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NEW IMAGING TECHNIQUES (S RAIS-BAHRAMI AND K PORTER, SECTION EDITORS)

Use of Dynamic MRI of the Pelvic Floor in the Assessment of Anterior Compartment Disorders

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Abstract

Purpose of Review Approximately 25% of women in the USA suffer from pelvic floor disorders. Disorders of the anterior compartment of the pelvic floor, in particular, can cause symptoms such as incomplete urinary voiding, urinary incontinence, pelvic organ prolapse, dyspareunia, and pelvic pain, potentially negatively impacting a woman's quality of life. In some clinical situations, clinical exam alone may be insufficient, especially when patient's symptoms are in excess of their pelvic exam findings. In many of these patients, dynamic magnetic resonance imaging (dMRI) of the pelvic floor can be a valuable imaging tool allowing for comprehensive assessment of the entire pelvic anatomy and its function.

Recent Findings Traditionally, evaluation of the anterior compartment has been primarily through clinical examination with occasional use of urodynamic testing and ultrasound. In recent years, dMRI has continued to gain popularity due to its improved imaging quality, reproducibility, and ability to display the entire pelvic floor. Emerging evidence has also shown utility of dMRI in the postoperative setting. In spite of advances, there remains an ongoing discussion in contemporary literature regarding the accuracy of dMRI and its correlation with clinical examination and with patient symptoms.

Summary Dynamic pelvic MRI is a helpful adjunct to physical examination and urodynamic testing, particularly when a patient's symptoms are in excess of the physical examination findings. Evaluation with dMRI can guide preoperative and postoperative surgical management in many patients, especially in the setting of multicompartmental disorders. This review will summarize relevant pelvic floor anatomy and discuss the clinical application, imaging technique, imaging interpretation, and limitations of dMRI.

Keywords Anterior compartment · Dynamic MRI of the pelvic floor · MR defecography · Urinary incontinence · Pelvic organ prolapse

This article is part of the Topical Collection on *New Imaging Techniques*

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Introduction

The term pelvic floor disorder encompasses a variety of conditions including pelvic organ prolapse, urinary incontinence, and a range of defecatory dysfunctions. In the USA, the prevalence of pelvic floor disorders is approximately 25% among nonpregnant women 20 years of age or older, with 17% suffering from moderate-to-severe urinary incontinence [1].

This review focuses on anterior compartment disorders, which involve the bladder, urethra, and their associated support structures. Anterior compartment disorders account for the majority of pelvic floor disorders and can have a negative impact on a woman's quality of life. Patients with anterior compartment disorders can have a variety of symptoms including incomplete emptying, urinary incontinence, symptomatic bulge, dyspareunia, and pelvic pain. Women often have at least one or more risk factors including advanced age, multiparity, pelvic surgery and trauma, chronic increase in abdominal pressure such as with chronic constipation or chronic obstructive pulmonary disease, obesity, vigorous lifting, injury to the pudendal nerve, connective tissue disorders such as Ehlers-Danlos syndrome, and family history of pelvic floor disorders [1].

While physical exam and occasionally urodynamic testing are fundamental in diagnosing and guiding appropriate management of pelvic floor disorders, dynamic magnetic resonance imaging of the pelvic floor (dMRI) can be an important adjunctive tool that can potentially alter surgical management in select patients with pelvic floor disorders [2–5]. This is especially true in cases where pelvic organ prolapse quantification system (POP-Q) and urodynamic testing are insufficient or inconclusive and the patient's symptoms are in excess of the clinical exam findings. Dynamic pelvic MRI allows for comprehensive assessment of pelvic anatomy and function without the use of ionizing radiation. The pelvic floor, including all three compartments and their complex support structures, is imaged with high resolution and excellent soft tissue contrast. Furthermore, changes during strain and evacuation can be visualized dynamically and reported objectively. Visualization of the three compartments simultaneously by dMRI facilitates the evaluation of multicompartmental disorders and has been shown to change surgical management in up to 67% of patients [6]. This article will review the pelvic floor anatomy, describe a typical dMRI exam protocol, discuss imaging analysis of common anterior compartment pathology, and review the use of dMRI in the postoperative patient.

Anatomy

Understanding the complex anatomy of the pelvic floor is essential to accurately recognize various pathologies. The field of view in dMRI includes the bladder and urethra in the anterior compartment; the uterus, cervix, and vagina in the middle compartment; and the rectum and anal canal in the posterior compartment. The primary components of the pelvic floor support system include the endopelvic fascia, pelvic diaphragm, and urogenital diaphragm, each of which have elements that support the bladder and urethra.

Endopelvic Fascia

The endopelvic fascia is a thin superior layer of fibromuscular connective tissue that covers the pelvic viscera and levator ani complex and inserts into the arcus tendineus fascia pelvis. The endopelvic fascia has several components. Anteriorly, the pubocervical fascia extends from the pubic bone to the cervix, providing support to the urethra and bladder neck. In addition, the three condensations of the endopelvic fascia known as the urethral ligaments include periurethral, paraurethral, and pubourethral ligaments (Fig. 1a). These structures also provide support to the urethra and bladder neck. The anterior vaginal wall and its attachments to the levator ani muscles and arcus tendineus fascia pelvis also provide support to the urethra and bladder in a similar fashion as a "sling" or a "hammock" [7] (Fig. 1b).

The parametrium and paracolpium are the fascial extension to the pelvic sidewalls which arises from the uterus and cervix and from the vagina, respectively. The parametrium forms condensations which are the cardinal and uterosacral ligaments that support the uterus and upper vagina. The posterior extension of the endopelvic fascia between the vagina and rectum is the rectovaginal fascia.

Levator Ani Complex

The levator ani complex and ischiococcygeus (coccygeus) muscles form the pelvic diaphragm, which tones and elevates the pelvic organs in a superior and anterior fashion. The levator ani complex is comprised of the puborectalis, pubococcygeus, and iliococcygeus muscles. Of these, the puborectalis muscle, which arises from the pubic bone anteriorly and creates a sling around the anorectal junction forming the urogenital hiatus, keeps the pelvic floor organs together and against the pubic bones, preventing prolapse. The iliococcygeus muscle is horizontally oriented with an inferior concavity and attaches to the arcus tendineus and coccyx, best observed in the coronal view. The pubococcygeus arises from superior pubic ramus and attaches to the arcus tendineus and coccyx, also best seen in coronal view.

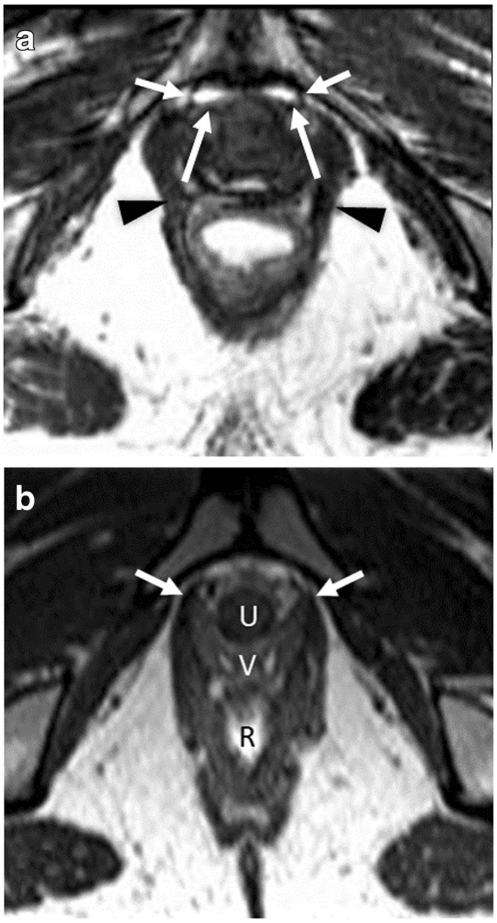

Fig. 1 Anatomy of urethral support structures. **a** 3D Axial T2-weighted image in a 63-year-old female demonstrates maintained pubourethral (short arrows) and periurethral ligaments (long arrows). The puborectalis muscles are also seen (arrowheads). **b** Axial T2-weighted image in a 29-year-old female demonstrates the "hammock" support from the normal H-shape of the vagina (V) and the symmetric vagino-levator attachments (arrows). Urethra (U) and rectum (R) are also labeled

Urogenital Diaphragm

The urogenital diaphragm forms the inferior pelvic floor consisting of muscle and connective tissue which attach to the pubic symphysis, ischial rami, and perineal body. The urethra and vagina pierce through the urogenital diaphragm. The muscle component is comprised of the sphincter urethrae, which encircles the urethra providing continence, and the deep transverse perineal muscle, which provides support to the distal vagina.

MRI Technique

Dynamic MRI protocols vary among institutions. At our institution, the patient is asked to fast for 4 h. Some institutions may use a mild bowel preparation to decrease stool and gas in the rectum, which can help prevent artifact. The technicians are trained in providing education and important instructions before and during the MRI to optimize the exam and provide a more comfortable environment for the patient. Patient preparation and education are critical to acquiring a high-quality dMRI exam. The patient is asked to completely empty the bladder and bowel prior to the exam so that during the exam the bladder begins to partially fill. Over distention can decrease accuracy by underestimating bladder prolapse and limiting evaluation of other compartments [8].

At our institution, 120 mL of sterile lubricating jelly is instilled into the rectum using a syringe to simulate defecation and assess for complete evacuation. Additionally, 10–20 mL of jelly is instilled into the vagina. No filling of the bladder is required due to the intrinsic high signal of urine on T2-weighted imaging as it partially fills with urine during the course of the exam.

The exam is typically performed on a 1.5 Tesla (T) MR scanner with the patient in a supine position with a pillow under the knees. A 3T MR scanner can also be used, although this can increase susceptibility artifact associated with bowel gas. In claustrophobic patients, the exam can be performed in a 0.25T or 0.5T open MRI in a sitting position. While this may be physiologic, an open MRI is not widely available and typically has diminished image quality due to poor signal-to-noise ratio. Intravenous contrast is unnecessary for dMRI.

Once the patient is positioned with a phased array surface coil centered on the pubic symphysis, a large field of view T2-weighted localizer is acquired to include the pelvic floor and identify anatomic landmarks. Next, fast (turbo) spin echo technique with optimized isotropic T2-weighted 3-dimensional (3D) imaging is performed (for example, 3D SPACE—Sampling Perfection with Application optimized Contrast using different flip angle Evolution) with thin slices (1 mm) obtained at rest, which can be reconstructed in multiple planes and are used to evaluate many of the pelvic floor support structures including the urethral ligaments and levator ani musculature. Subsequently, T2-weighted half-Fourier acquisition single-shot turbo spin echo (HASTE) images in coronal, sagittal, and axial planes are obtained through the pelvic organs at rest and during strain as the patient performs Valsalva maneuver. For the evacuation images, midsagittal T2-weighted HASTE images are acquired as the patient is evacuating. At least 15 midsagittal images are obtained during each evacuation attempt, so the movement can be evaluated on a cine display. This is repeated for a second evacuation attempt. Effective evacuation is assessed with near complete emptying of the rectal gel. If the rectal gel is not emptied by the second evacuation attempt, additional attempts are made to ensure at least partial emptying. In patients with partial or no rectal gel emptying, the technician assesses effort during the evacuation phase by evaluating for protrusion of the anterior abdominal wall. Post-evacuation axial or coronal imaging can be obtained to assess for lateral hernia or lateral prolapse as suggested by the Society of Abdominal Radiology (SAR) Disease-Focused Panel (DFP). This can be especially beneficial in protocols that only perform sagittal strain and evacuation images. At our institution, the axial and coronal strain images that are performed can typically provide the necessary information. After the evacuation images, the examination is completed.

Imaging Analysis

Image interpretation begins with review of the three orthogonal T2-weighted sequences acquired during the resting state to evaluate the basic anatomy and position of the pelvic organs. The 3D coronal T2-weighted sequence provides additional anatomic detail. Subsequently, strain and evacuation images are evaluated for functional information.

The rest images provide a point of reference when interpreting strain and evacuation images. The pubococcygeal line (PCL) is the most commonly used line of reference and is drawn from the inferior border of the pubic symphysis to the first or second coccygeal joint in the midsagittal plane. This line demarcates the pelvic floor and corresponds to the levator plate. The midpubic line (MPL), originally described by Singh et al., is less frequently used [8]. This line runs along the longitudinal axis of the pubic symphysis corresponding to the vaginal hymen and has been shown to have moderate correlation between clinical and MRI findings [9]. Additional lines of reference such as the perineal line (PL) have also been suggested but are not widely used [10]. The preference for PCL versus MPL varies among radiologists (Fig. 2a). A retrospective study by Lieneman et al. found correlation to exist between dMRI and clinical exam using the PCL for the anterior compartment and the MPL for the posterior compartment [11]. In a review by Broekheis et al., no clear advantage was demonstrated among PCL, MPL, and PL [12]. We will use PCL, as this is the most common practice.

The compartmental reference points are the bladder base for anterior compartment, tip of the cervix or vaginal apex in patients with hysterectomy for middle compartment, and anorectal junction for posterior compartment (Fig. 2b). Disorders of the anterior compartment diagnosed on dMRI include distortion of the supporting structures, cystocele, urethral hypermobility, and urethral muscle deficiency.

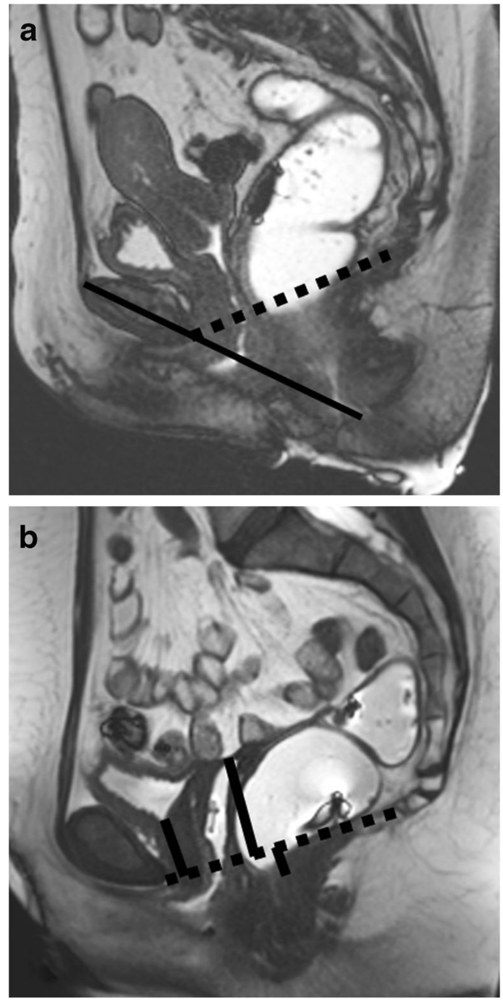

Fig. 2 Reference lines. Midsagittal T2-weighted HASTE images obtained during rest in two different patients. **a** The PCL (dashed line) is drawn from the inferior pubis to the last visible coccygeal joint. The MPL (solid line) is drawn along the longitudinal axis of the pubic symphysis. **b** The reference line for the anterior compartment (first perpendicular line) extends from the PCL (dashed line) to the bladder neck. The reference line for the middle compartment (second perpendicular line) extends from the PCL to the vaginal apex in this patient who has undergone a hysterectomy. The reference line for the posterior compartment (third perpendicular line) extends from the PCL to the anorectal junction

Distortion of Urethral Support Structures

The muscles, ligaments, and fascia are assessed by characterizing their signal intensity and integrity on dMRI. The complex pelvic floor support structures can become lax or disrupted and involve the anterior compartment in isolation or in conjunction with the middle and posterior compartments. Ligaments and fascia appear as thin structures, whereas muscles can vary in thickness. All three have homogeneous low signal intensity on T2-weighted imaging. Increase in signal intensity, fraying of the muscle fibers, symmetric or asymmetric thinning, and complete disruption are pathologic findings seen with pelvic floor disorders. Dynamic pelvic MRI can demonstrate pathology associated with anterior compartment support structures including urethral ligaments, pubocervical fascia, and puborectalis muscle which can result in a cystocele and urethral hypermobility. In particular, anatomic defects of the pubourethral ligaments may contribute to stress urinary incontinence in women.

The levator ani complex can be easily identified on dMRI. The iliococcygeus muscle can be of varying thicknesses between rest and stress measuring 2.9–3.9 mm [9]. The puborectalis muscle typically measures 4.9–6.5 mm and can have slight asymmetry between the right and left muscles [9]. The pubococcygeus component is difficult to differentiate from the iliococcygeal muscle. Levator ani complex injury can be seen on dMRI as attenuation, increased signal, or focal disruption of the muscle fibers that may become more pronounced on dynamic images (Fig. 3). Levator ani complex injury has been documented in 19–28% of women after vaginal delivery [13, 14]. Lockhart et al. performed dMRI before and after delivery demonstrating a direct association between levator tears and pelvic organ prolapse due to pregnancy and delivery [15]. Others have also shown an association between levator ani complex defects and prolapse, especially in the anterior compartment [13, 16]. As measured by dynamic MRI, independent of prolapse status, women with levator defects have perineal structures located more distally and have larger genital hiatuses [17].

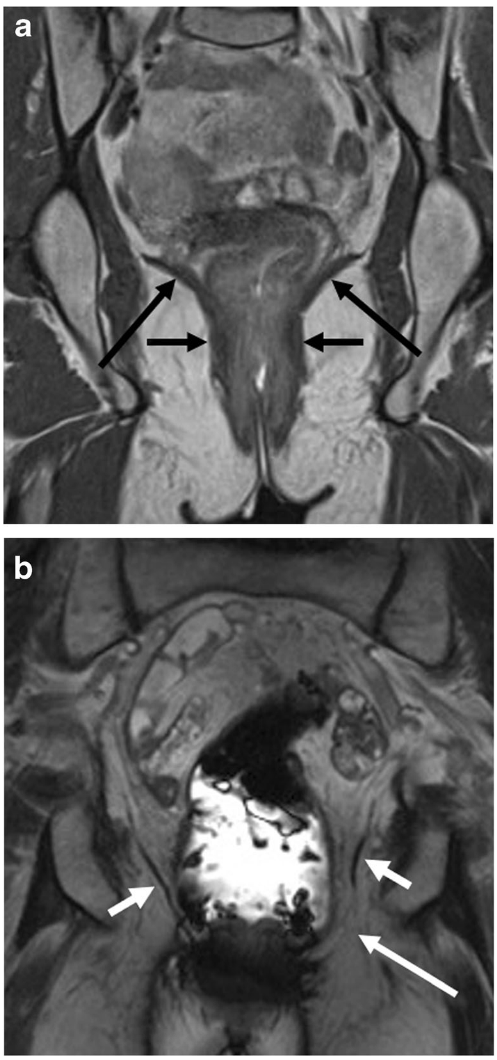

Fig. 3 Levator ani complex abnormality. **a** 3D Coronal T2-weighted image in a 19-year-old female demonstrates symmetric levator ani complex with normal thickness illiococcygeus muscle (long black arrows) and puborectalis muscles (short black arrows). **b** Coronal T2-weighted HASTE image performed at rest in an 86-year-old female demonstrates atrophy of the illiococcygeus muscles (short white arrows) with focal defect on the left (long white arrow) with early changes of a lateral hernia

The H line and M line are measurements used to evaluate the levator hiatus. The H line is the distance from the inferior pubic symphysis to the posterior anorectal junction, reflecting the anteroposterior distance. The H line normally measures < 6 cm; an increase in the distance results in abnormal widening of the levator hiatus which is graded as mild when 6–8 cm, moderate when 8–10 cm, and severe when > 10 cm. The M line is the distance from the PCL to the distal aspect of the H line at the anorectal junction. The M line normally measures < 2 cm; an increase in distance results in abnormal pelvic floor descent which is graded as mild when 2–4 cm, moderate when 4–6 cm, and severe when > 6 cm.

Cystocele

Cystocele, or prolapse of the anterior compartment, refers to descent of the bladder base. Cystoceles usually present at strain or defecation but can also occur at rest. With increasing severity, a cystocele can elongate the pelvic floor and protrude into the anterior vagina, causing a palpable bulge and may be associated with bladder symptoms including urinary incontinence, and/or voiding dysfunction. This can develop with weakening of the pubocervical fascia and the puborectalis muscle [18].

At rest, the normal bladder neck sits above the PCL. With strain, the bladder neck normally sits no lower than 1 cm below the PCL line [19]. On dMRI, cystocele is easily graded in reference to the PCL using the "rule of three" where descent of the bladder 1–3 cm below the PCL is mild, 3–6 cm below the PCL is moderate, and > 6 cm below the PCL is severe (Table 1, Fig. 4) [20]. Many studies have stressed the importance of the dynamic component of the scan to assess for cystocele, including Arif-Tiwari et al. who compared defecatory and

Table 1 Anterior compartment prolapse grading based on the pubococcygeal line (PCL)

Grade	Distance from the PCL
Mild	1–3 cm below
Moderate	3–6 cm below
Severe	> 6 cm below

The inferior descent of the bladder neck below the PCL is used for grading. Similar grading scale is used for the middle compartment using the tip of the cervix to evaluate for uterine prolapse

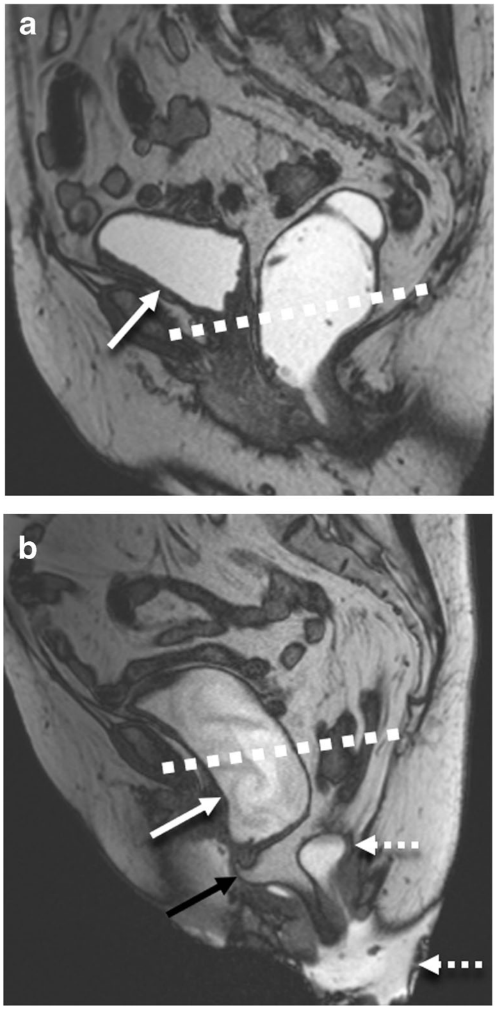

Fig. 4 Cystocele. Midsagittal images in a 77-year-old female demonstrate **a** normal position of the bladder (white arrow) at rest and **b** inferior descent of the bladder during evacuation (white arrow). Adequate evacuation is demonstrated with near complete emptying of the rectal gel. Also, note the vaginal prolapse and widening of the rectovaginal space with development of the peritoneocele (black arrow)

nondefecatory (Valsalva maneuver) images in 237 symptomatic women. They demonstrated significantly more cystoceles on defecatory images (83.1%) with a median descent of 3.4 cm below PCL during evacuation compared to cystoceles seen on nondefecatory images (45.6%) with a median descent of 1 cm below PCL during Valsalva maneuvers [21••].

On clinical exam, prolapse is objectively staged using a standardized assessment known as the pelvic organ prolapse quantification examination (POPQ), using points Aa and Ba as the anterior points with the hymen as the reference point [22]. This exam is performed in the dorsal lithotomy and/or standing position while asking the patient to perform a Valsalva maneuver. Point Aa is along the anterior wall approximately 3 cm proximal to the hymen and ranges from − 3 to + 3 cm. Point Ba is the most distal point on the anterior vaginal wall and ranges from − 3 cm to + TVL (total vaginal length). Prolapse is then staged from 0 to 4. Stage 0 represents no prolapse. Stage 1 describes prolapse where the most distal aspect is > 1 cm proximal to the hymen. Stage 2 prolapse is within 1 cm of the hymen, < 1 cm proximal and distal to the hymen. Stage 3 prolapse protrudes > 1 cm distal to the hymen but < 2 cm less than the total vaginal length. Stage 4 prolapse describes complete eversion with the distal aspect of the prolapse protruding to at least 2 cm less than the total vaginal length (Fig. 5).

Urethral Hypermobility

The normal urethra is retropubic and perpendicular to the pelvic floor on the midsagittal view at rest and strain. Occasionally, there may be slight horizontal angulation of the urethra.

In patients with urethral hypermobility (UH), the urethra will have a more drastic horizontal rotation during strain/evacuation secondary to deficient urethral ligaments, which can lead to stress urinary incontinence. In clinical practice, hypermobility is diagnosed using the Q-tip test with a change in the angle by 30 degrees or greater during strain. In cases where UH is not identified, urodynamic studies can be performed to assess Valsalva leak point pressures and urethral closure pressures [23]. Similar to the clinical Q-tip test, dMRI demonstrates UH when the angle of the urethra changes by 30 degrees or greater (Fig. 6). A severe cystocele can result in abnormal descent of the urethrovesical junction, which can mask urinary incontinence symptoms if concurrent UH is present [24, 25].

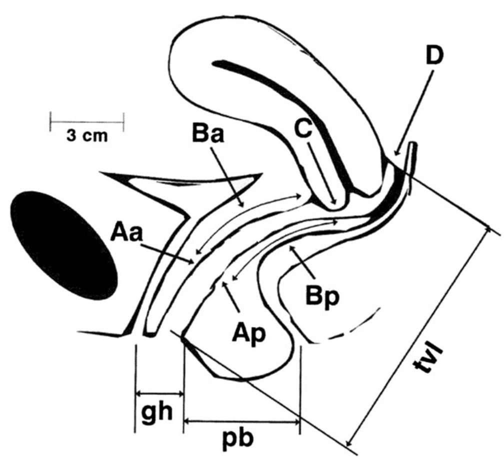

Fig. 5 Aa, point A anterior; Ap, point A posterior; Ba, point B anterior; Bp, point B posterior; C, cervix or vaginal apex; D, posterior fornix; gh, genital hiatus; pb perineal body; tvl total vaginal length. Reprinted from Am J Obstet Gynecol, 175 (1), Bump et al., The standardization of terminology of female pelvic organ prolapse and pelvic floor dysfunction, pages: 10–17, Copyright (1996), with permission from Elsevier [22]

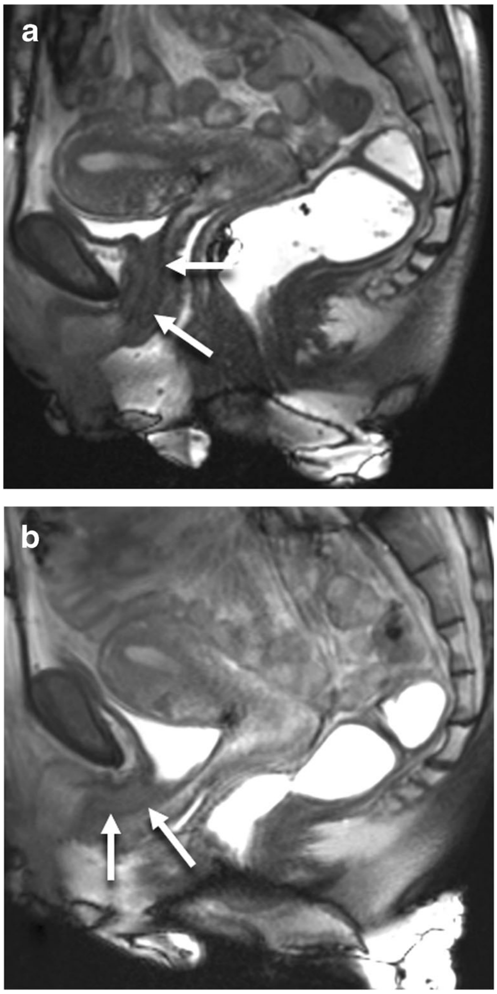

Fig. 6 Urethral hypermobility. Midsagittal T2-weighted HASTE image in a 72-year-old female **a** at rest and **b** during evacuation demonstrating horizontal rotation of the urethra by nearly 90 degrees (white arrows). Additional attempts at evacuation were performed (not shown) as the patient only partially emptied the rectal contents

Urethral Muscle Deficiency

The normal urethra has a targetoid appearance on axial T2-weighted images. The mucosa, submucosa, and outer striated muscle are hypointense, while the middle smooth muscle layer is hyperintense. Shortened urethra and loss of sphincter muscle can be assessed on dMRI and are seen with intrinsic sphincter deficiency. Patients usually present with stress urinary incontinence, similar to UH. A shortened urethra measures < 3 cm longitudinally on midsagittal images [26••]. Additionally, thinning of the striated urethral sphincter muscle is also associated with incontinence [27, 28], although this correlation is controversial [26••]. Bladder funneling, which represents widening of the proximal urethra, is associated with intrinsic sphincter deficiency [29].

Urethral sphincter weakening can result in urethral diverticulum. This can appear in the setting of obstruction with subsequent infection of the paraurethral glands. The diverticulum can be of varying sizes, with larger ones creating a fluid-filled saddlebag appearance around the urethra. MRI is the imaging modality of choice for identifying urethral diverticulum. The dynamic component of dMRI is not necessary to establish this particular diagnosis.

Multicompartment Evaluation

Diagnosis of multicompartment involvement can be difficult with clinical analysis alone, despite its frequent occurrence. Dynamic pelvic MRI provides visualization and functional analysis of all three compartments and can be particularly useful when a patient's symptoms are greater than expected based on the clinical exam. In cases of complex and multicompartmental disorders, preoperative evaluation with dMRI can often alter surgical management [2–4].

Impairment of the middle compartment support structures can lead to uterine or vaginal prolapse. Middle compartment prolapse is graded similar to cystocele using the "rule of three" [20].

Patients with a normal pelvic floor maintain abdominopelvic contents no deeper than 5 cm below the posterior vaginal wall. However, laxity of the rectovaginal fascia can result in an enterocele, peritoneocele, or sigmoidocele, which are easily recognized on dMRI, but difficult to assess clinically.

Prolapse in the posterior compartment is referred to as a rectocele and results from anterior bulging of the anterior rectal wall. Clinically, this is seen or felt as a bulge at or beyond the hymen. Other disorders of the posterior compartment which can also be assessed with dMRI include pelvic dyssynergia, intussusception, and fecal incontinence.

Postoperative Imaging

The utility of dynamic pelvic MRI in the postoperative state of the pelvic floor has not been as widely adapted as in the preoperative setting. Most clinicians use physical exam, urodynamic testing, and ultrasound to monitor postoperative changes and assess for complications. Static multiplanar pelvic imaging with and without intravenous contrast can evaluate for postoperative complications such as infection and hemorrhage.

Analysis of surgical material used in the anterior compartment, including midurethral slings and urethral bulking agents for stress urinary incontinence, can be performed with MRI, although this is usually not necessary. The material used for midurethral slings typically appears as thin long hypointense structures supporting the urethra. The slings are placed tension-free and are anchored into soft tissue structures. The location varies and includes retropubic and transobturator. Complications such as bladder erosion secondary to midurethral slings can be seen on MRI as loss of fat plane with embedding of the sling in the bladder wall [30].

Most urethral bulking agents used for stress urinary incontinence appear as circumferential hyperintense material in the muscle of the urethra on T2-weighted images [30]. The bulking agents can mimic a urethral diverticulum. Occasionally, susceptibility artifact may be noted within the urethra, possibly secondary to air, hemosiderin, or calcifications [30]. Recurrence of urinary incontinence may occur if the bulking agent becomes reabsorbed or extruded into the adjacent tissues.

In the late postoperative period, dMRI can evaluate for recurrent or new pelvic organ prolapse, or evaluate for an alternative etiology of persistent symptoms that did not improve following surgery. Alt et al. found that although clinical exam may be slightly more sensitive than dMRI in showing recurrent issues of the anterior compartment after surgery, dMRI was significantly superior to clinical exam for diagnosing recurrent multicompartment defects, as well as for diagnosing new posterior compartment prolapse after anterior mesh repair [31••]. Furthermore, at the 5-year postoperative period, dMRI had better correlation with patients' subjective impressions of their pelvic floor symptoms compared to physical exam [31••].

Limitations of dMRI

While dynamic MRI is a useful tool in identifying complex pelvic floor disorders, several pitfalls have limited its routine use. Measurements based on dMRI, clinical examination, and intraoperative findings for POP often depend on the compartment and measuring technique, which introduces variability. Gousse et al. reported high sensitivity, positive predictive value, and negative predictive value when correlating cystocele on dMRI with intraoperative findings [32]. Alternatively, Gupta et al. found poor agreement between findings on dMRI and clinical exam in all three compartments [33], and Ramage et al. demonstrated poor correlation of dMRI with patient-reported symptom severity [34•]. Fauconnier et al. found good intra- and inter-observer reliability using dMRI, however, demonstrated poor correlation with clinical exam findings in all three compartments [10]. A study by Rosenkrantz et al. showed that POP was observed on dMRI in asymptomatic women, which was of unclear significance and suggested that clinical correlation is necessary [35•]. The range of results among these studies demonstrates the ongoing discussion on the best practice for dMRI use which requires further research.

The subjective assessment of the patient's effort to strain and maximally evacuate during the exam is typically performed by trained technicians. This can be difficult if a patient is confused or uncomfortable during the dynamic portion of the exam. Quality assurance should be routinely performed to optimize the technique. Additionally, physiology effects of gravity are also not evaluated on a 1.5T MRI.

Furthermore, the exam is time-consuming requiring an outpatient appointment and morning preparation. In straightforward cases, the exam can incur costs that may outweigh any added clinical benefit. Clinical exam, urodynamic studies, and even translabial ultrasound can also provide the essential information needed in the majority of preoperative and postoperative situations.

Conclusion

Dynamic MRI is a reproducible, high-resolution exam which can identify disorders involving the organs and support structures of the anterior compartment, providing a visual correlation to clinical findings. This can be particularly helpful in patients with a complex history or confounding exam and in patients with multicompartment disorders. The addition of dynamic imaging allows for visualization of the functional changes in pelvic floor disorders between rest, strain, and defecation resulting in better correlation with the patient's symptoms. While dMRI is not a substitute for clinical assessment, it can be used as an adjunctive tool with the ability to overview the entire pelvic floor. This allows one to objectively assess the complex pelvic floor structures, identify multicompartment disorders, and plan for surgical repair.

Compliance with Ethical Standards

Conflict of Interest Ayushi Gupta, Prerna Raj Pandya, My-Linh Nguyen, Tola Fashokun, and Katarzyna J. Macura each declare no potential conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

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period demonstrated that clinical exam may be more sensitive than dMRI in diagnosis of recurrent or de novo POP in the anterior compartment. The authors also showed that dMRI was significantly superior to clinical exam for diagnosing recurrent multicompartment defects and POP in the posterior compartment.

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