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FULL PAPER

MRI for the diagnosis and staging of deeply infiltrating endometriosis: a national survey of BSGE accredited endometriosis centres and review of the literature

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Objectives: Our objective was to establish the primary mode of imaging and MR protocols utilised in the preoperative staging of deeply infiltrating endometriosis in centres accredited by the British Society of Gynaecological Endoscopy (BSGE).

Methods: The lead consultant radiologist in each centre was invited to complete an online survey detailing their protocols.

Results Out of 49 centres, 32 (65%) responded to the survey. Two centres performed transvaginal ultrasound as the primary method for preoperative staging of deeply infiltrating endometriosis and the remainder performed MRI. 21/25 centres did not recommend a period of fasting prior to MRI and 22/25 administered hyoscine butylbromide. None of the centres routinely offered bowel preparation or recommended a specific pre-procedure diet. 21/25 centres did not time imaging according to the woman's menstrual cycle, and instructions regarding

bladder filling were varied. Rectal and vaginal opacification methods were infrequently utilised. All centres preferentially performed MRI in the supine position – six used an abdominal strap and four could facilitate prone imaging. Just under half of centres used pelvic-phased array coils and three centres used gadolinium contrast agents routinely. All centres performed T1W with fat-suppression and T2W without fat-suppression sequences. There was significant variation relating to other MR sequences depending on the unit.

Conclusions: There was significant inconsistency between centres in terms of MR protocols, patient preparation and the sequences performed. Many practices were out of line with current published evidence.

Advances in knowledge: Our survey demonstrates a need for evidence-based standardisation of imaging in BSGE accredited endometriosis centres.

INTRODUCTION/BACKGROUND

Endometriosis is a chronic, oestrogen-driven condition which can be divided into three subtypes – peritoneal, ovarian or deeply infiltrating disease. Deeply infiltrating endometriosis (DIE) affects approximately 1% of women of reproductive age, of whom 90% have rectovaginal lesions.¹

Although laparoscopy is still considered the gold standard for diagnosis and mapping of DIE, thorough assessment of the pelvis is often limited by dense bowel adhesions, an obliterated pouch of Douglas and fixed retroverted uterus, giving the appearance of a 'frozen pelvis'. Embarking on extensive adhesiolysis for the purposes of diagnosis and

staging is potentially risky, as colorectal and urological support is often not readily available in case of an injury.

The primary role of imaging in the preoperative workup of deeply infiltrating endometriosis is to establish the location and dimensions of endometriotic disease. Imaging is particularly useful in assessing the depth to which nodules penetrate the affected organs. In the case of the rectal wall, the extent of mucosal involvement and distance from the anal verge determines whether a rectal shave, disc resection or full bowel resection are warranted. Similarly, assessment of detrusor involvement will determine whether transurethral resection of a bladder nodule or partial cystectomy

are indicated. Imaging is also essential to determine the extent of ureteric involvement preoperatively. Early recognition of ureteric disease is crucial, as delay in diagnosis can lead to serious complications such as stenosis with hydroureter and hydronephrosis, and consequent loss of renal function. Where ureteric involvement is thought to be significant, placement of double J ureteric stents or a temporary ureteric catheter can aid intraoperative identification of the ureters and reduce the risk of intra- and postoperative ureteral complications. Accurate diagnostic mapping of disease for preoperative workup before surgical excision is therefore essential. Indeed, exclusion of obstructive uropathy and bowel stenosis is equally important in women opting for long-term medical management of DIE. In addition to high-quality imaging examinations and reporting, a close working relationship between the radiologist and surgical teams has been shown to improve the quality of patient outcomes.^{2–4}

Our objective was to establish the primary mode of imaging and survey MR protocols utilised in the preoperative staging of deeply infiltrating endometriosis in endometriosis centres accredited by the British Society of Gynaecological Endoscopy (BSGE). There are 48 accredited endometriosis centres in the United Kingdom, and one centre in Tehran, Iran.⁵

METHODS

The lead consultant radiologist for endometriosis at all 49 BSGE accredited endometriosis centres were invited to complete an online questionnaire by email. The survey remained open for six weeks and reminder emails were sent at two weekly intervals to encourage engagement. The structured survey consisted of 10 closed-ended questions with multiple response answers. A comments box was incorporated at the end of each question, where other details or explanations could be provided. The full questionnaire can be viewed as an appendix in 'Supplementary Material 1' (online only). The first question established the primary mode of imaging for preoperative staging of DIE at the centre. If transvaginal ultrasound was the first-line method, the question was divided to establish whether this was performed predominantly by a sonographer, radiologist or gynaecologist. Subsequent questions explored the centre's protocols specifically for MR imaging. Patient preparation by fasting, status of bladder filling, use of bowel preparation and timing in the menstrual cycle was surveyed. Questions also related to the use of abdominal strapping, anti-peristaltic agents and vaginal and rectal opacification. Patient position, array type and field strength were established, as well the specific sequences routinely obtained.

Data relating to patients were not exchanged and the survey was anonymous. In line with guidance from the Medical Research Council and NHS Health Research Authority, ethical approval was not deemed necessary.

RESULTS

Out of 49 centres, 32 (65%) responded to the survey. Seven respondents completed the first question only – two indicated that preoperative mapping of DIE was performed by a radiologist using transvaginal ultrasound, and therefore the remaining questions relating to MR imaging were not applicable. Five

respondents had indicated their centre used MR imaging as the primary method for preoperative staging but did not complete the survey. 23 centres completed the question relating to bladder filling and 21 completed the question relating to abdominal strapping. 25 centres completed the remaining questions. The results are summarised in [Table 1](#).

Out of 32 respondents, 28 centres used MRI for preoperative staging. Four centres used transvaginal ultrasound as their first-line method of staging – half were routinely performed by a radiologist and half by a sonographer. None of the surveyed centres operated a gynaecology-led ultrasound service for staging of DIE and none used transrectal ultrasound for this purpose.

Out of 25 respondents, 21 did not recommend a period of fasting prior to MRI. Two centres recommended a fasting period of 2 hours and two recommended 4 hours of fasting. No centres routinely offered bowel preparation or recommended a specific pre-procedure diet to women. Most centres (22/88%) administered hyoscine butylbromide (Buscopan®, Sanofi, UK) to prevent bowel peristalsis. Nine administered this intravenously, four intramuscularly and nine centres did not specify the route. No centres used glucagon as an antispasmodic agent.

Timing of MRI in the menstrual cycle was varied. 21/25 centres did not attempt to time imaging according to the woman's menstrual cycle. Three centres timed imaging to occur during the menstrual phase, while one centre specifically aimed to avoid the menstrual phase. None of the centres aimed to perform imaging mid-cycle, in the ovulatory phase.

Instructions regarding bladder filling were similarly heterogeneous. Eight centres did not give women instructions regarding status of bladder filling. 12 centres recommended a half-filled bladder (*e.g.*, voiding 1 h before the procedure), while three centres preferred an empty bladder.

Rectal opacification was not used in 24 out of 25 centres. One centre used water routinely. 22 centres did not use any method of vaginal opacification. Three centres used sonographic gel for vaginal opacification if it was indicated by the clinical history.

All 25 centres preferentially performed MRI in the supine position, and six centres used an abdominal strap. Four centres could facilitate prone imaging if this was indicated. Just under half of centres (12/25) used pelvic-phased array coils. 16 centres used a 1.5T magnet system and five used a 3.0T system – four centres had access to both.

14/25 centres did not use gadolinium contrast agents and eight centres stated that they would administer contrast if indicated. Specified indications were either 'adnexal masses' or 'suspicious adnexal masses'. Three centres administered intravenous gadolinium in all suspected cases of deeply infiltrating endometriosis.

The MR sequences performed in each unit have been summarised in [Table 2](#).

Table 1. MR protocols and patient preparation in surveyed BSGE accredited endometriosis centres

	Total Number of Respondents	Frequency
Primary mode of imaging for preoperative staging of DIE	32	
Transvaginal ultrasonography – performed by gynaecologist		0
Transvaginal ultrasonography – performed by radiologist		2
Transvaginal ultrasonography – performed by sonographer		2
Transrectal ultrasonography		0
MR imaging		28
Other		0
Fasting instructions	25	
None		21
1 h		0
2 h		2
3 h		0
4 h		2
5 h		0
6 h		0
Other		0
Timing of MR imaging	25	
Avoiding menstrual phase		1
Menstrual phase		3
Mid-cycle		0
N/A		21
Bowel preparation	25	
None		0
Oral laxative – state:		0
Enema – state:		0
Rectal suppository – state:		0
Specific diet – state:		0
Other		0
Antispasmodic agent to prevent bowel peristalsis	25	
None		3
Butyl-scopolamine (Buscopan)		22
IM administration		4
IV administration		9
SC administration		0
PO administration		0
Did not answer		9
Glucagon		0
Instructions regarding bladder filling	23	
None		8
Empty		3
Half filled		12

(Continued)

Table 1. (Continued)

	Total Number of Respondents	Frequency
Full		0
Patient positioning	25	
Supine		21
Prone		0
Usually supine, but prone if indicated		4
Rectal opacification	25	
None		24
Sonographic gel		0
Water		1
Vaginal opacification	25	
Yes - sonographic gel		0
Yes - water or saline		0
Yes - sonographic gel if indicated		3
No		22
Abdominal strapping	21	
Yes		6
No		15
Magnet (Tesla)	25	
1.5T		16
3.0T		5
Both		4
Pelvic phased array coils	25	
Yes		12
No		13
Contrast agents	25	
None		14
Intravenous gadolinium - selected cases only		8
Intravenous gadolinium - routine in all cases		3

Table 2. MR sequences performed for preoperative staging of DIE by 25 BSGE accredited endometriosis centres

	Number of Centres	Percentage of Centres
T_1 -weighted with fat-suppression	25	100%
T_1 -weighted without fat suppression	22	88%
3D T_1 -weighted	2	8%
T_2 -weighted with fat-suppression	4	16%
T_2 -weighted without fat-suppression	25	100%
3D T_2 -weighted	2	8%
Half-Fourier acquisition single shot turbo-spin-echo (SSFSE, HASTE)	4	16%
Diffusion-weighted	10	40%
Susceptibility-weighted	0	0%

DISCUSSION

There is a large amount of inconsistency among centres, in terms of MR protocols, patient preparation and the sequences performed. Suboptimal examinations may limit accurate interpretation of the extent of disease, or even miss subtle disease completely. Intraoperative evaluation of the extent of active endometriotic disease is often difficult due to extensive fibrosis, obliteration of the cul-de-sac and loss of surgical planes caused by chronic inflammation. Surgical teams frequently rely on imaging to guide surgical dissection, exploration and excision of lesions. This is particularly relevant when endometriotic nodules are not clinically obvious from the outset due to being concealed at depth, by bowel adhesions, or covered by overlying peritoneal endometriosis leading to an assumption that the disease is purely superficial. Deep vaginal, rectovaginal septal and sigmoid lesions are difficult to identify at laparoscopy alone, particularly for less experienced surgeons. Furthermore, visualisation of lesions affecting the ureters and pelvic nerves routinely requires dissection in to the pelvic side-wall and pararectal space.

In 2016, the European Society of Urogenital Radiology (ESUR) published a guideline on MRI of pelvic endometriosis.⁶ They recommended that MRI should be considered as a second-line examination (after ultrasound) in the evaluation of pelvic endometriosis. However, MRI prior to surgery for optimal preoperative staging is recommended. Our survey suggests that some centres use transvaginal ultrasound first-line for preoperative staging. Given the degree of evidence in support of transvaginal^{7–10} and transrectal^{8,10–12} ultrasound for mapping of deeply infiltrating endometriosis, it seems reasonable for endometriosis centres to continue this practice. However, the inherent disadvantage of ultrasound is that it is operator-dependent. Most centres do not have access to highly skilled sonographers and therefore rely on MRI.

Patient preparation

There is no strong evidence to recommend imaging during a particular phase of the menstrual cycle. Although most authors do not specifically mention timing of the examination within the menstrual cycle, many state they perform imaging regardless of the cycle, in line with our findings.^{13–16} Several authors have suggested that MRI should not be performed during the menstrual phase due to spontaneous T1 hyperintensity of blood^{17–20} and due to marked pseudothickening of the junctional zone leading to over diagnosis of adenomyosis.²¹ Botterill et al found no significant differences in image quality, disease extent or disease severity between menstruating and non-menstruating women with endometriosis undergoing MRI.²² Conversely, some authors advise performing imaging during the menstrual phase, to detect any small foci of endometriosis.²³ Bazot et al also suggested that the presence of free fluid in the pouch of Douglas (secondary to ovulation or retrograde menstruation) was a useful aid to image interpretation.²⁴ In practice, MRI can be performed regardless of the day of the menstrual cycle, but the date of the last menstrual period should be recorded to aid interpretation.²⁵

In agreement with our findings, there is consensus regarding the use of antispasmodic agents to reduce motion artefacts⁶ and most

authors mention its use. Hyoscine butylbromide (Buscopan®, Sanofi, UK) is the most commonly used and can be administered by an intravenous or intramuscular route. Glucagon (GlucaGen®, Novo Nordisk A/S, Denmark) is often used as an alternative when hyoscine butylbromide is contraindicated, but none of our surveyed centres used it routinely. However, several papers demonstrate that it may be superior when compared to hyoscine butylbromide.^{26,27} Fasting prior to MR examination also reduces bowel peristalsis and is recommended. The duration of fasting is variable in the literature^{7,8,14,17,24,25,28–30} and there is no evidence regarding an optimal regime. Bowel preparation can be performed by various methods and is generally recommended, despite a lack of controlled trials.⁶ The absence of instruction regarding fasting and bowel preparation in the majority of surveyed endometriosis centres may indicate a lack of awareness of the ESUR guideline.

A moderately full bladder is recommended for the assessment of deeply infiltrating endometriosis. Bladder filling corrects uterine anteversion and thereby allows better visualisation of the vesicouterine pouch.^{15,28,31–35} An empty bladder may prevent optimal visualisation of the ureters.³⁰ Interestingly, there is no evidence regarding the significance of bladder filling in the detection of bladder endometriosis. Detrusor contractions and patient discomfort caused by a full bladder may cause motion artefact so this is generally avoided. Asking the women to void 1 hour prior to the examination is recommended practice⁶ and this was implemented by just under half of the centres surveyed.

Prone scanning has been demonstrated to reduce anxiety, distress and the need for sedation in adults undergoing MR examinations and should be offered to women with claustrophobia.^{36,37} Only 4 out of 25 centres surveyed were able to offer this alternative. The supine position provides superior images and is recommended where there are no contraindications. Abdominal strapping was poorly utilised among the surveyed endometriosis centres. A broad abdominal strap applied at the end of expiration has been recommended to reduce motion artefact secondary to respiration.^{23,38–40}

Endometriotic lesions are fibromuscular and are often sited in other fibromuscular structures such as the uterosacral ligaments and the vaginal and rectal wall, making discrimination of the lesions on MRI difficult. Vaginal and rectal opacification for the purposes of expansion has been proposed as a solution to this issue. Differentiation of the structures surrounding the pouch of Douglas is thought to be improved; however, trials have not yielded consistent results. Schneider et al noted that care should be taken to avoid air bubbles as these can be confused with nodular wall thickening.²⁵ Acceptability and tolerability of both vaginal and rectal opacification is high.^{12,17,41}

In a prospective, blinded study, Chassang et al demonstrated increased sensitivity between pre- and post-contrast MRI in the diagnosis of deeply infiltrating endometriosis using vaginal ultrasound gel, which was particularly apparent for lesions localised to the vagina and rectovaginal septum.³³ Fiaschetti et al demonstrated vaginal opacification significantly increased the

visibility of the uterosacral ligament and vaginal endometriosis, while there was no difference in terms of visibility at the level of the pouch of Douglas and the rectovaginal septum.¹⁷ Sensitivity and specificity of complete cul-de-sac obliteration was significantly improved by vaginal ultrasonic gel administration in a study by Kikuchi et al.⁴² Conversely, Bazot et al did not find a significant increase in the diagnostic confidence of rectosigmoid colon and vaginal endometriosis with the addition of either rectal or vaginal opacification.⁴³ Both Hottat and Chamie et al noted degradation in image quality because of bowel peristalsis after rectal filling with ultrasound gel, even with the use of an antispasmodic agent.^{9,44} However, several authors suggest that rectal opacification with either sonographic gel or water/saline provides better identification of pouch of Douglas and rectosigmoid endometriosis,^{34,41,42,45} as well as evaluating the degree of bowel stenosis.³⁰

1.5T/3T Magnet

Both 1.5T and 3.0T appear valuable in the evaluation of DIE; however, there are no studies comparing the two systems directly. Comparison between magnet fields was not made as part of a Cochrane review in 2016¹⁰ due to the small number and size of studies; however, 3.0T systems do appear to be more accurate when comparing specificities and sensitivities across studies.^{19,28,44,46,47}

Array type

Just under a half of centres used pelvic-phased array coils, which provide a higher signal-to-noise ratio than body coils, and are therefore recommended.^{48,49} Endoluminal coils have been shown to be valuable in conjunction with pelvic-phased array coils, but drawbacks such as increased cost, patient acceptability and limitations to the field of view hinder their use in clinical practice.^{6,50–52}

MRI sequences

Sagittal, axial and oblique two-dimensional T2W (2D-T2W) MR sequences are recommended in the evaluation of DIE⁶ and all surveyed centres performed these without fat suppression. No studies demonstrate benefit in performing coronal views. Thin-section oblique 2D-T2W imaging has been demonstrated to improve assessment of uterosacral and parametrial endometriosis.^{53,54} Three-dimensional (3D) MRI reconstructions have been demonstrated to localise and measure the dimensions of deeply infiltrating bladder and rectosigmoid lesions with a higher sensitivity (83%) and diagnostic accuracy (86%) than standard MRI.⁵⁵

T1W MRI is the gold standard for the diagnosis of endometriomas and should be performed with and without fat suppression.^{6,56,57} All surveyed centres performed T1W sequences with fat suppression, and the vast majority also took sequences without fat suppression. High signal due to fat may be responsible for artefacts such as ghosting and chemical shift. The high signal can also mask subtle contrast difference in non-fatty tissue by filling the dynamic range of the receiver with mostly fat signal. Therefore, fat suppression techniques increase the sensitivity and specificity of MR in the diagnosis of endometriotic lesions. The 3D Dixon technique provides stronger fat

suppression versus a 3D fast-spoiled gradient-echo (FSPGR) sequence;⁵⁷ however, it has not been studied against conventional fat suppressed 2D T1W sequences. T1W gradient echo (GRE) sequences can be used in anxious patients to reduce the examination time, but are not favoured due to lower spatial resolution.²⁵

Low-resolution pelvic MRI appears to enable equally accurate assessment for DIE, independent of the radiologist's experience.⁵⁸ Acquisition times are over a third less, and therefore this method has been recommended in selected cases. Ultrafast T2W sequences have also been shown to reduce motion artefacts while maintaining comparable tissue contrast.⁵⁹ Other authors have found image quality significantly poorer with this technique.⁴⁴

MRI urography to assess for ureteric obstruction is most often utilised when paracervical endometriotic nodules measuring over 3 cm are noted, or if there is obvious ureteric involvement.^{9,14} It can be performed using either heavily T2W fast spin echo sequences or by using T1W 2D or 3D gradient echo sequences during the excretory phase after an injection of intravenous gadolinium.^{9,14,18,28}

Intravenous gadolinium should be used to depict strongly enhancing mural nodules in adnexal lesions, particularly where there are features of atypia.^{60,61} Gadolinium is also useful in differentiating an endometrioma from a haemorrhagic cyst or tubo-ovarian abscess, as intense wall enhancement is associated with pelvic inflammatory disease.^{62,63} Bazot et al found that gadolinium did not confer any benefit in the diagnosis of rectosigmoid, vaginal and bladder endometriosis.⁴³ Furthermore, contrast enhancement of normal fibromuscular pelvic structures as well as the parametrium, small pelvic veins and vascular or inflamed peritoneum can lead to diagnostic difficulties.⁴¹ The combination of MR colonography and 3D T1W MRI has been demonstrated to improve the recognition of colorectal endometriosis, however.⁶⁴ Contrast enhancement may also be beneficial in detecting abdominal wall endometriosis.⁶⁵ Recently, there have been increasing concerns regarding gadolinium deposition in the deep nuclei of the brain, particularly after repeated administrations.^{66,67} Despite the biological and clinical significance being unknown, there has been an international shift in the guidelines to restrict use of gadolinium-based contrast agents to specific clinical indications.^{66,68,69}

No analysis has been performed to differentiate endometriosis from other pathologies using quantitative diffusion-weighted MRI (DWI). However, apparent diffusion coefficient (ADC) values of pelvic DIE lesions are consistently decreased, independent of their location.⁷⁰ There may also be benefit in the assessment of abdominal wall and sacral nerve root endometriosis.^{70–72} Balaban et al found significantly lower ADC values in endometriomas compared with functional haemorrhagic ovarian cysts in all *b* values (a factor that determines the strength and duration of the diffusion gradients).⁷³ Inversely, a retrospective study by Lee et al⁷⁴ indicated the mean ADC values of endometriomas were significantly higher than that of haemorrhagic cysts. Hence, DWI is not advised routinely.

Susceptibility-weighted MRI (SWI) is sensitive in detecting chronic blood products and hence has potential for improving the detection of small endometriotic lesions on MRI. Studies are limited, but there are promising results of this technique in relation to differentiating cystic endometriomas, bladder, bowel and abdominal wall endometriomas.^{56,70,75,76} Due to the lack of evidence, SWI is not currently routinely advised and none of our surveyed centres were using it.

Half-Fourier acquisition single shot turbo spin echo (SSFSE, HASTE) is used to acquire multiphase and multislice images, in order to obtain kinematic information that may improve recognition of pelvic adhesions.⁷⁷ The technique is akin to observing the 'sliding sign' during ultrasound examination, where two adjacent structures are able to glide past one another on respiration or probe pressure. HASTE imaging evaluates the degree of uterine peristalsis, which is significantly reduced during the periovulatory phase in women with endometriosis.^{78,79} It is proposed that abnormal uterine peristalsis could interfere with sperm transport and fertility,⁸⁰ and uterine hyperperistalsis may be an explanation for the development of endometriosis and adenomyosis.⁸¹ Four centres were using these techniques in our survey.

CONCLUSIONS

Our survey demonstrates a need for standardisation of imaging protocols in the preoperative staging of deeply infiltrating endometriosis in BSGE accredited endometriosis centres. Not only could this improve quality of care for individual women, but it would also allow multicentre trials to be more effective and generalisable.

At present, accredited endometriosis centres are expected to name their dedicated gynaecological, colorectal and urological surgeons, as well as other supporting clinicians such as the endometriosis nurse specialist and pain specialists. At the time of writing, the BSGE did not hold any information on the lead

radiologist for endometriosis reporting in each centre. Good quality examinations and an experienced radiologist are essential to achieve high diagnostic accuracy. Given that imaging forms an integral part of the patient's pathway and is a key determinant used to inform management decisions, we believe the lead radiologist in each centre should be named as part of the endometriosis team. With a more inclusive, multidisciplinary approach and potential input from 49 expert consultant radiologists, the BSGE may be able to reach a consensus. For the time being, awareness of the ESUR guideline needs to be increased and its use endorsed.

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AUTHOR CONTRIBUTIONS:

- 1 guarantor of integrity of the entire study - MW
- 2 study concepts and design - MW, SP, JR, IS, EO
- 3 literature research - MW
- 4 clinical studies - MW
- 5 experimental studies / data analysis - MW
- 6 statistical analysis - MW
- 7 manuscript preparation - MW, SP, JR, IS, EO
- 8 manuscript editing - MW, SP, JR, IS, EO

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ETHICS APPROVAL

The Medical Research Council and NHS Health Research Authority did not qualify this survey as research and therefore ethical approval was not deemed necessary. Patient data was not exchanged and the questionnaire was anonymous.

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