmol/kg body weight). Dynamic scans after gadolinium administration were performed at 40, 70, 120, and 180 s. Acquisition at 70 s (enteric phase) was used for relative enhancement calculations.

2.3. MRI analysis

All images were examined with a dedicated workstation (EWS; Philips Medical Systems) by two radiologists with experience in abdominal imaging, in consensus, and blinded to the endoscopic and clinical results.

The following items were evaluated in the ileum, in order to stage CD activity with MRI.

2.3.1. Quantitative measurements

Wall thickness and percentage of luminal stenosis were measured with the proper tools of the EWS workstation, using electronic callipers. Maximum bowel wall thickness was considered normal when below 3 mm [16]. The cut-off point for an abnormal percentage of luminal stenosis was established as 60% [17]. To calculate the relative contrast enhancement, we determined the wall signal intensity (WSI) as the average of three ROIs placed at the maximum visual enhancement areas. Also three measurements outside the body were placed to obtain the standard deviation (SD) of the noise before and after gadolinium administration. The formula {(WSI postgadolinium − WSI pregadolinium)/(WSI pregadolinium)} × 100 × (SD noise pregadolinium/SD noise postgadolinium) [18] was used to calculate relative contrast enhancement (RCE) of the bowel.

Fig. 1. A 37-year-old male with multi-segment ileal stenoses. MR follow-through imaging showing stenotic ileal segments, and measurements made to calculate the percentage stenosis.

2.3.2. Qualitative evaluations

Motility and distensibility were evaluated subjectively by means of the coronal thick-slab dynamic sequence, viewed as cine-loop in the workstation. Bowel wall edema was defined as mural hyperintensity relative to the psoas muscle on T2-weighted sequences, discarding fat wall deposition in B-FFE sequences. Presence or absence of mucosal abnormalities (wall nodularity, ulcers, pseudopolyps), enlarged lymph nodes (short axis >10 mm), sinus tracts or fistulae, and inflammatory masses could be determined in any sequence (Figs. 1–5).

Besides this, a per-patient assessment of disease activity was performed using the MR score explained in Table 1. This score is a modification of that developed by Girometti et al. [14] in order to obtain an index fully comparable to the SES-CD. Some parameters, such as "mesenteric involvement" and "layered enhancement", which can also be present in chronic disease were removed. This was the reason for the loss of weight of the item "luminal stenosis" as well. In contrast, "bowel wall edema" was included because it is considered a marker of submucosal inflammation [19] and a

Table 1
MRI score modified from Girometti et al. (see Ref. [14]).

	0	1	2
Bowel wall thickness	<3 mm	3–4 mm	>4 mm
Relative enhancement	<70%	70–100%	>100%
Motility	Normal	Reduced	Absent
Percentage stenosis	≤60%	>60%	
Bowel wall edema	Absent	Present	
Mucosal abnormalities	Absent	Present	
Lymph nodes	Absent	Present	
Fistulae, sinus tracts	Absent	Present	
Inflammatory masses	Absent	Present	