MRI of pelvic floor dysfunction: a practical review.

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Learning objectives

The purpose of the study is to review the anatomy and etiology of pelvic floor weakness and to highlight the role of MRI as a non invasive method in the assessment of pelvic floor dysfunction in females.
Background

Pelvic floor dysfunction (PFD) is a major medical and social problem. It is a common disorder that can seriously jeopardize a woman's quality of life.

Weakening of the female pelvic floor is a prevalent and debilitating disorder. It results in abnormal descent of the urinary bladder, the uterovaginal vault, and the rectum, resulting in urinary incontinence, fecal incontinence, and pelvic organ prolapse. Pelvic floor weakening affects approximately 50% of women older than 50 years.

Pelvic floor weakness has many complex causes. The risk factors for PFD include pregnancy, multiparity, advanced age, menopause, obesity, connective tissue disorders, smoking, chronic obstructive pulmonary disease, and any other factors that result in a chronic rise in intraabdominal pressure.

Traditional imaging methods in assessment of pelvic floor weakness include urodynamics, voiding cystourethrography, ultrasonography of the bladder neck and anal sphincter, and fluoroscopic cystocolpodefecography.

To make a definite diagnosis of pelvic prolapse preoperatively, dynamic MR is an alternative to conventional fluoroscopic or sonographic examination, with the advantage of providing greater details, and thus helping the surgeon to have a good preoperative plan.

The pelvic floor is classically described as comprising three compartments: an anterior compartment containing the bladder and urethra, a middle compartment containing the vagina and uterus, and a posterior compartment containing the rectum (Fig. 1). The supporting structures of the female pelvis consist of a complex network of fascia, ligaments (fascial condensations), and muscles attached to pelvic bone. These structures form three contiguous layers from a superior to an inferior location: the endopelvic fascia, the pelvic diaphragm, and the urogenital diaphragm (Fig. 2).

**The endopelvic fascia**, the most superior layer of the pelvic floor, covers the levator ani muscles and pelvic organs in a continuous sheet. The endopelvic fascia provides three levels of fascial support (Fig. 3).

There are three groups of ligaments supporting the female urethra (Fig. 4). These ligaments and anterior vaginal wall provide a hammock-like support and play an important role in maintaining urinary continence in women (Fig. 5). Therefore, a tear in the pubocervical fascia or periurethral ligament can lead to a cystocele, urethral hypermobility, or urinary incontinence.
In the middle compartment, elastic condensations of endopelvic fascia known as the paracolpium and parametrium provide support to the vagina, cervix, and uterus, preventing genital organ prolapse.

The posterior compartment contains an important anchoring structure for muscles and ligaments, called the perineal body or central tendon of the perineum, which lies within the anovaginal septum and prevents the expansion of the urogenital hiatus. The rectovaginal fascia is a portion of the endopelvic fascia that extends from the posterior wall of the vagina to the anterior wall of the rectum and attaches to the perineal body, preventing posterior prolapse (Fig. 6). A tear in the rectovaginal fascia can be inferred from the presence of an anterior rectocele or enterocele.

**The pelvic diaphragm** lies deep to the endopelvic fascia and is formed by the ischiococcygeus muscles and the levator ani, which is composed of the iliococcygeus, puborectalis, and pubococcygeus muscles. In healthy people these muscles continuously contract, providing tone to the pelvic floor and maintaining the pelvic organs in the correct position. The two most important components of the levator ani are the iliococcygeus and puborectalis muscles (Fig. 7).

The location of the urogenital diaphragm is caudal to the pelvic diaphragm and anterior to the anorectum. The urogenital diaphragm is composed of connective tissue and the deep transverse muscle of the perineum, which originates at the inner surface of the ischial ramus. It has multiple attachments to surrounding structures including the vagina, perineal body, external anal sphincter, and bulbocavernosus muscle (Fig. 8).
Images for this section:

**Fig. 1:** Schematic in the midsagittal plane shows the three functional anatomic compartments of the female pelvis and the most important pathologic conditions that may occur in each: the anterior compartment (red), containing the bladder (B) and urethra (U); the middle compartment (blue), containing the uterus (Ut), cervix, and vagina (V); and the posterior compartment (green), containing the anus, anal canal, rectum (R), and sigmoid colon. A fourth "virtual" compartment called the cul-de-sac (violet) is also shown. Note that the puborectalis muscle surrounds the bladder neck, vagina, and rectum. PS = pubic symphysis.

**Fig. 2:** Schematic in the coronal plane at the level of the vagina (V) depicts the three levels of pelvic floor support: the endopelvic fascia, the pelvic diaphragm (levator ani level), and the urogenital diaphragm. B = bladder, BC = bulbocavernosus muscle, F = femur, I = iliacus muscle, IOM = internal obturator muscle, Is = ischial ramus, PB = puborectalis muscle, PC = pubococcygeus muscle, UT = uterus.

**Fig. 3:** Endopelvic fascia. Midline sagittal FSE T2-weighted MR image shows the bladder (B), uterus (U), and rectum (R). The three levels of the endopelvic fascia, upper to lower, are indicated: level I (solid yellow outline) suspends the uterus and upper vagina to the uterosacral ligaments and pelvic sidewalls, level II (curved green lines) suspends the posterior bladder wall and middle vagina, and level III (curved solid pink line) suspends the urethra and lower vagina. The lower anterior vaginal wall and lower posterior urethral wall are fused without intervening fasciae. The uterosacral ligaments (dashed yellow line) and pubic insertion of the endopelvic fascia through the Arcus tendineus levator ani (dashed pink line) are projected as they are offset from the midline.

**Fig. 4:** Normal female pelvic floor anatomy. Axial T2-weighted MR images show the ligaments that support the female urethra at superior (a) and inferior (b) levels: the periurethral ligaments (arrows), which arise from the puborectalis muscle (*); paraurethral ligaments (arrowheads in a), which arise from the lateral wall of the urethra (U); and periurethral and pubourethral ligaments (curved arrow in b), which arise from the pubic bone and extend to the ventral wall of the urethra. Note the typical H- or butterfly-like shape of the vagina (V) and the close apposition of the puborectalis muscle to the vaginal wall. PS = pubic symphysis, R = rectum.

**Fig. 5:** The urethra is supported by a hammock of anterior vaginal wall suspended to the levators (pubococcygeus muscles) and the fascial attachments to the tendinous arch of the pelvic fascia

**Fig. 6:** Normal female pelvic floor anatomy. Sagittal T2-weighted MR image shows the pubocervical fascia (#) and the rectovaginal septum (S). The levator plate (arrowheads) at rest follows the vaginal and anorectal angulation and the perineal body (PB) in the anovaginal septum. B = bladder, PS = pubic symphysis, R = rectum, U = urethra, Ut = uterus, V = vagina

Fig. 7: Normal female pelvic floor anatomy. Coronal (a) and axial (b) T2-weighted MR images show the normal configuration of the iliococcygeus (arrowheads) and pubococcygeus (*) muscles. Arrows in a indicate the external anal sphincter. A = anal canal, C = coccyx, PS = pubic symphysis, R = rectum, U = urethra, V = vagina.

**Fig. 8:** Schematics show the anatomy of the female pelvic floor at the level of the pelvic diaphragm (a) and the urogenital diaphragm (b). The pelvic diaphragm is composed of the ischiococcygeus muscle and levator ani muscle, the latter of which consists of the iliococcygeus, puborectalis, and pubococcygeus muscles. The location of the urogenital diaphragm is caudal to the pelvic diaphragm and anterior to the anorectum. It is composed of connective tissue and the deep transverse muscle of the perineum. It originates at the inner surface of the ischial ramus and has multiple attachments to surrounding structures including the vagina, perineal body, external anal sphincter, and bulbocavernosus muscle. C = coccyx, GM = gluteus muscle, IT = ischial tuberosity, PS = pubic symphysis
Findings and procedure details

Interpretation and Grading of Pelvic Floor Disorders with MR Imaging: The HMO System

To help standardize interpretation and grading of PFD with MR imaging, the HMO (H line, M line, organ prolapse) system was developed, which is applied to a midsagittal rapid half-Fourier T2-weighted image obtained during maximal patient strain. On the midsagittal image obtained during maximal strain, three points of reference are first defined: A, the inferior margin of the symphysis pubis; B, the convex posterior margin of the puborectalis muscle sling (the posterior levator plate); and C, the junction between the first and second coccygeal segments. Two anatomic fixed references in the HMO system are (a) the pubococcygeal line (PCL), which is drawn between points A and C, and (b) point B. The degree of pelvic floor relaxation is then graded as a measure of two components: hialtal widening (enlargement) and hialtal descent.

The puborectal hiatus line (H line) allows grading of the maximal widening of the pelvic sling in the anteroposterior dimension during straining and is the linear distance between points A and B. (Fig.9).

HMO Grading of Pelvic Organ Prolapse

Pelvic organ prolapse is any protrusion of a given organ (bladder, urethra, vagina, uterus, small bowel, or rectum) through the puborectal hiatus or the H line. In case of the rectum, prolapse may also be defined as bulging of the anterior rectal wall anterior to the transverse perineus muscle (anterior rectocele). This constitutes the final O component of the HMO classification system and is measured as the shortest distance between the most caudal aspect of a given organ during the Valsalva maneuver and the H line. The HMO system allows consistent definition, differentiation, and grading of pelvic organ prolapse and pelvic floor relaxation (Table. 1,2).

Interpretation of Dynamic MRI:

(A)Urinary Incontinence and Anterior Compartment Prolapse:

- Small urethral muscle volume or a short urethra:

The mean normal thickness of the urethral sphincter was reported as 4.3 mm +/- 0.9 (total striated and smooth muscle thickness anteriorly at the midurethra level), and the length of the urethra has been reported as 38 mm +/- 3(Fig. 10).
• **Defects in the Urethral Sphincter:**

A simple urethral diverticulum is round or oval and usually located lateral or posterior to the urethra, a U-shaped diverticulum extends partially around the urethra, and a circumferential diverticulum extends completely around the urethra, often having a "saddlebag" appearance. Urethral diverticula are classically most conspicuous on T2-weighted images, since the fluid-containing cystic cavity is hyperintense relative to the surrounding soft tissues (Fig. 11).

• **Distortion of the urethral support ligaments:**

Normal ligaments are seen as continuous T2 hypointense bands of tissue stretched tight between the points of attachment. Disruption of the urethral ligaments may be complete or partial. In complete disruption, there is discontinuity of the ligament, complete attenuation of a portion of the ligament, or loss of its attachment. In partial disruption, fluttering of the lax ligament or focal thinning or attenuation can be seen (Fig. 12).

• **Level III fascial defect:**

It is recognizable by the drooping mustache sign, which is caused by the fat in the prevesical space against the bilateral sagging of the detached lower third of the anterior vaginal wall from the arcus tendineus fascia pelvis (Fig. 13).

• **Cystocele and Urethral Hypermobility:**

At MR imaging, a cystocele is diagnosed when the bladder base descends more than 1 cm below the PCL. When the bladder base descends, it tends to bulge into the anterior vaginal wall; consequently, eversion of the vaginal mucosa can be observed in severe cases (Fig. 14 and 15).

• **Asymmetric Pubococcygeus Muscle:**

Loss of the symmetric appearance of the pubococcygeus muscle and lateral deviation and thinning or complete attenuation have been shown in patients with urinary incontinence (Fig. 16).

• **Increased Vesicourethral Angle:**

The vesicourethral angle is best evaluated at MR imaging on sagittal images as the angle between the axis of the urethra and the posterior bladder base. A posterior vesicourethral angle below 115° is considered normal; however, this angle is variable in both the continent and incontinent populations and is not a reliable marker in pelvic floor assessment.

• **Enlargement of the Retropubic Space:**
The retropubic space is defined by the distance between the posterior aspect of the symphysis pubis and the anterior urethral wall. It has been shown that the retropubic space may enlarge in incontinent patients. This may be explained as being a result of the damage to the posterior urethral support mechanism, leading to posterior displacement of the urethra.

- **Abnormal Shape of the Vagina:**

The vagina with maintained paravaginal attachments assumes an H-shaped configuration, as seen on axial images. Alteration of the morphologic features of the vagina may be indicative of paravaginal tears. These tears lead to urinary incontinence by weakening the urethral support mechanism provided by the vagina to the middle and distal portions of the urethra embedded in the anterior wall of the vagina. With the loss of paravaginal attachments, the vagina has a flattened appearance (Fig. 16).

**(B) Middle compartment prolapse:**

- **Uterine and Vaginal Vault Prolapse:**

As previously discussed for cystocele, in cases of uterine prolapse the H and M lines are elongated. The vagina loses its normal vertical-oblique orientation and is directed in a more horizontal axis (Fig. 17).

- **Level I and II endopelvic fascial defect:**

In the axial plane, a paravaginal defect in the fascia is visualized as sagging of the posterior urinary bladder wall, caused by the detachment of the vaginal supporting fascia from the lateral pelvic wall, known as the saddlebags sign. A central defect is indicated by sagging of the central part of the urinary bladder posterior wall (Fig. 18).

- **Iliococcygeus muscle in the coronal plane:**

The iliococcygeus muscle is assessed for loss of the normal symmetrical appearance of its muscle slings or defect and/or disruption of its attachment to the obturator internus muscle (Fig. 19).

**(C) Posterior Compartment Abnormalities:**

- **Intussusception and Rectal Prolapse:**

Rectal prolapse is an invagination of the rectal wall and may be classified as internal or external. Internal rectal prolapse may be classified as intrarectal and intraanal internal prolapse. The distance of parietal inversion from the anal verge should be assessed when
evaluating invagination and further classified as intrarectal (distal, middle, or proximal with respect to rectal length (Fig. 20).

- **Descending Perineal Syndrome:**

  On dynamic images, perineal descent can be quantified by measuring the descent of the anorectal junction from the PCL, considered abnormal if exceeding 2 cm. Since the width of the pelvic hiatus is greater in descending perineal syndrome, the H and M lines will be longer as well (Fig. 21).

- **Fecal incontinence:**

  The Anorectal angle (ARA) as measured with dynamic MR was substantially more obtuse in patients with fecal incontinence than in patients with constipation or in control subjects. Also moderate or severe descent of the rectum was noted in patients with fecal incontinence. In addition, results show that abnormal descent of the posterior pelvic floor compartment is often combined with abnormal descent of the middle or anterior pelvic floor compartment.

- **Spastic pelvic floor syndrome- Anismus:**

  MR imaging clearly shows lack of descent of the pelvic floor during defecation and paradoxical contraction of the puborectalis muscle with failure of the ARA to open, thus resulting in prolonged or incomplete evacuation. The puborectalis muscle is frequently hypertrophic and makes a prominent impression on the posterior rectal wall during voiding (Fig. 22).
Fig. 9: Midsagittal T2-weighted single-shot fast SE relaxed image, obtained in a female patient who had undergone hysterectomy, shows anatomic landmarks used in the HMO classification system. Point landmarks are A (the inferior margin of the symphysis pubis), B (the posterior aspect of the puborectalis muscle sling), and C (the junction between the first and second coccygeal elements). Reference lines are the PCL, which is drawn from A to C and is a fixed anatomic reference line; H (the puborectal line), which represents the anteroposterior hiatal dimension and is drawn from A to B; and M, which is the shortest distance between B and the PCL and is a measure of pelvic floor descent. (4) Two components of pelvic floor relaxation. (a) Midsagittal T2-weighted single-shot fast SE image, obtained in a female patient in a relaxed position, shows the two vectors (components) of pelvic floor relaxation or prolapse: widening and descent. On radiologic images, these vectors are defined as an enlarging H and an enlarging M, respectively. H is the anteroposterior dimension of the levator hiatus, whereas M represents the descent of the levator from the PCL. (b) Diagram shows changes associated with pelvic floor descent. (c, d) Diagrams show a normal (c) and a pathologically widened (d) pelvic hiatus.
Table 1: Grading of Pelvic Floor Relaxation.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Hiatal enlargement (cm)</th>
<th>Pelvic floor descent (cm)</th>
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</thead>
<tbody>
<tr>
<td>0 (normal)</td>
<td>&lt;6</td>
<td>0-2</td>
</tr>
<tr>
<td>1 (mild)</td>
<td>6-8</td>
<td>2-4</td>
</tr>
<tr>
<td>2 (moderate)</td>
<td>8-10</td>
<td>4-6</td>
</tr>
<tr>
<td>3 (sever)</td>
<td>&gt;= 10</td>
<td>&gt;= 6</td>
</tr>
</tbody>
</table>
### Table 2: Grading of Pelvic Organ Prolapse


<table>
<thead>
<tr>
<th>Grade</th>
<th>Organ location relative to the H line*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (no prolapse)</td>
<td>Above</td>
</tr>
<tr>
<td>1 (mild or small)</td>
<td>0-2 cm below</td>
</tr>
<tr>
<td>2 (moderate)</td>
<td>2-4 cm below</td>
</tr>
<tr>
<td>3 (sever)</td>
<td>&gt;= 4 cm below</td>
</tr>
</tbody>
</table>
Fig. 10: Intrinsic sphincter deficiency at urodynamics and a short urethral sphincter at MR imaging in a 55-year-old woman. (A) Coronal T2-weighted fast spin-echo image shows a urethra with a length of 2.5 cm between the internal and external meatus (arrowheads). The average length of the urethra in continent women is 38 mm +/- 3. (B) Sagittal single-shot fast spin-echo image obtained during straining shows the short urethra (arrowheads). Note the minimal funnelling at the urethrovessical junction. (C) Coronal MR image obtained in a continent patient for comparison with (A) shows a 3.8-cm-long urethra (arrowheads).

**Fig. 11:** Axial fat suppressed T2W Image showing posterior urethral diverticulum.

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Fig. 12: Complete disruption of the periurethral ligament in a 54-year-old woman with urethral hypermobility and incontinence. R coil = endorectal coil. Axial T2-weighted fast spin-echo image shows an irregular and discontinuous left periurethral ligament (arrow). Note the loss of the left vaginolevator attachment (black arrowhead). The right vaginolevator attachment and right periurethral ligament attachment are intact (white arrowhead).

**Fig. 13:** Static axial T2-weighted at level of proximal urethra shows a level III endopelvic fascial defect, indicated by the "drooping mustache" sign (arrows), misalignment of the urethra (U), and distorted H-shaped vagina (© El Sayed R, El Mashed S, Farag A et al. Pelvic Floor Dysfunction: Assessment with Combined Analysis of Static and Dynamic MR Imaging Findings. Radiology 2008; 248:518-530.)
**Fig. 14:** Midsagittal Dynamic image showing mild Cystocele, urethral hypermobility with rotation to the horizontal plane. Note the presence of associated mild anterior rectocele with intrarectal intussusception.

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**Fig. 15:** Mid sagittal T2 maximum straining image showing mild cystocele and moderate rectal prolapse.

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**Fig. 16:** (A) Symmetric pubococcygeus muscle in a 38-year-old woman without urinary dysfunction. Axial T2-weighted fast spin-echo image shows a normal symmetric H shaped vagina (white arrowheads) and an intact symmetric pubococcygeus portion of the levator ani (black arrowheads). R = rectum. (B) Disrupted pubococcygeus muscle in a 68-year-old woman with urinary incontinence. Axial T2-weighted fast spin-echo image shows the pubococcygeus muscle (black arrowheads), which is completely disrupted on the right with a large gap (arrows). Note the asymmetric configuration of the vagina (white arrowheads), which is "dropping" on the right. R = rectum

**Fig. 17:** Sagittal Dynamic image showing total uterine prolapse.

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**Fig. 18:** Axial T2W Image showing central and right lateral fascial defect with sagging of the urinary bladder on the right side.

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Fig. 19: Coronal T2-weighted image shows mild convex downward deformity of the iliococcygeal muscle (arrow)

Fig. 20: Drawings and corresponding sagittal FIESTA images illustrate degrees of intrarectal intussusception: proximal (a, a’), middle (b, b’), and distal or intraanal (c, c’). Double-headed arrows show the distance from the point of parietal inversion to the anal verge. External rectal prolapse is an invagination of the rectal wall through the anal canal and is a clinical diagnosis.

Fig. 21: Descending pelvic floor syndrome in a 45-year-old multiparous woman with incomplete defecation after hysterectomy and rectopexy. (A) Dynamic MRI obtained with the patient at rest shows a bulging perineum. A cystocele is also evident (arrow). (B) Dynamic MRI obtained during maximal contraction of the anal sphincter shows insufficient pelvic lift. Because of the combination of these three findings, this case meets the criteria for general pelvic floor insufficiency (all three compartments). (C) Dynamic MRI obtained after several defecation maneuvers shows incomplete stool evacuation along with a small rectocele (arrowhead).


Fig. 22: A 70-year-old female with long history of constipation. Sagittal TrueFISP images through the midline pelvis during rest (A), Kegel (B), and attempted defecation (C) show normal levator plate at rest with expected narrowing of the levator plate to anal canal.
angle at Kegel due to contraction of the puborectalis (arrow in B). During attempted defecation, there is paradoxical narrowing of the angle with marked impression on the posterior rectal wall from abnormal contraction of the puborectalis (black arrow in C) instead of relaxation. The anterior bulging of the anterior abdominal wall (white solid arrow in C) and downward displacement of the bladder, vagina, and rectum (in C) signifies increase in intra-abdominal pressure during attempted defecation, features which would not be present during suboptimal effort or if patient had erroneously repeated a Kegel maneuver when instructed to defecate.

Conclusion

MR imaging is a necessary tool in the diagnosis of PFD and it provides good concordance with clinical examination. As abnormalities of the three pelvic compartments are frequently associated, so a complete survey of the entire pelvis is necessary before surgical repair. Static MR Imaging can be also useful to identify the defects responsible for pelvic organ prolapse and stress urinary incontinence, and so help perform site specific repair in surgery, to avoid the high recurrence rates. Findings reported at dynamic MR imaging of the pelvic floor are valuable for selecting candidates for surgical treatment and for indicating the most appropriate surgical approach (Fig. 23).

The concordance of dynamic MR Imaging findings with clinical examination in the staging of pelvic organ prolapse is generally good in this study, yet non significant agreement regarding anterior and superior compartment prolapse was found.
Fig. 23: Diagram summarizing the MRI findings in PFD.

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References


1. Chi TW, Chen SH. Dynamic magnetic resonance imaging used in evaluation of female pelvic prolapse: experience from nine cases. 2007; 23(6):302-8.


