MR Imaging of the Female Pelvic Floor

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1. Risk Factors for Pelvic Floor Defects:

Pelvic floor defects are common and are seen in 50% of parous women, especially over the age of 50 [1-2]. Risk factors include: pregnancy, childbirth, hysterectomy, congenital or acquired connective tissue abnormalities, white race, denervation or weakness of the pelvic floor, advancing age, estrogen deficiency, obesity, smoking and other factors associated with chronically elevated intra-abdominal pressure. Surgery for pelvic organ prolapse and urinary incontinence is performed in 1 of 9 women [3]. Successful surgical treatment for pelvic organ prolapse involves repair of site-specific defects in pelvic floor support. Surgical failures and re-operations, reported in one third of patients, have been attributed to the lack of a thorough preoperative evaluation of the female pelvis and to inadequate diagnosis and staging of pelvic floor dysfunction [2]. MR imaging can be used in the initial evaluation of patients with pelvic organ descent, especially those who have symptoms of multicompartmental involvement and are evaluated prior to a complex pelvic floor reconstruction, or as a problem solving modality for those patients who have failed previous repairs.

2. Pelvic Floor Anatomy:

The primary supportive structures of the pelvis consist of the pelvic fascia and pelvic floor musculature.

The fascial sheaths intertwine to provide a skeleton-like endopelvic fascial framework that provides support for the internal female organs in the center of the pelvis and allows them to maintain their relationship with each other. Pelvic floor has three layers, superior to inferior: endopelvic fascia, pelvic diaphragm, and perineal membrane (formerly called urogenital diaphragm). Pelvic fascia covers the levator ani muscle and viscera in a continuous sheet. Pelvic diaphragm is mainly composed of levator ani muscle, which has three components with different visceral insertions: pubo-coccygeus, ilio-coccygeus, and coccygeus. The perineal membrane is a dense triangular membrane below the levator ani muscles and a transverse sheet of muscles spanning the triangular space between ischiopubic rami. It is located anterior to the anorectum and is penetrated by urethra and vagina [3].

The muscular components of the pelvic diaphragm, the puborectalis part of pubo-coccygeus muscle that forms a sling around the rectum and the ilio-coccygeus muscle that has horizontal orientation and fuses in the midline anterior to coccyx forming a levator plate, are well seen on MR imaging. However, the fascial condensations cannot be directly visualized on MR imaging, therefore their defects can only be assessed indirectly through secondary findings. Progressive weakening of the pelvic floor musculature leads to stretching and tears of the overpowered endopelvic fascia, and subsequently to prolapse of unsupported pelvic organs such as the urinary bladder and urethra (cystocele, urethrocele), the uterus or vaginal apex in post-hysterectomy patient (uterine or vaginal vault prolapse), peritoneal fat or small bowel or sigmoid colon (peritoneocele, enterocele, sigmoidocele), or rectum (rectocele, intrarectal intussusception, complete rectal prolapse).

3. Imaging Technique:

Pelvic coil and fast T2-weighted (T2W) sequences, such as single-shot fast spin echo, half Fourier acquisition turbo spin echo, or steady-state free precession sequences (true FISP) are typically used for

dynamic pelvic floor MR imaging. On the T2W images, the fluid in the bowel and urine in the bladder, as well as pelvic fat have bright signal, which allows clear delineation of the pelvic organs. To achieve good visualization of the vagina and rectum, intraluminal gel (sterile lubricating gel), which gives high T2 signal, should be instilled. About 120 cc of warmed gel is instilled into the rectum, and 20 cc into the vagina. MR imaging of the pelvic floor can be performed without endoluminal contrast, however lack of vaginal and rectal distention may lead to suboptimal evaluation [4-10]. Vaginal gel allows better visualization of the anterior and posterior vaginal walls, therefore improves detection of the apex of the vagina and its inversion, if present, which can be difficult to reveal otherwise. Without rectal distension with gel, adequate straining, evacuation, and rectal emptying cannot be properly documented and recto-vaginal septum defects and posterior rectal wall laxity and intrarectal intussusception may not be visualized during the exam while contributing to defecatory dysfunction in the real life. Also, non-emptying of a large rectocele may obscure an enterocele. Over distention of the bladder can mask prolapse in other compartments, therefore patients are asked to void prior to the study.

Imaging is usually performed in three planes (axial, sagittal, and coronal). Images acquired in the sagittal plane at midline can be viewed in a cine loop to visualize pelvic organs descent during strain maneuvers and Valsalva. Sagittal images are used to evaluate and measure pelvic organ position at rest and their descent during strain. Coronal images are used to assess the symmetry of the levator ani muscles. Axial images are important in the assessment of the levator hiatus, the shape of the vagina, and lateral defects. Patients are imaged in the supine position or in the left lateral decubitus position in the standard closed magnet configuration. For the patients to be imaged in the upright position, the open magnet system can be used. Patients are instructed to perform different maneuvers during the scanning, such as Kegel squeeze or strain and defecation, to allow the dynamic evaluation of the pelvic floor function. The combination of gravity and rectal evacuation maximizes the stress on the pelvic floor. Rectal evacuation during MR scan in supine position is especially important due to diminished effects of gravity in this body orientation. Majority of patients can defecate in the supine position. Some patients need to have their knees bent over the pillow to facilitate rectal emptying. Typically, the study is completed in less than 20 minutes.

4. Anatomical Landmarks on MR Imaging:

The level of the pelvic floor can be defined on MR imaging using the ***pubococcygeal line*** **(PCL)** [4]. PCL is a line extending from the most inferior portion of the symphysis pubis to the sacrococcygeal joint [11]. The advantage of this reference line is that it can be easily drawn and reproduced in all patients, and it is independent of the pelvic tilt.

The degree of descent of the organs within the three pelvic compartments can be evaluated as the vertical distance between the resting and strain positions of the urinary bladder neck, the cervix/vaginal apex, and the anorectal junction in reference to PCL. Slightly different reference points are used in the HMO system [6] for grading pelvic organ prolapsed, where the H-line is used to measure the anteroposterior width of the pelvic hiatus from the pubis to the posterior rectal wall, the M line measures the descent of the levator plate relative to PCL, and the O characterizes the degree of visceral prolapse. Mid pubic line (a line extending along the long axis of the symphysis pubis) that approximates the level of the hymen on clinical exam has also been used for quantitative assessment of prolapse. It is important to establish a consensus with referring clinicians regarding the grading system to be used for reporting of MR imaging findings in order to avoid confusion, to maintain consistency, and to assure that clinicians understand how the measurements are performed so they can correlate them clinically.

5. Imaging Findings:

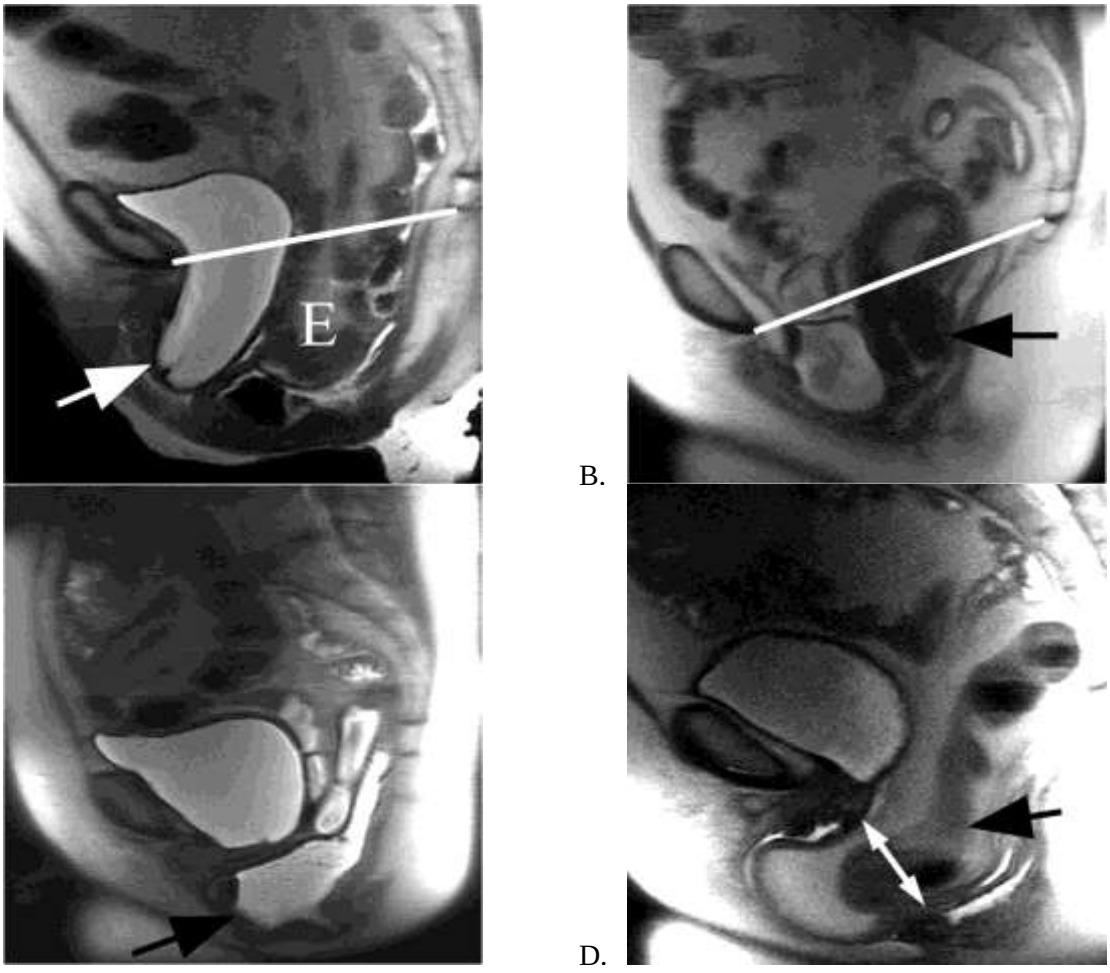
When communicating with the referring clinicians, it is crucial to establish a consistent reporting and grading system for pelvic floor evaluation so that MR imaging findings can be reported effectively. A wide variety of vaginal and abdominal surgical techniques are available for the treatment of pelvic organ prolapse, and these techniques can address site-specific defects. Therefore, the reporting template for a

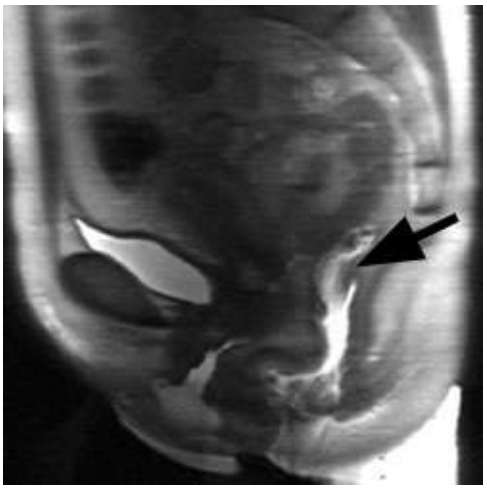
pelvic floor study should include several details that can explain patients' symptoms and pelvic floor defects involved, and can guide management. Consistency in reporting will also facilitate post-surgical follow-up.

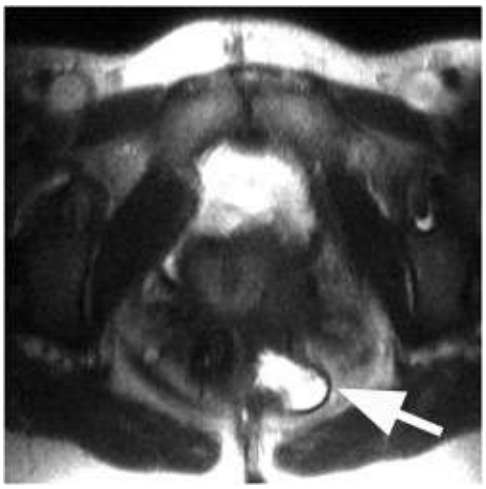
The following findings should be routinely reported: (a) findings for the anterior compartment, such as the presence of urethral hypermobility or cystocele: (b) findings for the middle compartment, such as cervical or vaginal vault descent; (c) findings for the posterior compartment, such as the presence of rectocele, widening of recto-vaginal space, presence and type of enterocele, rectal intussusception, or perineal body defect. The symmetry of levator ani muscle should be evaluated and any defects or lateral trans-levator hernia should be mentioned. Paravaginal attachments should be assessed by evaluation of vaginal shape and vagino-levator attachments. Anorectal angle is helpful to assess in cases of anal sphincter spasm which can contribute to defecatory dysfunction.

Illustrating examples of pelvic floor defects:

A. Urethral hypermobility and cystocele (arrow), enterocele (E)
B. Cervical/uterine descent (arrow) below PCL
C. Rectocele (arrow)
D. Widening of recto-vaginal space and sigmoidocele (arrow)
E. Intra-rectal intussusception (arrow)
F. Levator ani muscle defect and left lateral hernia (arrow)



E. 

F. 

6. **Summary:**

Traditional imaging methods for the assessment of women with pelvic floor weakness include voiding cystourethrography, ultrasonography, and fluoroscopic cystocolpodefecography. However, over the last two decades MR imaging of the female pelvic floor has been shown to be very effective in the detailed pre-operative assessment of the pelvic organ descent [4-10]. When evaluating for cystocele, MR imaging had a sensitivity of 100%, a specificity of 83%, and a positive predictive value of 97% compared with intraoperative findings [11]. When evaluating for middle compartment defects, a sensitivity of 100%, a specificity of 54%, and a positive predictive value of 33% for vaginal vault prolapse, and 83%, 100%, 100% respectively for uterine prolapse were reported when compared with intraoperative findings. MR imaging had a sensitivity of 87%, a specificity of 80%, and a positive predictive value of 91% for enterocele when compared with intraoperative findings [11]. MR imaging is superior in detecting enteroceles in comparison with physical examinations. In addition, MR imaging is able to differentiate the enteroceles according to their contents (small bowel, large bowel, or mesenteric fat). Uterine prolapse and enteroceles are detected more frequently on MR imaging than on fluoroscopy because of better visualization of the cervix and rectovaginal space on MR images. Correct diagnosis of rectocele can be made in 100% of patients studied with MR imaging when compared with intraoperative findings [12]. However, due to the supine position of the patient during MR exam, the severity of the prolapse detected on MR imaging may be less than on fluoroscopy [5].

Pelvic floor defects are a complex group of anatomical and functional problems, and imaging can help in the evaluation of the presence and extent of pelvic floor abnormalities. MR imaging is particularly effective in a comprehensive pelvic floor assessment of integrity of the pelvic floor support structures, of the pelvic organ prolapse, and of the specific defects related to urinary incontinence and defecatory dysfunction [13-18].

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