Introduction

Increased importance has been placed on evaluating small bowel disease to guide management in often chronic conditions such as Crohn’s disease. Imaging of the small bowel has always played a key role in diagnosis and decision making. Traditionally, fluoroscopic studies such as barium follow through and small bowel enteroclysis have been used. More recently, the gold standard of evaluating the small bowel has moved towards cross sectional modalities with computed tomography (CT) and magnetic resonance (MR) imaging.

MR has the properties to make it well suited for small bowel imaging. It has the ability to show good mucosal detail, transmural inflammation, extra-luminal changes and fistula formation. These qualities outperform barium techniques and provide important clinical distinction between active, inflammatory and chronic disease.

The major limitation to a complete shift to MR imaging is lack of access to scanner facilities, time and radiological expertise. This is gradually improving and indeed many centres employ cross sectional imaging as their first line of investigation.

Two MR techniques are currently used – MR enteroclysis and MR enterography. In enteroclysis, enteric contrast material is administered through a nasoenteric tube which is normally inserted under fluoroscopic guidance, whereas in enterography, contrast material is administered orally. The use of oral contrast medium is associated with better patient tolerance and compliance, and avoids the radiation and staffing required for fluoroscopic nasojejunal tube placement, although there is evidence that enteroclysis allows slightly better bowel wall distension. At the authors’ centre, enterography is the preferred technique.

When should we employ MR over CT?

The vital benefit of MR is lack of ionising radiation dose to the patient. This is particularly significant for young patients in the setting of Crohn’s disease, taking into consideration that many will undergo many repeat investigations.

From an imaging perspective, MR is superior to CT in distinguishing wall oedema from fat. It has the ability to acquire multiplanar primary image datasets and sequential image series over the long acquisition time.

CT is generally preferred in imaging of suspected acute complications, such as suspicion of perforation or abscess and patients in whom there are MR contraindications. Furthermore, access to CT imaging is usually faster in the acute setting.

Patient preparation and MR technique

For a patient, the preparation usually consists of fasting for a few hours prior to the procedure, with a restricted diet the day before. Careful attention needs to be applied to proper technique in order to obtain high quality images. Policies will differ from centre to centre. The factors that need to be considered are method of contrast administration, patient positioning, need for anti-peristaltic medication and imaging sequences and planes. The patient will need to ingest around 1200-1400ml of an iso-osmotic solution of water mixed with polyethylene glycol and electrolytes, eg Klean-Prep. Often, just prior to the scan, intravenous buscopan and intravenous gadolinium are injected.

Patients are placed prone in the MR scanner. This position usually exerts mild pressure to the anterior abdominal wall, facilitating separation of the small bowel loops.

There are often specific protocols for different clinical settings. A combination of good bowel distension and fast MR imaging sequences is required.

The MR protocol consists of using a thick slab 50mm coronal HASTE sequence with fat saturation. This allows for luminal distension, peristalsis and retrograde filling of the stomach. The coronal thick slab HASTE images can visualise fixed bowel loops and luminal stenosis. The higher spatial and contrast resolution of a morphologic series can help identify bowel wall morphology, folds, ulceration and extraluminal abnormalities (eg lymphadenopathy). Bowel wall thickness more than 3mm is generally considered abnormal.

Following this, coronal and axial true fast imaging with steady state precession (FISP) sequences with fat saturation are performed with slice thickness of 5mm. These allow morphological changes to be studied in detail. Insensitivity to motion artefact, homogenous endoluminal opacification and high contrast between the small bowel lumen and the bowel wall are the major advantages of the true FISP sequences.

When there is maximal distension, multislice HASTE images with fat saturation and unenhanced and enhanced (0.1mmol/kg gadolinium) coronal and axial fast low-angle shot (FLASH) 3D images with fat saturation are obtained.

Fat saturation images are used to demonstrate enhancement of the abnormalities and evaluate disease activity, particularly in Crohn’s disease. T1-weighted sequences (VIBE) with intravenous contrast medium administration are performed to assess enhancement (with more perfusion) in the small bowel.

At the authors’ centre, axial and coronal T2, HASTE and true FISP sequences are performed, as well as pre, post and delayed gadolinium-enhanced T1 VIBE axial, coronal and FLASH sequences. A dedicated high resolution right iliac fossa sequence is also performed in most cases for evaluation of the terminal ileum and a dynamic cine sequence to assess motility.
Crohn’s disease
The earliest signs of Crohn’s disease can be less visible on MR and CT than fluoroscopy, but are generally detected by direct inspection at endoscopy which is often performed in combination with MR.

MR imaging is specifically becoming the examination of choice in patients with suspected Crohn’s disease and for follow-up.

For Crohn’s disease, the imaging protocol allows identification of both the diagnosis and its extent. Functional information can be used to differentiate between collapsed normal bowel wall, active disease, inactive disease and bowel stenosis. Within the morphological series, the most important features of disease (ie bowel wall oedema, ulcerations and increased mesenteric vascularity) are seen. Increased bowel wall enhancement and mesenteric lymph nodes can also be detected.

Inactive disease often has no abnormalities or can show relative low signal intensity representing fibrosis with limited homogeneous contrast enhancement. Fat accumulation in the submucosa can be found in the subacute or chronic stage. MRI can also show infiltration of mesenteric fat that can evolve into a fistula. Abscesses are more readily identified on contrast enhanced images as well as other associated complications such as intussusception, stricture formation and malignancy (figure 3). Other small bowel diseases

Other small bowel inflammatory diseases can have features that resemble Crohn’s disease. Coeliac disease is a malabsorption syndrome, characterised by villous atrophy and crypt hyperplasia of the small intestinal mucosa. MRI can demonstrate small bowel atonia, mucosal thickening, increased fold separation and increased ileal folds known as jejunisation (figure 4). Jejunitis is focal inflammation of the jejunum, often without a proven cause. It is characterised by a thickening of all jejunal wall layers with serosal oedema.

Intestinal tuberculosis is a rare manifestation in which the ileocaecal region is the most common region involved with ulceration and, later, scarring effects on the bowel wall. Eosinophilic granulopathy is another rare disorder, characterised by peripheral eosinophilia and infiltration of all three layers of the bowel wall. It can involve any segment of the gastrointestinal tract, especially the stomach. It is characterised by a loss of mucosal folds in the small bowel, bowel wall thickening and bowel atonia. Sclerosing peritonitis, another rare condition, affects patients undergoing peritoneal dialysis. MRI can demonstrate poor peristalsis and diffuse bowel wall thickening. Radiation enteritis is a complication that can occur within two years after radiation therapy but can often present much later. The disease is characterised by diffuse mild thickening, intense contrast enhancement, loss of folds and lack of peristalsis of the small bowel loops in the radiation therapy region. Although less well established, the increasing acceptance of MR in small bowel imaging has also paved the way for initial recommendation in investigating primary small bowel neoplasms. Intra and extra-luminal MR findings, combined with contrast enhancement and functional information, can help detect and characterise small bowel tumours.

Gastrointestinal stromal tumours (GIST) are often large exophytic small bowel masses. Carcinomas are often seen in the jejunum and are prone to stricture. Carcinoid tumours are hypervascular submucosal or mesenteric mass. Lymphomas can cause aneurysmal dilation, with large nodes and should be high on the differential if a mass is seen to encase the bowel. Incidental findings to look out for include peritoneal and ovarian disease. Other tumours such as renal or gynaecological in origin can also be detected. Disease manifestations such as free fluid, hydronephrosis and hepato- and splenomegaly should also be looked for.

Conclusion
MR enterography has emerged as the technique of choice for evaluating the small bowel in patients with Crohn’s disease, as well as several other small bowel diseases. The detailed morphological and functional imaging provides reliable diagnosis and information in guiding treatment and decision-making. As well as the enhanced imaging properties, the lack of radiation exposure in often young patients is a key advantage.

MR techniques will continue to develop with specific and improved sequences to define stricture morphology and also diffusion and perfusion techniques.

References
Figure 1
Coronal T2 true FISP reduced field of view: Crohn’s disease – thickening of the small bowel in the right iliac fossa with ulceration, mural thickening and adjacent fatty hypertrophy. The ‘comb sign’ can be recognised.

Figure 2A
MR axial T1 weighted VIBE fat saturation post contrast: Marked inflammatory changes in the fat and thickening of adjacent small bowel loops in a patient with Crohn’s disease. There is a small central abscess with local ileal perforation.

Figure 2B
MR axial T1 weighted VIBE fat saturation post contrast in the same patient: Abnormal thickened ileal loops are clearly seen.

Figure 3
MR coronal T1 weighted VIBE fat saturation post contrast: A thick walled ileal loop is adhered to a thick walled bladder in a patient with Crohn’s disease. A fistula was seen on cystoscopy.

Figure 4
Coronal T2 weighted true FISP. Jejunisation of the ileum with increased ileal folds, fold separation and mild bowel wall thickening in a patient with coeliac disease.