Title: Pelvic Floor Imaging in Asymptomatic Subjects

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ABSTRACT

Objectives

To determine the range of normal imaging features during total pelvic floor ultrasound (TPFUS) (transperineal, transvaginal, endovaginal and endoanal) and defaecation MRI (dMRI).

Methods

Twenty asymptomatic female volunteers (mean age was 36.5 years) were prospectively investigated with dMRI and TPFUS. Subjects were screened with symptom questionnaires (ICIQ-B, St Mark's faecal incontinence score, obstructed defaecation syndrome score, ICIQ-V, BSAQ).

dMRI and TPFUS were performed and interpreted by blinded clinicians according to previously published methods.

Results

There were six parous and 14 nulliparous women, of which three were post-menopausal.

There were three with a rectocoele on both modalities and one with a rectocoele on dMRI only. There was one with intussusception on TPFUS. Two had an enterocoele on both modalities and one on TPFUS only. There were six with a cystocoele on both modalities, one on dMRI only and one on TPFUS only.

On dMRI, there were twelve with functional features. Four also displayed functional features on TPFUS. Two displayed functional features on TPFUS only.

Conclusion

This study demonstrates the presence of abnormal findings on dMRI and TPFUS without symptoms. There was a high rate of functional features on dMRI. This series is not large enough to redefine normal parameters but is helpful to appreciate the wide range of findings seen in health.

Advances in knowledges

This manuscript reiterates that pelvic defaecatory dysfunction is multifactorial and an isolated anatomical abnormality may not cause symptoms. It emphasises the importance of interpreting pelvic floor imaging in context and range of normal variability.

INTRODUCTION

Pelvic floor defaecatory dysfunction includes evacuatory difficulties, faecal incontinence and rectal prolapse. It is increasingly common and affects quality of life. The pelvic floor includes the anterior, middle, and posterior compartments; multicompartmental dysfunction often co-exists. Causation is multifactorial with anatomical, functional, and psychological contributing factors. Anatomical pelvic floor abnormalities include rectocoele, enterocoele, intussusception and cystocoele. Functional disorders refer to abnormalities in co-ordination of the pelvic floor muscle, including dyssynergia, or poor propulsive effort, leading to incomplete evacuation. The Rome IV Criteria provide diagnostic criteria for functional gastrointestinal disorders based on stool consistency, straining, and completion of defecation [1].

Pelvic floor dysfunction may be investigated with defaecatory imaging (Barium defaecatory proctography (DP), defaecation MRI (dMRI)) and, more recently, integrated total pelvic floor ultrasound (transperineal, transvaginal, endovaginal and endoanal) (TPFUS). TPFUS has the advantage of providing a screening tool for anatomical and functional abnormalities associated with defaecatory dysfunction [2,3]. It avoids radiation, can be performed in the one stop clinic without a separate radiology appointment, and can be used to immediately show the patient the findings.

The link between anatomical and functional features on imaging and symptom severity is poorly understood. Ramage found that symptom severity in patients correlated poorly with features on dMRI and our group have found that it is not possible to predict findings on imaging based on bowel symptom severity [4,5].

There is debate surrounding the range of normality on imaging investigations, and concerns that imaging may overestimate pathology. There have been some studies of DP in health [6–8] but the examination of TPFUS and dMRI in those without symptoms is less well reported on [9–13]. Three previous studies have examined TPFUS in health but only report upon functional features, rectal mucosal prolapse and the integrity of the rectovaginal septum [11–13]. For the clinical utility of TPFUS to increase it is important to understand normal findings.

We have conducted a prospective observational case study of twenty asymptomatic female volunteers. The primary aim of the study was to report upon ‘normal’ findings for pelvic floor anatomical and functional features on TPFUS and dMRI so that normal variability may be better understood.

MATERIALS AND METHODS

We investigated 20 asymptomatic subjects with dMRI and TPFUS. Recruitment took place in South London and purposive sampling of twenty participants was based on convenience and budget for imaging. As there was no financial compensation and participation was entirely voluntary, 20 subjects were also a realistic number of asymptomatic volunteers that could be recruited. No voluntary participants were excluded. Ethical approval and informed consent of participants were obtained.

Each subject was screened with symptomatic severity questionnaires to ensure they were asymptomatic (ICIQ-B [14], St Mark's faecal incontinence score [15], obstructed defaecation syndrome score [16], ICIQ-VS [17], BSAQ [18]). Information leaflets were dispatched, and consent gained. Median values were nil as patients were only accepted if asymptomatic. Ranges for questionnaires consist of: ICIQ-B score 0 to 95, St Mark's faecal incontinence score 0 to 24, obstructed defaecation syndrome score 0 to 20, ICIQ-VS 0 to 121, BSAQ. Pelvic floor examinations were not performed prior to imaging.

There were 20 women included (6 parous and 14 nulliparous, of which 3 were post-menopausal) with a mean age of 36.5 years (median 34, range 22 – 53). The parity of the six women ranged from 1-3 with a median of 3.

All images were reported on by an independent, blinded clinician, who was unaware of the history and the results of the corresponding imaging, and verified by at least one further clinician.

Ultrasound Technique

TPFUS was performed by three of the authors who are independently qualified ultrasound practitioners (A Hainsworth, D Solanki, S Morris) according to our previously published pictorial review using a standard B & K Medical scanner (B & K Medical, Sandhoften, Denmark) [19]. Transvaginal, endovaginal and transperineal ultrasound were performed with the subject supine, with the legs drawn up, flexed and abducted. Endoanal ultrasound was performed prone. No bowel preparation was required; no rectal or vaginal contrast was used. Subjects were asked not to empty their bladder for one hour prior. Transvaginal and transperineal ultrasound were performed while asking the subject to squeeze up, relax, bear down and cough.

MRI Technique

dMRI was performed using 1.5T Siemens and a 3.0 Phillips MRI scanner. The rectum was emptied with a Fleet® sodium phosphate enema. Ultrasound jelly (three 60 ml syringes) was inserted into rectum. The subject was placed supine in a continence nappy with the legs flexed and asked to squeeze up and bear down to evacuate the jelly. A mid sagittal cine T2* weighted balanced gradient echo sequence was acquired through the pelvis (100 measures over 1.5 minutes). Three sequences were acquired to capture rectal expulsion. If there was incomplete evacuation, correct defaecatory techniques were taught and a fourth sequence performed.

Image Interpretation

All images were reported on by an independent, blinded clinician, who was unaware of the history and the results of the corresponding imaging, and verified by at least one further clinician.

Bladder Neck Support

On anterior transvaginal ultrasound the bladder neck position was noted at rest, on squeezing up, and on Valsalva. The movement of the bladder neck less than 2cm was considered normal for this study [18].

Cystocoele and middle compartment prolapse

Transperineal Ultrasound

Transperineal ultrasound enables the dynamic visualisation of the entire pelvic floor from anterior to posterior compartments in the mid-sagittal view. The descent of the bladder was examined, and a cystocoele graded according to the Green classification (prolapse of the bladder with straining onto (**Grade I**), into (**Grade II**) and through (**Grade III**) the vagina). Due to limitations of transperineal ultrasound, it was not possible to distinguish between descent of the small bowel (enterocoele), sigmoid colon (sigmoidocoele) and uterus. In addition, peritoneocoele could not be visualised (defined as widening of the rectovaginal space over 2cm without any descending viscera [20]). Severity of middle compartment prolapse was graded according to the maximal descent of the descending structure (e.g. small bowel) relative to the vagina: reaches the **upper** third **(grade I)**, **middle** third **(grade II)** or **lower** third **(grade III)** [20].

MRI

On dMRI a cystocoele, enterocoele, sigmoidocoele and uterine/ vaginal vault descent were graded in relation to the pubococcygeal line (PCL) (defined as a line drawn from the last coccygeal joint to the inferior aspect of the pubic symphysis on MRI [21]). Maximal descent below the PCL: **grade I** – **less than 3cm**, **grade II** – **3 – 6cm** and **grade III** – **more than 6cm** [21].

Rectocoele

On transperineal ultrasound a rectocoele is a bulge from the rectal ampulla over the perineal body [22]. On posterior transvaginal ultrasound a rectocoele is the bulge of the rectal ampulla towards the vaginal probe. On dMRI, a rectocoele is bulge of the anterior rectal wall beyond the expected anterior rectal wall. A rectocoele was defined as **normal** (0 – < 2cm), **moderate** (2 – 4cm) and **large** (>4cm).

Intussusception

The infolding of the rectal wall can be seen on posterior transvaginal ultrasound and dMRI and graded according the Oxford Radiological Grading System (23,24). Recto-rectal (grade I – II) intussusception was considered a normal variant [23].

Levator plate and anal sphincter integrity

On endoanal ultrasound, the internal and external anal sphincters were examined; any defects in the sphincters were described in their radial and cranio-caudal extent. Internal anal sphincter thickness was measured (normal 1 – 2 mm) [25]. On endovaginal ultrasound the integrity of the levator plate muscles was graded (0-6 **mild**, 7-12 **moderate**, >13 **severe**) [26].

Functional Features

Dyssynergy was defined as a failure to relax or a paradoxical increase in the anorectal angle when straining or attempting to defecate. On TPFUS poor co-ordination and poor propulsion were evaluated during Valsalva by measurement of the anorectal angle at rest, on squeeze and on straining and by estimating the propulsive force exerted. Coordination was considered abnormal if the ratio of anorectal angle measured at rest compared to on straining was greater than or equal to 1. Abnormal propulsive effort was subjectively determined by the experienced ultrasound practitioner performing the scan. Bladder neck descent was evaluated on TPFUS as descent >2cm in relation to the pubic bone indicates poor support [19].

On dMRI, the inability to expel more than 70% of the paste was defined as incomplete evacuation. The anorectal angle was also measured, and similar parameters as mentioned above were used for determining abnormal values.

RESULTS AND FINDINGS ON IMAGES

Table one outlines the features seen on each imaging modality.

Table 1: The anatomical and functional features seen on imaging

	Feature on defecation MRI

			Y	N
Feature on integrated total pelvic floor ultrasound	Rectocele	Y	3	0
		N	1	16
	Intussusception	Y	0	1
		N	0	19
	Enterocele	Y	2	1
		N	0	17
	Cystocele	Y	6	1
		N	1	12
	Functional	Y	4	2
		N	8	6

1. Anatomical Features - Anterior Compartment

Bladder Neck Descent (Anterior Transvaginal Ultrasound) (Figure 1)

There were fifteen women with no bladder neck descent (<2cm), two with bladder neck descent of 2cm and three with bladder neck descent over 2cm (<2cm usually considered ,'normal'). Of the six parous women two had no bladder neck descent (<2cm), two had bladder neck descent of 2cm and three had bladder neck descent >2cm.

Cystocoele (Transperineal Ultrasound, dMRI) (Figure 2)

Seven demonstrated a cystocoele on transperineal ultrasound (four grade I, three grade II). Seven had a cystocoele on dMRI (six grade I, one grade II). Six had a cystocoele on both modalities (grading the same in five of the six cases, grade higher on transperineal ultrasound in one). Of the six parous women, four had cystoceles on transperineal ultrasound (one grade I, three grade II) and four had cystocele confirmed on both ultrasound and dMRI (grading lower in three cases, grading the same in one case).

2. Anatomical Features - Middle and Posterior Compartments (Figures 2 and 3)

There were five women with posterior compartmental anatomical features on TPFUS and dMRI and one on dMRI only.

Rectocoele (Transperineal and transvaginal ultrasound, dMRI)

Four rectocoeles were visualised (two cases were from parous women); three on both modalities (2 – 4cm on transperineal ultrasound and dMRI) and one on dMRI only (2.6cm on dMRI and 0.5cm on transperineal ultrasound). The largest was 2.5 cm on ultrasound and 2.7cm on dMRI. There were four cases with a rectocoele less than 2cm on TPFUS and two less than 2cm on dMRI (i.e., expected normal variant).

There were no rectocoele seen on transvaginal ultrasound.

Enterocoele (Transperineal and transvaginal ultrasound, dMRI)

Three enterocoele were seen (two on both modalities (one grade II on both modalities, one grade I on dMRI and grade II on transperineal ultrasound) and the only parous case was seen on ultrasound only (grade III)). Re-review of the images for the case where a grade III enterocoele was seen on TPFUS but not on dMRI confirmed there was no other structure descending on dMRI.

There were no enterocoele on posterior transvaginal ultrasound scanning.

Intussusception (Transvaginal ultrasound, dMRI)

There was one case of intussusception (seen on TPFUS only (grade III on posterior transvaginal ultrasound, grade II on dMRI)). There were nine with grade I – II intussusception on posterior transvaginal ultrasound (five of which are parous women) and two with grade I – II intussusception on dMRI (none of which are parous women).

3. Anatomical Features - Anal Sphincter and Levator Plate Integrity

Endoanal scanning of the anal sphincters demonstrated an intact internal anal sphincter in all (mean and median thickness 2mm, range 1 – 3.9) and an intact external anal sphincter in 18/20.

Endovaginal scanning of the levator plate showed a defect in the levator plate in 3/20, and all three cases were parous women.

4. Functional Features (Figure 4)

A high proportion displayed functional features (co-ordination and/or propulsive problems on evacuating), particularly on dMRI (50% incomplete evacuation, three of six parous women included). There were six with functional features on TPFUS (none were parous women) and twelve with functional features on dMRI (including three of six parous women). Four had functional features on both, eight on dMRI only, two on TFUS only.

DISCUSSION

This is the first series to examine anatomical and functional features on TPFUS and dMRI in asymptomatic subjects. It has shown that a range of abnormalities may be found without symptoms. This highlights the complexity of pelvic floor dysfunction and serves as a reminder that symptoms cannot be automatically contributed to radiological findings. It also calls into question 'normal' parameters on imaging. Recent consensus documents have provided definitions for the interpretation of defaecatory pelvic floor imaging [28,29]. However, we should continue to strive to understand the range of findings seen on imaging and their relation to the presence or lack of symptoms. Consensus for TPFUS interpretation is still awaited.

Previous Studies

Three previous studies examined ultrasound findings in health with relation to defaecatory function [11–13]. Brusciano found 22% of healthy controls displayed dyssynergy compared to 53% of patients and 13% of healthy controls demonstrated recto-rectal intussusception compared to 51% of patients [11]. Van Outryve showed paradoxical movement of the puborectalis in 30% of asymptomatic subjects compared to 85% of patients [12]. Dietz visualised a discontinuity of the anterior rectal wall in 12% of 171 asymptomatic nulliparous women (depth of herniation 10 to 25mm) [13]. There is one previous study of dMRI in asymptomatic volunteers (a rectocoele seen in 8 out of 10 subjects (average size 25.9mm) [10]) and Goh performed dynamic MRI (no contrast expulsion) on 25 female asymptomatic volunteers (three demonstrated cystocoele and three uterocervical prolapse [9]).

Anatomical Aspects

Our study demonstrates the presence of abnormal findings (rectocoele, enterocoele, intussusception cystocoele) on dMRI and TPFUS in asymptomatic women. This reiterates that there are many factors contributing to pelvic defaecatory dysfunction; an isolated anatomical abnormality may not cause symptoms. It emphasises the importance of interpreting pelvic floor imaging in context [8,27].

Examination of these subjects calls into question normal anatomical parameters although given the small sample size, 'normal' parameters on TPFUS cannot be redefined. On DP, Palit suggests a rectocoele should only be pathological if 4cm in depth and the true relevance of an enterocoele has been questioned [6]. Supine dMRI (where evacuation is difficult) may underestimate measurements of pathology compared to DP (for example, intussusception) [13]. However, even the limited studies of dMRI and dynamic MRI in health call for the reevaluation of pathological values [9,10]. Given the position and lack of rectal gel used during TPFUS, one may expect a relative underestimation of pathology on ultrasound too [20]. Perhaps, if the volunteers had undergone TPFUS with contrast or DP or upright dMRI even more anatomical features may have been demonstrated. (Contrast was not used because of the previous use of TPFUS without contrast showing pathology [2] and it was not possible to access an open magnet for upright MRI scanning.)

A total of four rectocoeles (i.e., ≥2cm) were visualised. In three subjects a rectocoele was seen on both modalities and in one it was only seen on dMRI (only measured 0.5cm on transperineal ultrasound). The largest rectocoele was 2.5 cm on transperineal ultrasound and 2.7cm on dMRI. These are similar results to Shorvon [7] (17 of 21 women had a rectocoele on DP only 1 was over 2cm [38]). However, Palit [6] found a rectocoele up to 3.9cm in health (26 of 28 subjects had a rectocoele with a mean depth of 2.5cm). Dietz and colleagues have found the depth of herniation of a rectocoele on transperineal ultrasound is up to 25mm in health [13] but have also found that depth of rectocoele is associated with symptoms of obstructed defaecation [29]. There appears to be a spectrum on rectocoele size on imaging in both health and within those with symptoms. Traditionally, a rectocoele of 2cm or more on defaecatory imaging and 1cm or more on transperineal ultrasound is considered pathological. However, our study and others demonstrate a wide range of normal variability. This means management decisions in patients cannot be based on depth of rectocoele alone (e.g., surgical repair of a rectocoele). Other factors, such as stool quality [30], determine which rectocoele causes symptoms.

There were no rectocoele seen on posterior transvaginal ultrasound. Splinting from the vaginal probe may mean only large rectocoeles are demonstrable [31].

This series only showed one grade III intussusception on TPFUS but none on dMRI (no grade IV – V on either modality). More intussusception was seen on ultrasound than dMRI (though still mainly grade I – II). Visualisation of intussusception on dMRI relies upon evacuation of contrast. TPFUS avoids the problem of retained contrast preventing the rectal wall from infolding, however it may be that an intussusception cannot develop to its' full extent with propulsion alone.

Recto-rectal intussusception is widely accepted as a normal variant. Palit found 20% of women displayed recto-rectal intussusception on DP but there were no cases of recto-anal intussusception [6]. However, Shorvon found intussusception which impinged on the internal anal canal orifice in 50% of volunteers who evacuated enough contrast to assess rectal wall infolding (10/20 women) [7]. Intussusception may cause constipation or incontinence [23]; intussusception on DP in patients may have a different morphology to asymptomatic subjects [8].

There were three enterocoeles visualised on TPFUS and two on dMRI. There was one case where a grade III enterocoele was visualised on transperineal ultrasound but not dMRI. This may be due to a positional change or a lack of rectal contrast (may obliterate the rectovaginal space and prevent small bowel descent). Similarly, Shorvon found 2 out of 21 women had a possible enterocoele on DP (no contrast was used so it was not possible to confirm exactly which structure was descending) [7]. It is not clear what the sequela of an enterocoele visualised on DP is in the patient population [32].

Cystocoele was a frequent finding on both imaging modalities (mainly grade I only). Schreyer observed a cystocoele in 6 out of 10 asymptomatic volunteers on dMRI [10]. Goh surmised that cystocoele was a normal finding during dynamic MRI; this may also be the case for dMRI and TPFUS [9].

Functional Aspects

A high proportion of subjects displayed functional features, particularly on dMRI (50% displayed incomplete evacuation). Younger women may prefer transperineal ultrasound to defaecatory imaging [33]. The young cohort examined here may explain these findings, but it also emphasises that defaecatory dynamics should be interpreted with caution and may not represent real life [27,34]. Supine dMRI has already been associated with incomplete evacuation [27]. Inadequate effort needs to be excluded prior to a diagnosis of dyssynergy [35] and the observation of certain features, for example a 'trapping' rectocoele, are only possible if evacuation takes place. Palit observed three different patterns of evacuation in DP in health: the range of 'normal' defaecatory dynamics may be wider than previously appreciated [6].

Thirty percent of volunteers displayed functional features on TPFUS, similar to previous literature [11,12]. All those who demonstrated functional features on TPFUS were nulliparous (as were most women in this cohort, so this may not be of relevance). The two subjects with poor co-ordination on TPFUS only displayed poor co-ordination on posterior transvaginal scanning. An endoluminal probe may prevent the subject from freely bearing down and impede movement [36,37]. The observation of poor propulsion on TPFUS is highly subjective.

Overall, there was poor agreement between dMRI and TPFUS for functional abnormalities. The high proportion of subjects with 'functional' abnormalities in this cohort, combined with the poor agreement between modalities for ‘functional’ abnormalities highlights the difficulty in diagnosing functional pelvic floor problems. Indeed, previous studies highlight poor agreement between various modalities for the diagnosis of dyssynergy [38].

Manometry was not felt to be mandatory in these cases as the aim of this study was to examine imaging and manometry is also not a reliable method for diagnosis of dyssynergy [38].

Limitations

This cohort does not represent the patient population usually seen in pelvic floor clinic in terms of age, menopausal status, and parity. There were more nulliparous subjects, this may relate to the availability of volunteers but also may indicate that parous women are more likely to suffer with symptoms. Imaging results were not correlated to clinical examinations or anal manometry data which may limit significance of findings. Defaecation MRI served for comparison with TPFUS. However, given that there is no ‘gold standard’ imaging tool for the pelvic floor and little is known of normal findings on dMRI it is difficult to understand the true relevance of any differences between the two tests. With regards to assessing intussusception, incomplete evacuation of rectal gel during dMRI may prevent rectal wall infolding [27]; lack of rectal contrast during ultrasound avoids this making it difficult to directly compare results of dMRI and TPFUS. It was not possible for asymptomatic subjects to undergo DP due to the radiation exposure necessary for this procedure. As there are more published studies of the examination of DP in asymptomatic subjects than any other modality it would be interesting to compare TPFUS with DP. In terms of future development, it may be valuable to re-assess the volunteers in 5 to 10 years’ time. Those with anatomical features may develop symptoms with increasing parity and age.

CONCLUSIONS

This study outlines the range of findings encountered in health and is the first series to examine anatomical and functional features on TPFUS and dMRI in asymptomatic subjects. Abnormal findings (rectocoele, enterocoele, intussusception, cystocoele) are seen on dMRI and TPFUS in asymptomatic women. This study is not large enough to redefine 'normal' values. However, it helps us to appreciate the range of findings and understand symptoms cannot be automatically attributed to abnormal findings on imaging. There are many contributing factors and pelvic floor imaging must be interpreted in context.

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