Received:
10 June 2016

Revised:
4 October 2016

Accepted:
10 October 2016

<https://doi.org/10.1259/bjr.20160522>

Cite this article as:

Hainsworth AJ, Pilkington SA, Grierson C, Rutherford E, Schizas AMP, Nugent KP, et al. Accuracy of integrated total pelvic floor ultrasound compared to defaecatory MRI in females with pelvic floor defaecatory dysfunction. *Br J Radiol* 2016; **89**: 20160522.

FULL PAPER

Accuracy of integrated total pelvic floor ultrasound compared to defaecatory MRI in females with pelvic floor defaecatory dysfunction

¹ALISON J HAINSWORTH, BSc, MRCS, ²SOPHIE A PILKINGTON, MD, FRCS, ³CATHERINE GRIERSON, MRCS, FRCR, ³ELIZABETH RUTHERFORD, MRCS, FRCR, ¹ALEXIS M P SCHIZAS, MD, FRCS, ²KAREN P NUGENT, MEd, FRCS and ¹ANDREW B WILLIAMS, MS, FRCS

¹Pelvic Floor Unit, Colorectal Unit, St Thomas' Hospital, London, UK

²Colorectal Unit, University Hospital Southampton, Southampton, Hampshire

³Radiology Departments, University Hospital Southampton, Southampton, Hampshire

Address correspondence to: Miss Alison J Hainsworth

E-mail: allyhainsworth@googlemail.com

Objective: Defaecatory MRI allows multicompartamental assessment of defaecatory dysfunction but is often inaccessible. Integrated total pelvic floor ultrasound (transperineal, transvaginal, endoanal) may provide a cheap, portable alternative. The accuracy of total pelvic floor ultrasound for anatomical abnormalities when compared with defaecatory MRI was assessed.

Methods: The dynamic images from 68 females who had undergone integrated total pelvic floor ultrasound and defaecatory MRI between 2009 and 2015 were blindly reviewed. The following were recorded: rectocele, enterocele, intussusception and cystocele.

Results: There were 26 rectoceles on MRI (49 rectoceles on ultrasound), 24 rectoceles with intussusception on MRI (19 rectoceles on ultrasound), 23 enteroceles on MRI (24 enteroceles on ultrasound) and 49 cystoceles on MRI (35 cystoceles on ultrasound). Sensitivity and specificity of

total pelvic floor ultrasound were 81% and 33% for rectocele, 60% and 91% for intussusception, 65% and 80% for enterocele and 65% and 84% for cystocele when compared with defaecatory MRI. This gave a negative-predictive value and positive-predictive value of 74% and 43% for rectocele, 80% and 79% for intussusception, 82% and 63% for enterocele and 48% and 91% for cystocele.

Conclusion: Integrated total pelvic floor ultrasound may serve as a screening tool for pelvic floor defaecatory dysfunction; when normal, defaecatory MRI can be avoided, as rectocele, intussusception and enterocele are unlikely to be present.

Advances in knowledge: This is the first study to compare integrated total pelvic floor ultrasound with defaecatory MRI. The results support the use of integrated total pelvic floor ultrasound as a screening tool for defaecatory dysfunction.

INTRODUCTION

Pelvic floor defaecatory dysfunction may result from an anatomical (rectocele, intussusception, enterocele, sigmoidocele and rectal prolapse)^{1–3} or a functional problem (dyssynergy).¹ Up to half of the females also have anterior and middle pelvic floor dysfunction.^{4,5} Multicompartamental imaging (imaging the anterior, middle and posterior pelvic compartments) of females with pelvic floor defaecatory dysfunction may be useful for treatment planning.⁶

Conventional defaecation proctography assesses the rectum and small bowel but involves radiation.⁷ Defaecatory MRI visualizes the entire pelvic floor in high resolution and multiple planes but is expensive.^{8,9} Defaecatory imaging may be poorly tolerated and findings should be interpreted

with caution.^{10–12} Integrated total pelvic ultrasound (endoanal, transvaginal, transperineal)¹³ allows dynamic multicompartamental pelvic floor assessment with simultaneous endoanal assessment of the anal sphincter complex and is cheap, safe, portable and well tolerated.^{12,14,15}

While treatment options for pelvic floor defaecatory dysfunction are continually developing, the assessment algorithm also requires refinement. Defaecation proctography may overestimate pathology¹⁶ but equally defaecation MRI may underestimate pathology.¹⁰ The “gold standard” for these investigations has not been established yet. Comparisons between pelvic floor ultrasound and defaecation proctography suggest that ultrasound provides a suitable screening tool for defaecatory dysfunction with a high positive-predictive value (PPV) for pathologies associated

with defaecatory dysfunction.^{12,17} However, the relation between total pelvic floor ultrasound and MRI has not been assessed.

The aim was to compare both anatomical (rectocele, intussusception, enterocoele and cystocoele) and functional (dyssynergy) findings on integrated total pelvic floor ultrasound with defaecatory MRI in females presenting with pelvic floor defaecatory dysfunction.

METHODS AND MATERIALS

The retrospective examination of all consecutive females undergoing total pelvic floor ultrasound and defaecatory MRI for pelvic floor defaecatory dysfunction between January 2009 and October 2015 in a colorectal pelvic floor tertiary centre. As was routine practice, all patients with pelvic floor defaecatory dysfunction whose symptoms failed to resolve after a period of conservative treatment underwent investigation. Since the introduction of integrated total pelvic floor ultrasound to the service 5 years ago, this is now performed instead of stand-alone endoanal ultrasound assessment. However, given that integrated total pelvic floor ultrasound is a relatively new technique, it is not solely relied upon and patients also undergo defaecation MRI.

Integrated total pelvic floor ultrasound

Scans were performed by two authors (SP and KN) in conjunction with clinical assessment. No contrast was used. All scans were performed in the lithotomy position.¹⁸ The entire sonographic assessment took approximately 15 min per patient.

Transvaginal scanning was performed using a rotating single crystal probe (12 MHz). Anterior and posterior views were acquired while asking the patient to perform three manoeuvres: cough, squeeze and strain.¹⁸ Transperineal scanning was performed using a conventional curved-array probe (6 MHz). The transducer was rested on the perineum to obtain mid-sagittal views and the patient was asked to cough, squeeze and strain. Each manoeuvre was digitally recorded.

Defaecatory MRI

The MRI machine (GE Signa Excite 1.5T,[®] General Electric Worldwide Partners, California, USA) had a 1.5-T magnet and the sequences were all sagittal T_2 Fast Imaging Employing Steady-state Acquisition (FIESTA) (single midline image). The rectum was instilled with 150 ml of ultrasound gel. The patient was scanned supine with the legs flexed and was asked to evacuate the paste. The patient was asked to evacuate three times. A senior radiographer (with more than 10 years' experience) explained the procedure and gave instructions to the patient during the scan.

Interpretation of images

Dynamic images were analyzed by blinded clinicians to give a consensus view [ultrasound—AH (2 years' experience), AS (5 years' experience), MRI—AH (2 years' experience) and CG (over 10 years' experience)].

Rectocele

MRI: the protrusion of the rectal wall beyond the expected projected anterior anal canal wall¹⁹ (≥ 2 cm significant)¹⁶ (Figure 1a). A "trapping rectocele" was retention of gel within the rectocele despite rectal emptying.

Ultrasound: the protrusion of the anterior rectal wall with impingement onto the perineal body on anterior transvaginal scanning¹⁸ (Figure 1b) and the bulge of the anterior rectal wall into the vagina on transperineal scanning [distance beyond the perineal body (≥ 1 cm significant)^{17,19–21} (Figure 1c)].

Intussusception

MRI: graded according to the Oxford Radiological Classification System:^{16,22}

- Grade I–II: rectorectal (Figure 2a)
- Grade III–IV: rectoanal
- Grade V: overt rectal prolapse.

Posterior transvaginal scanning: graded by the infolding of the rectal wall in relation to the anal canal (*i.e.* puborectalis and perineal body).²³ This is an ultrasound interpretation of the Oxford Radiological Classification System:

- Grade I–II: the infolding rectal wall ceased prior to the edge of puborectalis (Figure 2b)
- Grade III–IV: the infolding reached beyond puborectalis and into or onto the anal canal
- Grade V: the infolding rectal wall prolapsed through the anal canal
- Grade III–V: are pathological.

Enterocoele

MRI: the descent of the small bowel (Figure 3a) was graded according to the maximal descent below the pubococcygeal line; from 0 to <3 cm (Grade I), 3–6 cm (Grade II) and >6 cm (Grade III).²⁴

Posterior transvaginal scanning: the presence of bowel between the rectum and probe (Figure 3b).¹⁸

Transperineal scanning: graded according to the maximal descent of the small bowel in relation to the vagina—the cranial third (Grade I), the middle third (Grade II) and the caudal third (Grade III) (Figure 3c).²⁵

Cystocoele

MRI: the descent of the bladder below the pubococcygeal line (Grade I descent <3 cm, Grade II descent 3–6 cm and Grade III >6 cm).²⁴

Transperineal scanning: the descent of the bladder was graded in relation to the vagina; the bladder prolapsed onto (Grade I), into (Grade II) and through (Grade III) the vagina.²⁶

Dyssynergy

Failure to relax or a paradoxical increase in the anorectal angle on bearing down during posterior transvaginal or transperineal ultrasound or during attempted evacuation during defaecation MRI was labelled dyssynergy.

The descent of the bladder neck >2 cm in relation to the pubic bone on anterior transvaginal scanning indicated poor support.²⁷

Figure 1. (a) Rectocoele depth of defaecation MRI is the distance from the expected projected anterior rectal wall to the maximal bulge; (b) a rectocoele on posterior transvaginal scanning; (c) a rectocoele on transperineal scanning is the depth of the bulge beyond the perineal body (PB). A, anal canal; PB, perineal body; PR, puborectalis; R, rectum.

Retention of more than two-third of the gel at the end of the MRI was incomplete evacuation.²⁸

Statistical analysis was performed using StatsDirect (Cheshire, UK) software. Accuracy of ultrasound was calculated by comparison with MRI. Agreement was calculated with Cohen's kappa coefficient for categorical variables and Bland-Altman (intraclass correlation coefficient) for continuous variables. Correlation coefficient r was used to calculate correlation for continuous and Spearman's rank correlation coefficient ρ for categorical variables. Two-tailed Fisher's exact test was used to compare categorical and unpaired t -test to compare continuous variables. Significance was $p < 0.05$.

No ethical approval was required as this was a study of routine practice.

RESULTS

There were 91 females who underwent total pelvic floor ultrasound and defaecation MRI for pelvic floor defaecatory dysfunction [23 images were excluded (5 images unavailable, in 18 women the

time between the two tests was over 1 year)] (Table 1). A total of 68 paired examinations were assessed [mean age 60 years, median 62 years (range 24–82 years); mean time between tests was 4 months, median 3 months (range 0–12 months)].

Rectocoele

There were 26 rectocoeles on MRI and 49 rectocoeles on ultrasound. Total pelvic floor ultrasound had a PPV of 43% (21 true positives, 28 false positives) and a negative-predictive value (NPV) of 74% (14 true negatives, 5 false negatives) yielding a sensitivity of 81% and a specificity of 33% (Table 1). Agreement was poor (Table 1). Visualization of rectocoele on ultrasound did not predict a rectocoele on MRI ($p = 0.01$).

On MRI, mean size of the rectocoele was 2.9 cm (median 2.8 cm, range 2–5 cm). Of the 49 rectocoeles on ultrasound, 45 rectocoeles were seen on both transperineal and transvaginal scanning (mean size 2.2 cm; median 2 cm, range 1–4 cm) and 4 rectocoeles only on transvaginal scanning. There was a weak positive correlation for rectocoele size on ultrasound compared with MRI (correlation coefficient r 0.4). There was fair

Figure 2. (a) Grade II intussusception (arrows are showing the infolding of the rectal wall into the rectum) on defaecatory MRI; (b) Grade II intussusception (arrows are showing the infolding of the rectal wall into the rectum) on posterior transvaginal ultrasound. A, anal canal; PB, perineal body; PR, puborectalis; R, rectum.

agreement between measurements (intraclass correlation coefficient 0.41) and the mean difference in rectocele size was 0.01 cm. However, 95% of the differences in rectocele size between ultrasound and MRI lay between -2.8 and 2.78 (95% limits of agreement). The difference for an individual would be between -2.8 and 2.78 cm.

There were 12 trapping rectoceles. There was a trend for trapping rectoceles to be larger on MRI (mean size 3.1 cm *vs* 2.7 cm) and ultrasound (mean size 2.6 cm *vs* 2.0 cm), but this failed to reach significance.

Intussusception

There were 24 patients with intussusception on MRI and 19 on posterior transvaginal ultrasound. Total pelvic floor ultrasound had a PPV of 79% (15 true positives, 4 false positives) and an NPV of 80% (39 true negatives, 10 false negatives) giving a specificity of 91% and a sensitivity of 60% (Table 1). If intussusception was seen on ultrasound, then it was likely seen on MRI ($p < 0.0001$). Agreement was moderate (Table 1).

On MRI, there were 22 patients with no intussusception, 6 with Grade I intussusception, 15 with Grade II intussusception, 9 Grade III intussusception, 4 Grade IV intussusception and 12 Grade V intussusception 13. On ultrasound, there were 18 patients without any intussusception, 14 Grade I intussusception, 17 Grade II intussusception, 8 Grade III intussusception, 2 Grade IV intussusception and 9 Grade V intussusception. There was a positive correlation between grading on ultrasound and MRI (Spearman's ρ 0.43; $p < 0.01$).

There were 25 rectoceles with incomplete evacuation on MRI. In those with incomplete evacuation, there was no significant correlation between grading on ultrasound and MRI (Spearman's ρ 0.018; $p = 0.9$). There was a positive correlation between grading on ultrasound and MRI in those without incomplete evacuation (Spearman's ρ 0.47; $p < 0.01$).

Enterocoele

There were 23 enterocoeles on MRI and 24 enterocoeles on ultrasound. PPV was 63% (15 true positives, 9 false positives) and NPV was 82% (36 true negative, 8 false negative), which gave a sensitivity of 65% and specificity of 80% (Table 1). If an enterocoele was seen on ultrasound, then it was likely that an enterocoele was also seen on MRI ($p = 0.0003$). Agreement was moderate (Table 1).

The 23 enterocoeles seen on MRI were: 7 Grade I enterocoeles, 6 Grade II enterocoeles and 10 Grade III enterocoeles. Of the 24 enterocoeles on ultrasound, 5 enterocoeles were on transvaginal scanning only, 8 enterocoeles on transperineal scanning only and 11 on both. The 19 enterocoeles on transperineal scanning were: 3 Grade I enterocoeles, 4 Grade II enterocoeles and 12 Grade III enterocoeles. There was positive correlation between grading on ultrasound and MRI (Spearman's ρ 0.52; $p < 0.01$).

Anterior compartment

There were 49 cystocoeles on MRI (24 Grade I cystocoeles, 22 Grade II cystocoeles and 3 Grade III cystocoeles) and 35 cystocoeles on ultrasound (13 Grade I cystocoeles, 10 Grade II cystocoeles and 12 Grade III cystocoeles). PPV was 91% (32 true positives, 3 false positives) and NPV was 48% (16 true negatives,

Figure 3. (a) A Grade II enterocoele on MRI which is descending 4 cm below the pubococcygeal line (solid white line) into the rectovaginal space; (b) the presence of an enterocoele on posterior transvaginal scanning has been identified by the presence of the small bowel between the vaginal probe and rectal wall; (c) an enterocoele on transperineal scanning. A, anal canal; B, bladder; PR, puborectalis; R, rectum.

17 false negatives), resulting in a sensitivity of 65% and a specificity of 84% (Table 1).

If there was a cystocoele detected on ultrasound, then it was likely that there would be a cystocoele on MRI ($p = 0.0002$). Concordance was fair (kappa 0.40) (Table 1). There was a positive correlation between grading (Spearman's ρ 0.48; $p < 0.01$).

Of the 18 cystocoeles missed on transperineal ultrasound, 8 cystocoeles were Grade I, 5 cystocoeles were Grade II and 4 cystocoeles were Grade III.

30 females underwent anterior transvaginal scanning. Mean bladder neck descent was 1.7 cm [median 1.5 cm (range 0–4 cm)]. Poor support had a PPV of 83% (10 true positives,

Table 1. The accuracy and agreement of integrated total pelvic floor ultrasound when compared with defaecatory MRI as the gold standard

Pathology	Accuracy of total pelvic floor ultrasound				Agreement with MRI
	PPV (%)	NPV (%)	Sensitivity (%)	Specificity (%)	Cohen's kappa
Rectocoele	43	74	81	33	0.12
Intussusception	79	80	60	91	0.53
Enterocoele	63	82	65	80	0.45
Cystocoele	91	48	65	84	0.40
Dyssynergy	33	85	25	89	0.30

NPV, negative-predictive value; PPV, positive-predictive value.

Cohen's kappa: poor (0–0.20), fair (0.21–0.40), moderate (0.41–0.60), good (0.61–0.80) and excellent (>0.81).

2 false positives) and an NPV of 67% (6 true negatives, 12 false negatives) with a sensitivity of 46% and specificity of 75% for the presence of a cystocele on MRI.

Functional aspects

There were 5 cases of dyssynergy on total pelvic floor ultrasound and 12 cases of dyssynergy on defaecatory MRI. PPV was 33% (3 true positives, 2 false positives) and NPV was 85% (54 true negatives, 9 false negatives). This resulted in a sensitivity of 25% and specificity of 89%. Agreement was fair (Cohen's kappa 0.3) (Table 1).

There were 25 cases of incomplete evacuation during MRI. Those cases with incomplete evacuation were significantly more likely to display poor propulsion during ultrasound scanning ($p = 0.04$), although not significantly more likely to display anismus during ultrasound ($p = 0.13$). Those with incomplete evacuation were significantly likely to display anismus during MRI ($p = 0.004$).

DISCUSSION

This is the first series which correlates total pelvic floor ultrasound with defaecation MRI in pelvic floor defaecatory dysfunction.

The most important observations are the high NPV for rectocele, intussusception and enterocele and the high PPV for cystocele. This supports the use of total pelvic floor ultrasound as a screening tool in females with symptoms of pelvic floor defaecatory dysfunction; when ultrasound is normal, defaecatory MRI can be avoided, as rectoceles, intussusception and enteroceles are unlikely to be present. When a cystocele and to a lesser extent intussusception are visualized on ultrasound, they are likely to be seen on MRI. Although this assessment algorithm would mean that one in five anatomical abnormalities would not be identified during assessment with ultrasound, the nature of pelvic floor disease dictates that conservative measures would continue. The aim of treatment is symptom resolution, and the presence of persistent symptoms despite ongoing conservative measures would be a valid indication for further defaecatory imaging with MRI.

Rectocele

Although ultrasound appears to overdiagnose rectocele compared with MRI, this may represent underestimation on MRI. Comparisons between conventional proctography and defaecation MRI also report a relative underestimation of rectocele on MRI.⁸

Although neither was performed in the sitting position, the lithotomy position adopted during ultrasound may allow the development of a rectocele more readily than the supine position required for MRI. Supine imaging underestimates pathology.^{29,30} Stool type may be more important for the development of rectocele than patient position.³¹ There was no preparation or contrast prior to ultrasound and therefore no standardization regarding the presence of stool. However, it is likely that any stool present would have been thicker than the gel used during MRI, which may

contribute to increased rectocele development during ultrasound.

Concordance for rectocele detection was poor. Comparisons between ultrasound and defaecation proctography have shown fair to moderate concordance for all rectoceles,^{12,14,15,17} but excellent concordance for large rectoceles (>4 cm on proctography).¹⁴ Despite the widely accepted parameter that a 2-cm rectocele is pathological on proctography,¹⁶ an asymptomatic rectocele of 3.9 cm has been observed.³² This implies that normal findings on MRI also require further evaluation and highlights the flaws in comparing imaging modalities and the need to correlate sonographic findings with symptoms.

There was fair agreement between rectocele measurement on transperineal ultrasound and MRI. However, the maximum difference between rectocele size on ultrasound and MRI for an individual would be 2.8 cm (standard deviation $\times 2$). A difference as large as this would be clinically significant and measurements from transperineal ultrasound cannot be compared with those from MRI. Comparison of rectocele measurement on total pelvic floor ultrasound with defaecation proctography^{14,17} and MRI with defaecation proctography¹⁰ have also shown poor agreement.

Intussusception

Intussusception is more dependent on rectal evacuation than patient position.¹⁰ It may not be possible to grade intussusception on defaecatory imaging without evacuation.²² Although this series assumes that defaecation MRI is the "gold standard", it is less sensitive than defaecation proctography for intussusception^{8,10} owing to the difficulty in rectal emptying during supine MRI compared with upright defaecography.¹⁰ Straining during ultrasound may not be as sensitive for the detection of intussusception as rectal evacuation during defaecatory imaging. However, in the patient with anismus, mucosal infolding may be more apparent during Valsalva on ultrasound than in the presence of a rectal gel, preventing the infolding of rectal mucosa during MRI. In our series, although there was a significant correlation for grading of intussusception, this was not the case for those with incomplete evacuation; 11 of the 25 patients with incomplete evacuation demonstrated a higher grade of intussusception on ultrasound, which may represent underestimation of pathology on MRI.

Enterocele

Sensitivity and specificity for enterocele were high (65% and 80%) but not as high as in those series comparing ultrasound with defaecation proctography (82% and 92%).³³ Supine defaecatory MRI may underestimate enterocele compared with upright defaecography⁸ and rectal gel may compress the rectovaginal space to prevent an enterocele from developing.²⁵ The false positives seen on ultrasound may represent underestimation of pathology on MRI.

Enterocele may be more dependent upon position than evacuation,¹⁷ but despite the more tilted position, eight enteroceles visualized on MRI (four Grade I enteroceles, two Grade II enteroceles and two Grade III enteroceles) were not seen on ultrasound. There was a positive correlation between grading. Of

the 15 enterocoeles visualized on both, grading was higher on ultrasound in 3 enterocoeles but higher on MRI in only 1 enterocoele. There was a case where an enterocoele was detected on transperineal ultrasound, but only a peritoneocoele developed during MRI.

During ultrasound, it is not always possible to distinguish between a sigmoidocoele, uterine descent and enterocoele. One case labelled as uterine descent on transperineal ultrasound was an enterocoele on MRI. A gastrograffin meal prior to ultrasound can highlight small bowel descent, improving accuracy.²⁵

Cystocoele

There was high PPV and specificity for cystocoele. There was no standardized bladder volume, which may have affected concordance (a full bladder may reduce movement).³⁴ Bladder descent is known to be greater during sitting than lying in females who are incontinent.²⁹

Examination of bladder neck descent on anterior transvaginal scanning was not as accurate for the detection of cystocoele as visualization of cystocoele development on transperineal scanning. This may be because of the splinting effects of the transvaginal probe preventing the full development of prolapse.^{14,27}

The strength in this study lies in the blinded approach by the interpreter. However, the clinician performing the ultrasound

was not blinded and may have repeated certain movements to elicit pathologies. Weaknesses include the retrospective nature, a lack of comparison with symptoms and examination and the gap between tests, which add to the increasing body of evidence demanding test–retest repeatability. Interrater and intrarater repeatability has not been reported. Although the methods used during ultrasound interpretation have high repeatability,^{19,35} previous groups have shown that repeatability for MRI interpretation is less reliable.³⁶ Integrated total pelvic floor ultrasound requires training and expertise. Although transperineal ultrasound can be performed with a standard abdominal probe, endoluminal scanning requires access to specialized transducers.

This study assumes defaecation MRI is the “gold standard”, which is not necessarily the case. How findings on the imaging modalities relate to one another and symptoms will be the key to future work.

CONCLUSION

Our series supports the use of integrated total pelvic floor ultrasound as a screening tool for defaecatory dysfunction in clinic such that defaecatory MRI can be avoided in some. If ultrasound is normal, then rectocoele, intussusception and enterocoele are unlikely to be seen on MRI. If a cystocoele or intussusception is seen during ultrasound, then it is likely to be seen on MRI. If no pathology is seen during ultrasound, then MRI is unlikely to yield further information.

REFERENCES

- Andromanakos N, Skandalakis P, Troupis T, Filippou D. Constipation of anorectal outlet obstruction: pathophysiology, evaluation and management. *J Gastroenterol Hepatol* 2006; **21**: 638–46. doi: <https://doi.org/10.1111/j.1440-1746.2006.04333.x>
- Apostolis C, Wallace K, Sasson P, Hacker MR, Elkadry E, Rosenblatt PL. Assessment of women with defecatory dysfunction and manual splinting using dynamic pelvic floor magnetic resonance imaging. *Female Pelvic Med Reconstr Surg* 2012; **18**: 18–24. doi: <https://doi.org/10.1097/SPV.0b013e31823bdb98>
- Ellis CN, Essani R. Treatment of obstructed defecation. *Clin Colon Rectal Surg* 2012; **25**: 24–33. doi: <https://doi.org/10.1055/s-0032-1301756>
- González-Argenté FX, Jain A, Nogueras JJ, Davila GW, Weiss EG, Wexner SD. Prevalence and severity of urinary incontinence and pelvic genital prolapse in females with anal incontinence or rectal prolapse. *Dis Colon Rectum* 2001; **44**: 920–6.
- Nugent K. Three compartments—working with a multidisciplinary team. Lindsey I, Nugent K, Dixon T, eds. *Pelvic floor disorders for the colorectal surgeon*; 2010.
- Kapoor DS, Sultan AH, Thakar R, Abulafi MA, Swift RI, Ness W. Management of complex pelvic floor disorders in a multidisciplinary pelvic floor clinic. *Colorectal Dis* 2008; **10**: 118–23. doi: <https://doi.org/10.1111/j.1463-1318.2007.01208.x>
- Goei R, Kemerink G. Radiation dose in defecography. *Radiology* 1990; **176**: 137–9. doi: <https://doi.org/10.1148/radiology.176.1.2353082>
- Matsuoka H, Wexner SD, Desai MB, Nakamura T, Nogueras JJ, Weiss EG, et al. A comparison between dynamic pelvic magnetic resonance imaging and videoproctography in patients with constipation. *Dis Colon Rectum* 2001; **44**: 571–6. doi: <https://doi.org/10.1007/BF02234331>
- Mortele KJ, Fairhurst J. Dynamic MR defecography of the posterior compartment: indications, techniques and MRI features. *Eur J Radiol* 2007; **61**: 462–72. doi: <https://doi.org/10.1016/j.ejrad.2006.11.020>
- Pilkington SA, Nugent KP, Brenner J, Harris S, Clarke A, Lamparelli M, et al. Barium proctography vs magnetic resonance proctography for pelvic floor disorders: a comparative study. *Colorectal Dis* 2012; **14**: 1224–30. doi: <https://doi.org/10.1111/j.1463-1318.2012.02945.x>
- Maglinte DD, Bartram CI, Hale DA, Park J, Kohli MD, Robb BW, et al. Functional imaging of the pelvic floor. *Radiology* 2011; **258**: 23–39. doi: <https://doi.org/10.1148/radiol.10092367>
- Martellucci J, Naldini G. Clinical relevance of transperineal ultrasound compared with evacuation proctography for the evaluation of patients with obstructed defaecation. *Colorectal Dis* 2011; **13**: 1167–72. doi: <https://doi.org/10.1111/j.1463-1318.2010.02427.x>
- Haylen BT, De Ridder D, Freeman RM, Swift SE, Berghmans B, Lee J, et al. An International Urogynecological Association (IUGA)/International Continence Society (ICS) joint report on the terminology for female pelvic floor dysfunction. *Int Urogynecol J* 2010; **21**: 5–26. doi: <https://doi.org/10.1007/s00192-009-0976-9>
- Grasso RF, Piciocchi S, Quattrocchi CC, Sammarra M, Ripetti V, Zobel BB. Posterior pelvic floor disorders: a prospective comparison using introital ultrasound and colposcystodefecography. *Ultrasound Obstet Gynecol* 2007; **30**: 86–94. doi: <https://doi.org/10.1002/uog.4047>

15. Steensma AB, Oom DM, Burger CW, Schouten WR. Assessment of posterior compartment prolapse: a comparison of evacuation proctography and 3D transperineal ultrasound. *Colorectal Dis* 2010; **12**: 533–9. doi: <https://doi.org/10.1111/j.1463-1318.2009.01936.x>
16. Shorvon PJ, McHugh S, Diamant NE, Somers S, Stevenson GW. Defecography in normal volunteers: results and implications. *Gut* 1989; **30**: 1737–49. doi: <https://doi.org/10.1136/gut.30.12.1737>
17. Perniola G, Shek C, Chong CC, Chew S, Cartmill J, Dietz HP. Defecation proctography and translabial ultrasound in the investigation of defecatory disorders. *Ultrasound Obstet Gynecol* 2008; **31**: 567–71. doi: <https://doi.org/10.1002/uog.5337>
18. Hainsworth AJ, Solanki D, Schizas AM, Williams AB. Total pelvic floor ultrasound for pelvic floor defaecatory dysfunction: a pictorial review. *Br J Radiol* 2015; **88**: 20150494. doi: <https://doi.org/10.1259/bjr.20150494>
19. Hainsworth A, Collins E, Solanki D, Schizas A, Williams A. The measurement and assessment of rectocele using total pelvic floor ultrasound and proctography. *Neuro-urol Urodyn* 2015; **34**: S256–7.
20. Dietz HP, Korda A. Which bowel symptoms are most strongly associated with a true rectocele? *Aust N Z J Obstet Gynaecol* 2005; **45**: 505–8. doi: <https://doi.org/10.1111/j.1479-828X.2005.00486.x>
21. Dietz HP, Steensma AB. Posterior compartment prolapse on two-dimensional and three-dimensional pelvic floor ultrasound: the distinction between true rectocele, perineal hypermobility and enterocele. *Ultrasound Obstet Gynecol* 2005; **26**: 73–7. doi: <https://doi.org/10.1002/uog.1930>
22. Collinson R, Cunningham C, D'Costa H, Lindsey I. Rectal intussusception and unexplained faecal incontinence: findings of a proctographic study. *Colorectal Dis* 2009; **11**: 77–83. doi: <https://doi.org/10.1111/j.1463-1318.2008.01539.x>
23. Hainsworth AJ, Solanki D, Schizas AMP, Williams AB. A novel method for the diagnosis and grading of intussusception using transvaginal ultrasound. *Br J Surg* 2016; **103** (S3), 6–49.
24. Roos JE, Weishaupt D, Wildermuth S, Willmann JK, Marincek B, Hilfiker PR. Experience of 4 years with open MR defecography: pictorial review of anorectal anatomy and disease. *Radiographics* 2002; **22**: 817–32. doi: <https://doi.org/10.1148/radiographics.22.4.g02jl02817>
25. Beer-Gabel M, Assoulin Y, Amitai M, Bardan E. A comparison of dynamic transperineal ultrasound (DTP-US) with dynamic evacuation proctography (DEP) in the diagnosis of cul de sac hernia (enterocele) in patients with evacuatory dysfunction. *Int J Colorectal Dis* 2008; **23**: 513–9. doi: <https://doi.org/10.1007/s00384-008-0440-1>
26. Green TH Jr. Urinary stress incontinence: differential diagnosis, pathophysiology, and management. *Am J Obstet Gynecol* 1975; **122**: 368–400.
27. Santoro GA, Wiczorek AP, Dietz HP, Mellgren A, Sultan AH, Shobeiri SA, et al. State of the art: an integrated approach to pelvic floor ultrasonography. *Ultrasound Obstet Gynecol* 2011; **37**: 381–96. doi: <https://doi.org/10.1002/uog.8816>
28. Halligan S, Malouf A, Bartram CI, Marshall M, Hollings N, Kamm MA. Predictive value of impaired evacuation at proctography in diagnosing anismus. *AJR Am J Roentgenol* 2001; **177**: 633–6. doi: <https://doi.org/10.2214/ajr.177.3.1770633>
29. Fielding JR, Griffiths DJ, Versi E, Mulkern RV, Lee ML, Jolesz FA. MR imaging of pelvic floor continence mechanisms in the supine and sitting positions. *AJR Am J Roentgenol* 1998; **171**: 1607–10. doi: <https://doi.org/10.2214/ajr.171.6.9843296>
30. Bertschinger KM, Hetzer FH, Roos JE, Treiber K, Marincek B, Hilfiker PR. Dynamic MR imaging of the pelvic floor performed with patient sitting in an open-magnet unit versus with patient supine in a closed-magnet unit. *Radiology* 2002; **223**: 501–8. doi: <https://doi.org/10.1148/radiol.2232010665>
31. Dietz HP. Rectocele or stool quality: what matters more for symptoms of obstructed defecation? *Tech Coloproctol* 2009; **13**: 265–8. doi: <https://doi.org/10.1007/s10151-009-0527-x>
32. Palit S, Bhan C, Lunniss PJ, Boyle DJ, Gladman MA, Knowles CH, et al. Evacuation proctography: a reappraisal of normal variability. *Colorectal Dis* 2014; **16**: 538–46. doi: <https://doi.org/10.1111/codi.12595>
33. Beer-Gabel M, Carter D. Comparison of dynamic transperineal ultrasound and defecography for the evaluation of pelvic floor disorders. *Int J Colorectal Dis* 2015; **30**: 835–41. doi: <https://doi.org/10.1007/s00384-015-2195-9>
34. Dietz HP. Female pelvic floor dysfunction—an imaging perspective. *Nat Rev Gastroenterol Hepatol* 2012; **9**: 113–21. doi: <https://doi.org/10.1038/nrgastro.2011.213>
35. Hainsworth AJ, 17 Solanki D, Schizas AMP, Williams AB. A novel method for the diagnosis and grading of intussusception using transvaginal ultrasound. *Br J Surg* 2016; **103** (S3), 6–49.
36. Lockhart ME, Fielding JR, Richter HE, Brubaker L, Salomon CG, Ye W, et al. Reproducibility of dynamic MR imaging pelvic measurements: a multi-institutional study. *Radiology* 2008; **249**: 534–40. doi: <https://doi.org/10.1148/radiol.2492072009>