MRI-enema for the assessment of pelvic intestinal anastomotic integrity

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Abstract
Aim: Anastomotic leak causes significant morbidity for patients undergoing pelvic intestinal surgery. Fluoroscopic assessment of anastomotic integrity using water-soluble contrast enema (WSCE) is of questionable benefit over examination alone. We hypothesized that MRI-enema may be more accurate. The aim of this study was to compare MRI-enema with fluoroscopic WSCE.

Method: Patients referred for WSCE with pelvic intestinal anastomosis and defunctioning ileostomy (including patients with suspected or known leaks) were invited to participate. WSCE and MRI-enema were undertaken within 48 h of each other. MRI sequences were performed before, during and immediately after the introduction of 400 ml of 1% gadolinium contrast solution per anus. MRI examinations were reported to protocol by two blinded gastrointestinal radiologists. A Likert-scale patient questionnaire was administered to compare patient experience. Follow-up was >12 months after ileostomy reversal. Anastomotic leak was determined by unblinded consensus of examination and radiological findings.

Results: Sixteen patients were recruited, with a median age of 39 years (range 22–69). Ten were men, 11 had ileoanal pouch formation and five had low anterior resection. Five patients had anastomotic leak identified by MRI and four by WSCE. The radial location of the anastomotic defect was identified in all five patients by MRI versus two on WSCE. MRI revealed additional information including contents of a widened presacral space. Patient experience was equivalent. Eleven patients eventually had ileostomy reversal without complications.

Conclusion: MRI-enema is a feasible and tolerable alternative to WSCE and offers greater anatomical detail in the context of pelvic intestinal anastomotic leak. Larger prospective studies are required to define its potential role in the UK National Health Service.

KEYWORDS
MRI, anastomosis, leak, IPAA
INTRODUCTION

Anastomotic leak is ‘a communication between the intra- and extraluminal compartments owing to a defect of the integrity of the intestinal wall at the anastomosis between the colon and rectum or colon and anus’ [1]. Leaks have a significant and detrimental impact on patient outcome after colorectal surgery. Following restorative proctocolectomy, sepsis complicating anastomotic leak is a major predictor of ileoanal pouch failure [2–4]. In rectal cancer surgery, leak increases the likelihood of low anterior resection syndrome (LARS) and local recurrence and delays adjuvant therapy [5,6]. In order to minimize the consequences of a potential anastomotic leak, a defunctioning ileostomy is frequently formed in patients undergoing low pelvic anastomosis.

Several imaging investigations are available to help clinicians assess anastomotic integrity prior to the reversal of ileostomy and restoration of intestinal continuity [7,8]. Fluoroscopy with water-soluble contrast enema (WSCE) is widely available and most commonly used to assess the integrity of the anastomosis, colonic cul-de-sac (when a side-to-end anastomosis is formed) or seam of an ileoanal pouch [9,10]. A leak is diagnosed by the examining radiologist identifying extraluminal iodinated contrast first introduced through the anus via a catheter. WSCE utilizes x-ray fluoroscopy to investigate the flow of contrast through the anastomosis with representative fluoroscopic images acquired, supplemented by higher quality radiographs when required [11]. WSCE using x-ray fluoroscopy has a number of limitations, including limited accuracy with a sensitivity of 78% and a positive predictive value of 62% [10], use of ionizing radiation (particularly relevant for younger patients), limited two-dimensional images, paucity of anatomical information and diminishing fluoroscopy capacity in the UK National Health Service (NHS) and North America, with associated decrease in fluoroscopic skills and interpretative expertise [12]. Unsurprisingly, therefore, some surgeons consider clinical assessment superior and sufficient, questioning the need for routine WSCE [10,11,13]. Where WSCE has been requested, presacral widening is a relatively frequent finding, with MRI or CT required to interrogate the cause. Consequently, the authors of this study hypothesized that an MRI-enema technique could feasibly offer a more accurate assessment of anastomotic integrity and provide additional relevant information compared with WSCE and clinical examination alone.

METHOD

Regional ethical approval was obtained (REC reference 17/LO/0629, IRAS ID 191029) and the study registered with ClinicalTrials.gov (ID NCT04719169). The study did not meet the criteria for reporting according to the Standards for Reporting Diagnostic accuracy studies (STARD) guideline as calculating sensitivity and specificity was not appropriate in this cohort [14].

What does this paper add to the literature?

This paper is the first to describe MRI-enema as a feasible alternative radiological technique for assessing pelvic intestinal anastomoses. Compared with water-soluble contrast enema, MRI-enema offers more detailed assessment of anastomotic leak, with additional pelvic information and equivalent patient experience.

Inclusion criteria

Adult patients with diverting ileostomy created after low to mid rectal resection and pelvic anastomosis (ileoanal pouch reconstruction or colorectal/coloanal anastomosis) were recruited prospectively and consecutively from the waiting list for fluoroscopic WSCE as assessment of anastomotic integrity between September 2017 and March 2019. Recruitment was in a single NHS hospital setting and patients were excluded if they had a contraindication to MRI. Patients were included whether they had undergone uncomplicated primary surgery or had a known leak undergoing surveillance.

Fluoroscopic WSCE protocol

Fluoroscopic WSCE was performed according to standard practice in the host institution (see the WSCE protocol in Appendix S1 in the Supporting Information).

| TABLE 1 | Patient demographics, disease and operative characteristics and follow-up |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Variable        | n (%/mean or std variation/median and range) |
| Age at study scans (years) | 39 (22–69) |
| Sex             | 10/16 male (63%) |
| Operative pathology | Ulcerative colitis 7 (44%) |
|                 | Familial adenomatous polyposis (prophylactic) 4 (25%) |
|                 | Rectal adenocarcinoma 5 (31%) |
| Type of anastomosis | Ileal pouch–anal 11 (69%) |
|                 | Colorectal/coloanal end-to-end 3 (19%) |
|                 | Colorectal/coloanal end-to-side 2 (13%) |
| Previously diagnosed anastomotic leakage under surveillance | 7/16 (44%) |
| Index surgery to imaging (weeks) | 20 (6–151) |
| Imaging to last follow-up (weeks) | 36 (11–101) |
| Ileostomy reversed | 11/16 (69%) |
| Clinical leak postreversal | 0/11 |
| Patient | Sex | Pathology       | Operation and anastomosis                                      | Time from index surgery to imaging (weeks) | Leak diagnosed prescudy? | MRI leak? | WSCE leak? | Postimaging surveillance | Ileostomy reversed? (weeks postscan) | Postileostomy reversal surveillance |
|---------|-----|-----------------|----------------------------------------------------------------|-------------------------------------------|--------------------------|-----------|------------|---------------------------|---------------------------------------|-----------------------------------|
| A       | F   | Polyposis       | Ileal anastomosis with stapled anastomosis                     | 10                                        | No                       | No        | No         | No evidence of anastomotic leak | Yes, 46                               | No evidence of anastomotic leak    |
| B       | M   | Polyposis       | Ileal anastomosis with handsewn anastomosis                   | 103                                       | Yes, Grade B on MRI and EUA | Yes       | No         | Sinus present at EUA, surveillance until healed | Yes, 30                               | No evidence of anastomotic leak    |
| C       | M   | Rectal cancer   | Anterior resection with prostatic shave, stapled end-to-end 1.5 cm above dentate line | 77                                        | Yes, Grade C on CT and EUA | Yes       | Yes        | MRI mapping guided planning for joint urology and colorectal revision surgery | Yes, 76                               | No evidence of anastomotic leak    |
| D       | F   | UC              | Ileal anastomosis with stapled anastomosis                     | 151                                       | Yes, Grade B on CT and EUA | Yes       | Yes        | Persistent defect + dysplastic changes on pouchoscopy | No, 145                               | Complex surveillance due to dysplastic changes, potential pouch excision |
| E       | M   | UC              | Ileal anastomosis with handsewn anastomosis                   | 12                                        | No                       | No        | No         | No evidence of anastomotic leak | Yes, 23                               | No evidence of anastomotic leak    |
| F       | M   | UC              | Ileal anastomosis with stapled anastomosis                     | 37                                        | No                       | No        | No         | No evidence of anastomotic leak | Yes, 149                               | Adhesional small bowel obstruction immediately after reversal of ileostomy requiring reoperation and ileostomy |
| G       | M   | UC              | Ileal anastomosis with stapled anastomosis                     | 11                                        | No                       | No        | No         | No evidence of anastomotic leak | Yes, 15                               | No evidence of anastomotic leak    |
| H       | M   | UC              | Ileal anastomosis with stapled anastomosis                     | 15                                        | No                       | No        | No         | No evidence of anastomotic leak | Yes, 18                               | No evidence of anastomotic leak    |
| I       | M   | UC              | Ileal anastomosis with stapled anastomosis                     | 16                                        | No                       | No        | No         | No evidence of anastomotic leak | Yes, 2                                 | No evidence of anastomotic leak    |
| J       | M   | Polyposis       | Ileal anastomosis with stapled anastomosis                     | 6                                         | Yes, Grade B on CT and EUA | Yes       | Yes        | Tiny residual sinus on MRI. No identifiable defect at EUA | No, 116                               | Continued surveillance before reversal |
| K       | M   | Rectal cancer   | Anterior resection, handsewn end-to-end coloanal              | 62                                        | Yes, Grade B on CT and EUA | No        | No         | No evidence of anastomotic leak | Yes, 5                                 | No evidence of anastomotic leak    |
| L       | F   | Rectal cancer   | Anterior resection, stapled side-to-end coloanal              | 21                                        | No                       | No        | No         | No evidence of anastomotic leak | Yes, 9                                 | No evidence of anastomotic leak    |

(Continues)
MRI protocol

Multiplanar MRI sequences of the pelvis were acquired before, during (dynamic sequences) and after introduction of dilute MRI contrast, introduced through a Foley catheter inserted through the anus. Buscopan® (hyoscine butylbromide, Sanofi, UK) was used routinely to limit artefacts from bowel peristalsis. The detailed MRI protocol is given in Appendix S1.

Participants were invited to complete a nonvalidated 13-statement questionnaire about their experience of both imaging techniques immediately after each scan, with responses recorded on a five-point Likert scale for 13 statements related to comfort, dignity and ability to communicate with the healthcare team (Appendix S2).

Fluoroscopic WSCE and MRI investigations were performed within a maximum of 48 h of each other to avoid detection bias from anastomotic healing. Fluoroscopic WSCE investigations were reported according to standard practice on the same day as the examination by consultant radiologists with a subspeciality interest in tertiary gastrointestinal imaging or senior radiology trainees under direct consultant supervision. MRI-enemas were reported independently by two consultant radiologists with a subspeciality interest in tertiary gastrointestinal imaging (DB, AC) according to the parameters described in Appendix S2. The two MRI radiologists were blinded to the result of the WSCE and current clinical status but were provided with information regarding the patient’s index surgery.

The reference standard of whether a leak was present was determined at the end of the study in consensus between surgical and radiological co-investigators (SC, JJ, OF, DB, AC) taking into account unblinded radiological, operative and clinical findings.

Data analysis

Demographic, disease, patient and radiology variables were analysed using descriptive statistics. Normally distributed data are reported with mean and standard deviation, and nonnormally distributed data are reported with median and range. Data were analysed in SPSS (IBM Corp., IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY).

RESULTS

Patient characteristics and follow-up

Six patients were excluded or declined to participate - three for personal preference or logistical reasons, two due to claustrophobia and one because of inability to consent due to communication difficulties (despite use of a translator). Sixteen patients were recruited and demographic data, surgical findings and type of anastomosis are summarized in Tables 1 and 2. Ten (63%) of the patients were men and the median age was 39 years (range 22–69 years).
Eleven patients underwent ileoanal pouch formation, all with the ‘J’ configuration; seven of these patients had ulcerative colitis and four had familial adenomatous polyposis (FAP) without cancer. Eight patients had stapled pouch–anal anastomoses and three hand-sewn (in all cases the pouch body ‘seams’ were stapled). Five patients underwent low anterior resection for rectal carcinoma; three with end-to-end anastomosis and two with side-to-end anastomosis. All 16 patients had a primary defunctioning ileostomy formed at the time of index surgery.

Seven patients were already under surveillance for known anastomotic leak (six grade B, one grade C [1]) before participation in the study, hence their referral for WSCE assessment.

**MRI and WSCE reporting outcomes**

Four patients were identified by WSCE as having anastomotic leak compared with five by MRI. All the patients diagnosed with a leak by either technique were already under surveillance for an established anastomotic leak, suspected on standard CT or MRI and confirmed with examination under anaesthesia (EUA) including endoscopy (Table 3). There were no newly diagnosed leaks in the remaining 11 patients who had all undergone uncomplicated primary surgery. MRI also revealed new extraluminal information, including pelvic collection in three patients (all had an established leak), presacral fibrosis in six patients and no fibrosis in patients with no leak. Two of the five patients with an established leak prior to recruitment had no leak demonstrated on either WSCE or MRI in this study, implying healing.

Of the five MRI-detected leaks, the radial location of the anastomotic defect was identified in all cases. In contrast, accurate radial location was only possible in two of the four WSCE-detected leaks (even on retrospective review by the study radiologists DB and AC). For one patient, a colovesical fistula was demonstrated on both WSCE and MRI investigations, with the precise anatomical course only reported on MRI (Figure 1).

The width of the presacral space measured between posterior border of the pouch or rectum and anterior border of the sacrum at the junction between S3 and S4 was similar for both MRI (mean distance of 13.6 mm, SD 11.5 mm) and WSCE (14.5 mm, SD 12.6 mm). Presacral widening (>20 mm) was present in five patients on WSCE and four on MRI, three of whom had a known leak. The content of the presacral space could not be identified on WSCE, whereas MRI clearly revealed the presacral contents in all 16 patients – mesenteric fat in three, pouch/neorectum adherent to presacral fascia in 10, cavity in two and free fluid in one patient. Both techniques identified anastomotic stricture in the same two patients.

The median distance from the anastomosis to the top of the puborectalis, measured on MRI, was 5 mm (0–50 mm), with all ileoanal pouch and colo-anal anastomoses being 12 mm or less. The median distance from anastomosis to the anal verge (defined as the superficial border of the external sphincter muscle) was 48 mm (range 31–77 mm). No patient had evidence of local tumour recurrence or significant pelvic lymphadenopathy.

**Postimaging outcome**

The median time from radiological assessment to completion of follow-up was 125 weeks (range 95–172 weeks). Eleven patients underwent reversal of ileostomy with a median interval of 18 weeks.

| Variable                                      | MRI output (%/mean or std variation/median and range) | WSCE output (%/mean or std variation/median and range) |
|-----------------------------------------------|------------------------------------------------------|--------------------------------------------------------|
| Anastomotic leak                              | 5/16 (31%)                                           | 4/16 (25%)                                             |
| If leak, radial location identified?          | 5/5 (100%)                                           | 2/4 (50%)                                              |
| Fistula                                       | 1/16 (6%)                                            | 1/16 (6%)                                              |
| Presacral wideninga                          | 13.6 (SD 11.5)                                       | 14.5 (SD 12.6)                                         |
| Anatomic stricture                            | 2/16 (12.5%)                                         | 2/16 (12.5%)                                           |
| Content of the presacral space                | Mesenteric fat 3/16 (19%)                            | Bowel 10/16 (63%)                                      |
|                                              | Collection 3/16 (19%)                                |                                                        |
| Anatomosis to superior border of puborectalis (mm) | 5 (0–50)                                             |                                                        |
| Anatomosis to superficial border of external sphincter (mm) | 48 (31–77)                                           |                                                        |
| Pelvic cavity associated with leak            | 2/16 (13%)                                           |                                                        |
| Pouch/neorectal fibrosis                      | 6/16 (38%)                                           |                                                        |
| Lymphadenopathy                               | 0/16                                                 |                                                        |

*aIn millimetres from the junction of S3–4 to luminal contrast.*

**TABLE 3 MRI series and water-soluble contrast enema (WSCE): reported variables**
Individual case studies

Patient J

One male patient developed pelvic sepsis diagnosed on CT following ileoanal pouch surgery for FAP (Table 2). The radial location of the anastomotic defect was not identified by initial EUA, pouchoscopy or WSCE performed on two occasions. MRI-enema clearly demonstrated a pinpoint communication between the anastomotic lumen and pelvic cavity via an anastomotic defect at the 5 o'clock position (Figure 2). Consequently, at repeat EUA the defect was identified and a small-diameter trans-anastomotic drain was inserted through to the cavity, avoiding the need for an alternative approach to the collection or a more an extensive disruption of the anastomosis to drain the cavity.

Patient P

A female patient with previous anterior resection and known anastomotic leak was reported as having a blind-ending rectal remnant with possible fistula to the vagina on WSCE. However, MRI-enema clearly demonstrated a fibrotic stenosis of the colo-rectal anastomosis secondary to the leak with luminal continuity above (Figure 3). Combined cross-sectional pelvic review and luminal distension with contrast was of particular diagnostic benefit for this patient.

Patient B

A male patient with ileoanal pouch for FAP and normal WSCE had a clearly defined, small-volume anastomotic leak on MRI-enema (Figure 4). EUA confirmed the presence of a small sinus which was then surveyed for a further 7 months prior to successful ileostomy reversal. The patient had no pelvic sepsis up to 1 year after ileostomy reversal.

Patient experience

Both investigations were similarly well tolerated, with no statistically significant difference between Likert scores for overall experience and its component parts (Table 4).

DISCUSSION

This study has shown that MRI-enema is technically feasible and compares favourably to WSCE for detection and characterization of anastomotic leak in our patient cohort.

MRI-enema detected all the leaks present in our patient cohort and also identified a leak not reported or identifiable on WSCE. This finding was confirmed by endoscopy and clinical EUA.
MRI-enema is a new cross-sectional imaging technique which provides three-dimensional views of the pelvis with accurate depiction of the pelvic contents and can be used to accurately identify the radial location of leaks. The radial location was particularly important for one of our patients and directly obviated the need for early anastomotic revision surgery, guiding early salvage from pelvic sepsis. Moreover, in the authors’ experience, small anterior leaks (excluding fistula to the vagina) are very rarely diagnosed by WSCE, indicating a likely inherent weakness in this technique. Indeed, further experience of MRI-enema by the authors in routine clinical practice suggests detection of small anterior sinuses may be more commonplace and this in turn could be a contributory factor to LARS or pouch dysfunction. Further prospective comparative studies are required to investigate this further.

Presacral widening was found by WSCE in a third of our patient cohort, which in the authors’ clinical practice would prompt referral for standard MRI of the pelvis to help exclude occult sepsis. Such a strategy appears inefficient and inconvenient given that most causes of presacral widening are of low clinical importance, for example due to mesenteric fat, free fluid or resolving haematoma. MRI-enema efficiently combines assessment of anastomotic integrity with exclusion of important extraluminal complications such as occult sepsis or tumour recurrence.

Prior to this study, we had undertaken MRI-enema in a small select group of postoperative patients to help investigate their clinical symptoms and had found that administration of hyoscine butylbromide prior to MRI sequences reduced peristaltic artefacts. Three-dimensional views on MRI also showed an air-fluid level after introduction of gadolinium contrast in two patients, potentially thwarting accurate assessment of the anterior anastomosis with the patient supine (despite priming the catheter before insertion). If encountered in routine practice, we therefore recommend adding additional sequences with the patient positioned prone, repeating the contrast enema component if necessary.

The MRI-enema technique was refined further by this study, and with additional support and training our team of radiographers was able to undertake these examinations well without direct supervision and provided reproducibly high-quality examinations. However, wider dissemination of this technique will require additional training of both radiographers undertaking the examination and radiologists interpreting the findings. Anecdotally, fluoroscopy capacity and experience are diminishing in the NHS in favour of cross-sectional techniques and so this study appears timely. Although it is difficult to know whether this change is reflected internationally, a recent publication from Johns Hopkins in 2020 reviewing the status of fluoroscopy identified ‘insufficient training of residents, fewer staff with adequate expertise, and poor reimbursements relative to other modalities’ [12]. Notwithstanding, MRI will be more expensive and less accessible than fluoroscopy in many hospitals which could hamper...
its wider implementation. A more detailed cost-effectiveness comparison is required alongside further research evaluation to better understand the impact of MRI-enema on patient outcomes and resources.

A further advantage of MRI is avoidance of ionizing radiation, which is particularly relevant to younger patients with chronic disease (such as inflammatory bowel disease) who may undergo frequent imaging and regular exposure to ionizing radiation for disease assessment and monitoring.

Limitations of MRI-enema include the requirement for Buscopan™ and MRI contraindications, including patient claustrophobia and metallic implants.

CT with rectal contrast is described for the detection of anastomotic leak in the emergency postoperative setting but is rarely utilized for routine assessment before ileostomy reversal [7,15,16]. A comparative study of CT with rectal contrast enema (CT RCE) and MRI-enema would be of interest. However, a 2017 study showed that even high-quality CT RCE used in routine practice in a high-volume institution has relatively poor sensitivity (72%) for diagnosing leaks, albeit this included both rectal and abdominal anastomoses [17].

Limitations of this study include the small number of patients with associated recruitment bias and the single-centre design, which are in keeping with a developmental study of a new technique rather than a diagnostic impact assessment. Although MRI-enema provides inherently more anatomical information than fluoroscopy, a more detailed comparison of performance characteristics is required before we can recommend its wider implementation. To assist such research, we recommend a consensus amongst expert groups to agree an optimal reference standard for anastomotic leak [18,19].
This study shows that MRI-enema is a feasible and tolerable alternative to WSCE, and although the comparative sensitivity and specificity cannot be established in this study, MRI-enema offers greater anatomical detail in the context of pelvic intestinal anastomotic leak. Larger prospective studies of MRI-enema are required to better define its potential role in the NHS.

**TABLE 4**  Patient experience questionnaire results on five-point Likert scales

| Variable                                      | Mean Likert score for MRI | Mean Likert score for WSCE | p-value (Mann–Whitney) |
|-----------------------------------------------|---------------------------|-----------------------------|------------------------|
| Overall experience was good                   | 4.50                      | 4.44                        | 0.73                   |
| Physically comfortable during the procedure  | 4.25                      | 4.44                        | 0.52                   |
| Dignity was preserved                         | 4.75                      | 4.50                        | 0.24                   |
| Felt embarrassed                              | 2.06                      | 2.25                        | 0.52                   |
| Felt would be able to stop the procedure if required | 4.88                      | 4.56                        | 0.05                   |
| Physically comfortable immediately after procedure | 4.44                      | 4.63                        | 0.49                   |
| Would object to undergoing procedure again    | 1.81                      | 1.63                        | 0.55                   |
| Communicating with staff throughout the procedure was easy | 4.63                      | 4.69                        | 0.91                   |

*Abbreviation: WSCE, water-soluble contrast enema.*

**CONCLUSION**

![Figure 4](image)

Patient B. (A), (B) Water-soluble contrast enema images with no identifiable leak. (C) T2-weighted MRI-enema sagittal dynamic fill. The arrow shows a small anterior leak. (D),(E) T1-weighted axial MR postfill images with arrows showing the circumferential location of the leak at 12 o’clock at the level of the anastomosis.
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AUTHOR CONTRIBUTIONS
GW co-designed the study, gained ethical approval, recruited participants, coordinated the study, collected and analysed the results and drafted the manuscript. DB conceived and co-designed the study, reported the study findings, analysed the results and drafted the manuscript. AC co-designed the study, reported the study findings, analysed the results and drafted the manuscript. AC co-designed the study, reported the study findings, analysed the results and drafted the manuscript. OF co-designed the study, recruited patients, analysed the results and drafted the manuscript. RBC co-designed the study, gained ethical approval, recruited participants, coordinated the study and drafted the manuscript. OF co-designed the study, recruited patients, analysed the results and drafted the manuscript. SC co-designed the study, recruited patients, analysed the results and drafted the manuscript. All co-authors approved the final version of the manuscript before submission.

CONFLICT OF INTEREST
The authors declare no conflicts of interest.

ETHICAL STATEMENT
Regional ethical approval was obtained (REC reference 17/LO/0629, IRAS ID 191029) and the study registered with ClinicalTrials.gov (ID NCT04719169).

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SUPPORTING INFORMATION
Additional Supporting Information may be found online in the Supporting Information section.

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