

# Practical MR Imaging of Female Pelvic Floor Weakness<sup>1</sup>

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## CME FEATURE

See accompanying test at [http://www.rsna.org/education/rg\\_cme.html](http://www.rsna.org/education/rg_cme.html)

## LEARNING OBJECTIVES FOR TEST 5

After reading this article and taking the test, the reader will be able to:

- Use commercially available MR imagers and software to successfully image the female pelvic floor.
- Recognize the appearance of the normal female pelvic floor.
- Identify MR imaging markers of significant pelvic floor damage.

Pelvic floor weakness is common in middle-aged and elderly parous women and is often associated with stress incontinence, uterine prolapse, constipation, and incomplete defecation. Most patients with incontinence and minimal pelvic floor weakness can be treated based on physical examination and basic urodynamic findings. However, in women with symptoms of multicompartiment involvement for whom a complex repair is planned or who have undergone previous repairs, magnetic resonance (MR) imaging can be a useful preoperative planning tool. The MR imaging evaluation is performed with the patient in the supine position, without contrast agents, and within 15 minutes. A multicoil array and a rapid half-Fourier T2-weighted imaging sequence are used to obtain sagittal images while the patient is at rest and during pelvic strain, followed by axial images. On these images, the radiologist identifies the pubococcygeal line (which represents the level of the pelvic floor), the H and M lines (which are helpful for confirming pelvic floor laxity), and the angle of the levator plate with the pubococcygeal line (which is helpful for identifying small bowel prolapse). In the appropriate patient, MR images provide relatively easy three-dimensional conceptualization of the pelvic floor and can significantly influence treatment planning.

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## Introduction

Pelvic floor weakness—abnormal descent of the bladder (cystocele), uterus or vagina (uterine or vaginal vault prolapse), small bowel (enterocele), or rectum (rectocele)—is a significant women's health problem that primarily affects parous women over 50 years of age. Up to 50% of such women have some degree of pelvic prolapse. Symptoms and signs are present in 10%–20% of this group and most commonly include pelvic pressure, protrusion of tissue through the pelvic floor, and urinary incontinence (1–4). In addition to age, the risk factors for pelvic floor weakness include multiparity, menopause, and obesity.

The advent of high-quality surface coils and rapid T2-weighted imaging techniques has made magnetic resonance (MR) imaging a compelling competitor to voiding cystourethrography, ultrasonography, and defecography for the evaluation of these women. The purpose of this article is to describe a technique for production and review of MR images that can be used to quickly and accurately identify significant pelvic floor defects as an aid to treatment planning. In this article, the anatomy of the three compartments of the pelvic floor as well as the normal anatomic support structures, including the levator ani and multiple fascial condensations, are reviewed. Appropriate patient selection parameters to maximize the usefulness of MR imaging in treatment planning are also discussed. A standardized MR imaging protocol is presented that allows for complete imaging of the female pelvis in less than 15 minutes. Finally, several examples of defects such as cystocele, rectocele, and global pelvic floor weakness are presented. All images in this article were obtained as part of trials approved by an institutional review board and after obtaining informed written consent.

## Anatomy

The female pelvic floor can be divided into three compartments: the anterior containing the bladder and urethra, the middle containing the vagina, and the posterior containing the rectum. Each of these compartments is supported by the endopelvic fascia and the levator ani muscle. The two most important components of the levator

ani supporting the pelvic organs are the iliococcygeal and the puborectal muscles. The iliococcygeal muscle is a horizontal, sheetlike structure that arises from the same fibers as the external anal sphincter and then fans out to insert at the pelvic sidewall at the tendinous arch. Posteriorly, the fibers fuse anterior to the coccyx to form a midline raphe called the levator plate. The pubovisceralis, composed of the pubococcygeal and puborectal muscles, inserts just lateral to the pubic symphysis and forms a sling around the rectum. In healthy women at rest, the levator ani muscles are in contraction, thereby keeping the rectum, vagina, and urethra elevated and closed by pressing them anteriorly toward the pubic symphysis (5). The components of the levator ani muscles are clearly seen on T2-weighted MR images.

The pelvic organs are also supported by a series of fascial condensations called ligaments. Elastic condensations of the endopelvic fascia called the parametrium, the uterosacral ligaments, and the paracolpium support the uterus and vagina and prevent genital organ prolapse. The pubocervical fascia extends from the anterior vaginal wall to the pubis and supports the bladder. Loss of this support can lead to hypermobility of the urethra, cystocele, and urinary incontinence (6). The posterior vaginal wall and rectovaginal fascia support the rectum and prevent formation of an enterocele or rectocele. The majority of these fascial condensations are not directly visualized on MR images; however, damage can be inferred from the presence of secondary signs.

## Patient Evaluation and Selection

The mainstay of diagnosis of symptomatic pelvic floor damage is the physical examination. The physician notes the location of several anatomic landmarks when the patient is at rest and at pelvic strain and then scores the degree of pelvic descent (7,8). Physical examination findings are correlated with patient symptoms to determine the operation to be performed. A cystocele alone is treated with a retropubic (Burch) colposuspension, which entails suspending the lateral aspects of the bladder from the pelvic sidewalls. When the fascia is detached from the tendinous arch, a paravaginal fascial repair is added. Uterine prolapse is usually treated with a hysterectomy and

**Protocol for MR Imaging Evaluation of Incontinence and Pelvic Floor Weakness**

Pulse Sequence	Imaging Plane	TR/TE (msec)	FOV (cm)	Section Thickness/Gap (mm)	Flip Angle	Matrix Frequency × Phase	Number of Excitations
Scout	Sagittal	15/5	350–400	10/0	1°	160 × 256	...
HASTE*	Sagittal	4.4/90	300	10/0	180°	128 × 256	1, center low
T2 turbo SE	Axial	5,000/132	200–240	5/inter-leaved	180°	270 × 256	2
T2 turbo SE (optional)	Coronal	5,000/132	200–240	5/1	180°	270 × 256	2

Note.—FOV = field of view, HASTE = half-acquisition single-shot turbo spin echo, SE = spin echo, TR/TE = repetition time/echo time.

\*Repeat this sequence while the patient performs maximal pelvic strain (Valsalva maneuver).

uterosacral suspension, sometimes with the addition of mesh support. For an enterocele, the rectovaginal fascia is reapproximated. Repair of a rectocele entails a posterior colporrhaphy.

The vast majority of patients with incontinence and minimal pelvic floor weakness can be treated based on physical examination and basic urodynamic findings. These patients do not need to undergo MR imaging. Also, many continent, postpartum women will have some degree of pelvic floor weakness. Imaging these asymptomatic women is of no value.

In those patients with symptoms of multicompartiment involvement for whom a complex repair is planned and in those women who have undergone previous repairs, MR imaging can be very useful as a preoperative planning tool. Despite surgeons' best efforts, symptoms recur in 10%–30% of patients, and the cause of the problems often involves compartments of the pelvic floor that were not repaired initially (9). Preoperative MR imaging of the pelvic floor can help determine which compartments of the pelvis are damaged and can help identify specific muscle defects.

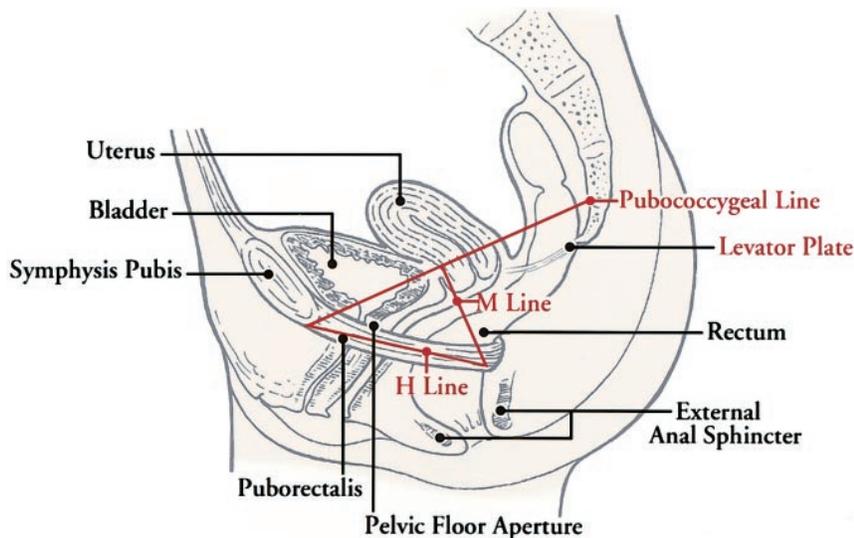
### **MR Imaging Evaluation of Pelvic Floor Weakness**

#### **Imaging Protocol**

Imaging with the patient in the supine position has been shown to be perfectly satisfactory for evaluating symptomatic pelvic floor weakness,

despite the fact that defects are most easily identified when patients are upright (10–14). The MR imaging protocol requires no oral or intravenous contrast agents, and the examination can be completed in 15 minutes. Once familiar with signs of pelvic descent, the radiologist can complete the interpretation in 5–10 minutes.

After the patient has voided, she is positioned on the MR imager table with a multicoil array wrapped low around the pelvis. Scout images are obtained to identify a midline sagittal section that shows the pubic symphysis, urethra, vagina, rectum, and coccyx. Next, 10-mm-thick sagittal images of the midline are obtained with a rapid half-Fourier T2-weighted imaging sequence, such as single-shot fast spin echo (SSFSE; GE Medical Systems, Milwaukee, Wis) or half-acquisition single-shot turbo spin echo (HASTE; Siemens, Iselin, NJ), and a 30-cm field of view. These images are obtained while the patient is at rest and during the Valsalva maneuver. Many patients require coaching to achieve maximal pelvic strain. Next, 5-mm-thick axial T2-weighted images of the pelvic floor centered on the puborectal muscle are obtained with a 20-cm field of view and a standard high-resolution sequence such as fast spin echo. Coronal images are optional. The complete protocol is summarized in the Table.



**Figure 1.** Drawing of the sagittal midline view of the female pelvis shows bony landmarks and the puborectal muscle, also called the levator sling. The pubococcygeal, H, and M lines and the levator plate are delineated in red.

### Image Interpretation

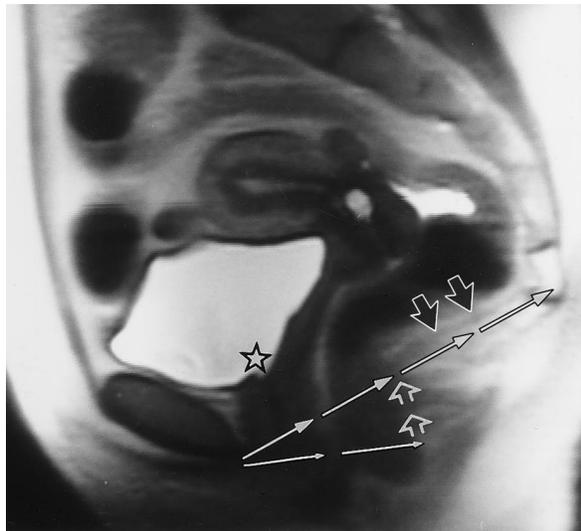
The radiologist should begin the interpretation of the sagittal MR images by drawing the pubococcygeal line, either electronically or by using a wax pencil (Figs 1, 2). This line extends from the inferior border of the pubic symphysis to the last joint of the coccyx and represents the level of the pelvic floor. The distance from the pubococcygeal line to the bladder neck, cervix, and anorectal junction should be measured on images obtained when the patient was at rest and at maximal pelvic strain. The bladder neck is easily identified in all women because of the high T2 signal of urine. The cervix and anorectal junction can be harder to identify; however, a reasonable estimate of their locations is usually possible. In healthy women, there is minimal movement of the pelvic organs, even with maximal strain. In a symptomatic patient, organ descent of greater than 1 cm below the pubococcygeal line indicates pelvic floor laxity, and organ descent greater than 2 cm is often indicative of the need for surgical intervention (15).

The next measurements to be made are the H line and the M line. These lines, which were initially described by Comiter et al (16), are not used by all surgeons but may be helpful for confirming pelvic floor laxity. The H line is the anteroposterior width of the levator hiatus and is

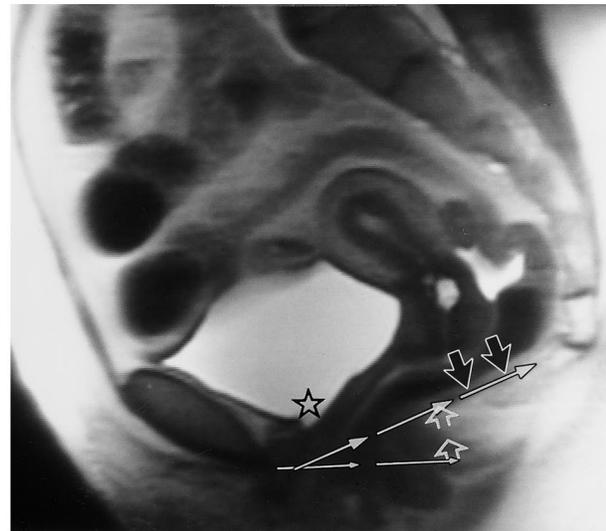
drawn from the inferior aspect of the pubic symphysis to the posterior wall of the rectum at the level of the anorectal junction. The M line is the vertical descent of the levator hiatus and is drawn as a perpendicular line dropped from the pubococcygeal line to the most posterior aspect of the H line. Both of these lines become elongated during the Valsalva maneuver in the patient with pelvic floor laxity. The posterior urethrovesical angle is extremely variable among continent and incontinent women and is of little value in the identification of significant pelvic floor weakness (17).

Finally, the angle of the levator plate with the pubococcygeal line is measured. In healthy women, the levator plate will parallel the pubococcygeal line at rest and during pelvic strain. Increased caudal inclination is an indicator of loss of posterior muscular support (18). Descent of the small bowel more than 2 cm between the vagina and rectum is indicative of enterocele. Anterior bulging of the rectum is evidence of an anterior rectocele. Sphincter tears and rectal ulcers cannot be identified with this MR imaging technique.

On the axial and coronal images, the puborectal and iliococcygeal muscles should be examined for thinning and tears. The width of the levator hiatus has not proved to be significant in the identification of pelvic floor laxity; however, it rarely exceeds 4.5 cm in women with intact pelvic floors. Paravaginal fascial tears can be inferred from posterior displacement of the vaginal fornix



a.



b.



c.

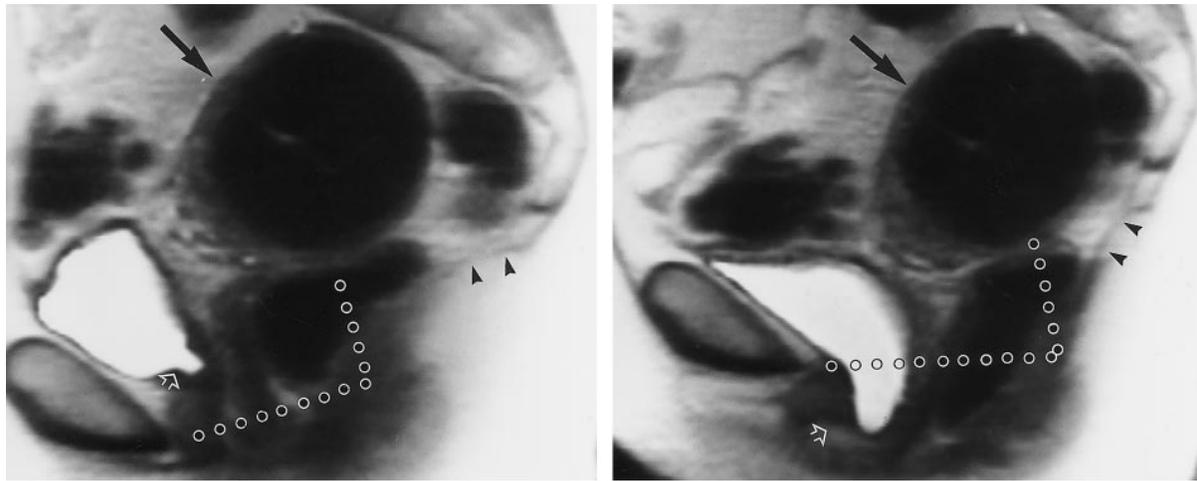
**Figure 2.** Pelvic MR images of a 46-year-old healthy, continent volunteer. (a, b) Sagittal T2-weighted images (2,200/96 [repetition time msec/echo time msec]) of the subject at rest (a) and during pelvic strain (b) show minimal (<1 cm) inferior movement of the pelvic viscera. The bladder neck is marked with a star. The levator plate (black arrows) remains parallel with the pubococcygeal line (upper line of white solid arrows). The H (lower line of white solid arrows) and M (open arrows) lines are less than 5 cm and 2 cm in length, respectively, indicating an intact levator hiatus. (c) Axial T2-weighted image (4,200/12) shows the normal butterfly shape of the vagina. The puborectal sling is intact (arrows). The anterior external urethral sphincter and lateral pubovesical ligaments (arrowheads) support the upper portions of the urethra and are part of the extrinsic continence mechanism.

(19). On axial images, the anterior external urethral sphincter and thin fascial condensations that support the upper portion of the urethra (sometimes called the lateral pubovesical ligaments) can also be seen (20).

**Normal Appearance of the Pelvic Floor**

In healthy, continent women, even with maximal downward pelvic strain, MR images demonstrate minimal descent of the pelvic organs. The bladder neck, vaginal fornices, and anorectal junction all remain at or above the pubococcygeal line. On sagittal images obtained during pelvic strain, the

urethra should maintain its normal, slightly anterior orientation to the bladder base. The H line should measure a maximum of 5 cm and the M line a maximum of 2 cm (21) (Fig 2). On axial images, the entirety of the levator sling should be of similar thickness and homogeneous low signal intensity. The right aspect of the puborectal muscle may appear slightly thinner than the left, a finding that is caused by chemical shift artifact in most cases (22). On coronal images, the iliococcygeal muscle should be intact and upwardly convex. As women age, some thinning of the levator ani muscle occurs normally; however, no tears should be identified. The vagina should have an H-shaped configuration, which indicates adequate lateral fascial support.



a.

**Figure 3.** Stress incontinence in a 42-year-old woman with moderate pelvic floor laxity on physical examination. The H line (from the pubic symphysis to the posterior wall of the rectum) and the M line (from the posterior aspect of the H line to the pubococcygeal line) are delineated by dots. (a, b) Sagittal T2-weighted images (2,200/96) of the patient at rest (a) and during pelvic strain (b) show significant descent of the bladder below the pubococcygeal line, forming a cystocele (white arrow). A large fibroid (black arrow) likely prevents descent of the uterus. On the strain image, the H and M lines are elongated and the levator plate is almost vertical (arrowheads), indicating loss of anterior and posterior support. (c) Axial T2-weighted image (4,200/112) shows intact pubovesical ligaments (arrows) and mild widening of the levator hiatus (distance between asterisks).

b.



c.

### Cystocele and Stress Incontinence

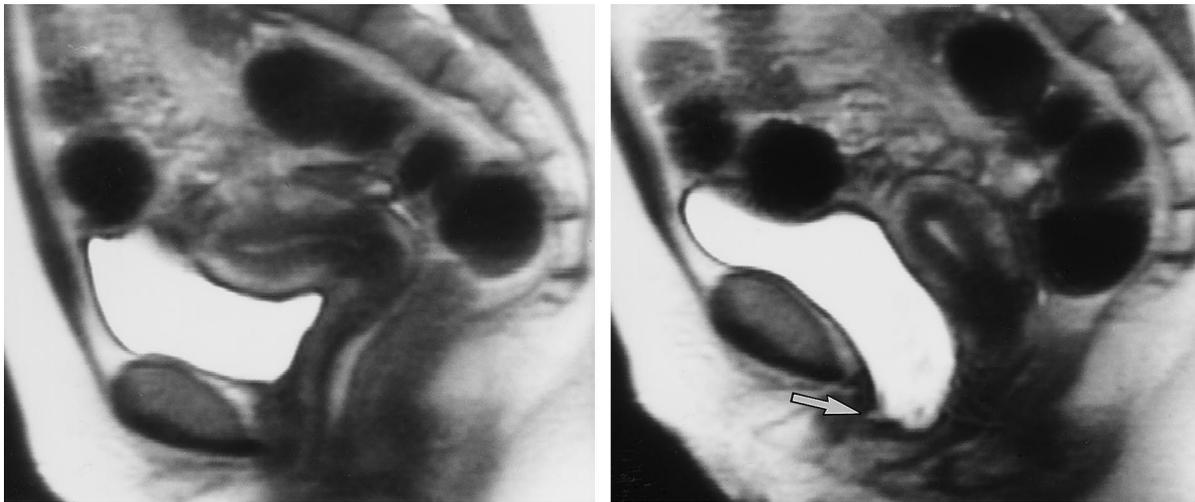
Stretching or tearing of the pubocervical fascia and levator ani muscle allows the posterior aspect of the bladder to descend below the pubococcygeal line and to bulge into the anterior vaginal wall. MR images obtained during pelvic strain show the change in position of the bladder and the resulting cystocele. The H line should exceed 5 cm and the M line should exceed 2 cm (Fig 3). Fascial defects may be midline, lateral, or a combination of the two (23,24). Beaking of the bladder neck at rest and at pelvic strain is a common finding and is not indicative of incontinence.

For uncomplicated stress incontinence, a retropubic urethropexy is the surgical procedure of choice. Loss of intrinsic urethral sphincter integrity and anterior fascial supports of the bladder neck leads to rotation of the bladder and urethra anteriorly and superiorly. In severe cases, the ap-

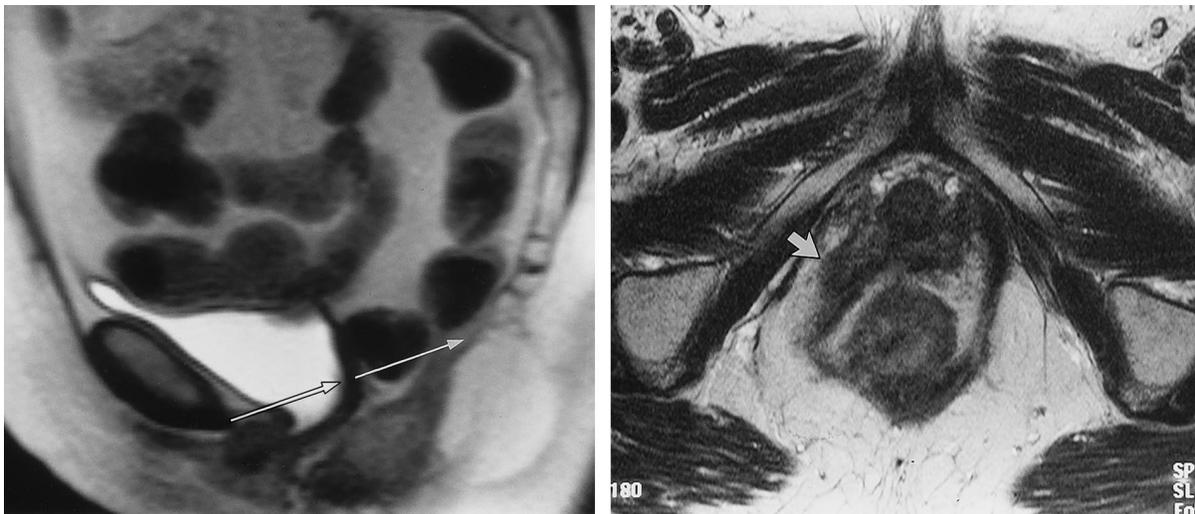
position of the urethra and anterior bladder wall will mask symptoms of stress incontinence. It is important to identify this urethral hypermobility because it usually requires a pubovaginal sling procedure for adequate repair (25) (Fig 4).

### Uterine or Vaginal Vault Prolapse

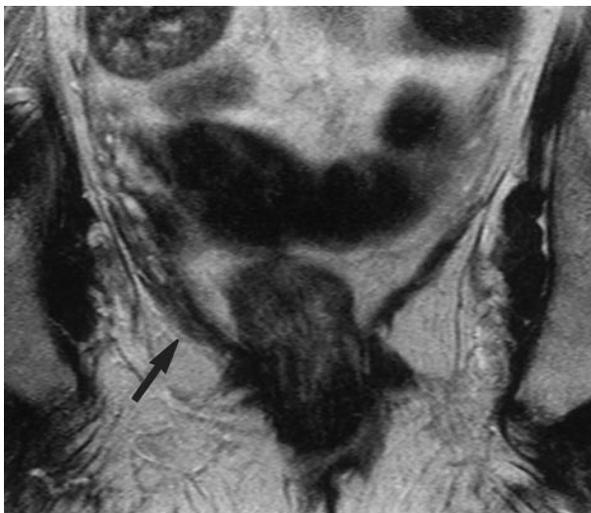
Muscle damage and stretching or tearing of the uterosacral ligaments allows descent of the vaginal fornices and uterus below the pubococcygeal line. In women with such damage on sagittal MR images obtained during pelvic strain, the H and M lines are elongated. On axial images, the cervix is often at the level of the pubic symphysis and there is loss of the normal H shape of the vagina, often with posterior displacement of the fornix on the affected side (Fig 5). In severe cases, the



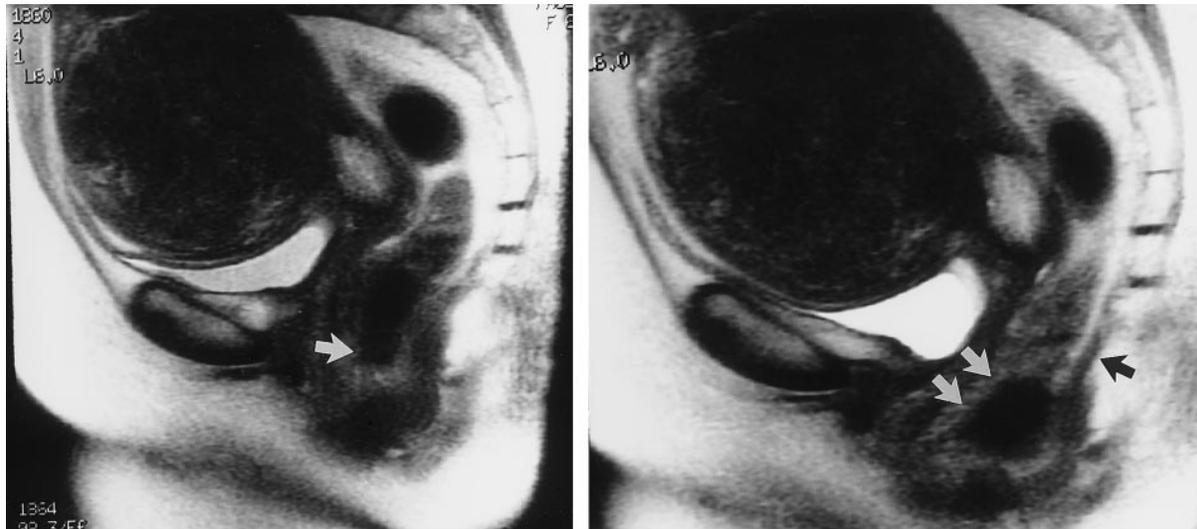
**a.** **b.**  
**Figure 4.** Stress incontinence and incomplete bladder emptying in a 55-year-old woman. **(a)** Sagittal T2-weighted image (2,200/96) of the patient at rest shows the pelvic organs and floor, which have a normal appearance. **(b)** Sagittal T2-weighted image (2,200/96) of the patient during pelvic strain demonstrates development of a cystocele and rotation of the urethra into the horizontal plane (arrow), indicating damage to the internal sphincter.



**a.** **b.**  
**Figure 5.** Firm, painful mass lateral to the left wall of the vagina in a 62-year-old woman. **(a)** Sagittal T2-weighted image (2,200/96) of the patient during pelvic strain shows only minimal descent of the pelvic organs below the pubococcygeal line (arrows). **(b)** Axial T2-weighted image (4,400/112) of the patient at rest shows detachment of the right aspect of the puborectal muscle from the parasymphyseal area and deformation of the right vaginal fornix (arrow). **(c)** Coronal T2-weighted image shows mild convex downward deformity of the iliococcygeal muscle (arrow). The intact, left aspect of the levator ani muscle was in spasm and responded well to biofeedback therapy.



**c.**



**a.** **b.**  
**Figure 6.** Incomplete bowel evacuation and posterior pressure in a 63-year-old woman. Sagittal T2-weighted images (2,200/96) of the patient at rest (**a**) and during pelvic strain (**b**) show descent and anterior bulging of the rectum consistent with a rectocele (white arrows). The levator plate is nearly vertical (black arrow). The large uterine fibroid likely prevents descent of the middle and anterior compartments.

puborectal muscle may be avulsed from its insertion on the pubic rami. On coronal images, the iliococcygeal muscle is flat or downwardly convex.

The standard repair of uterine or vaginal vault prolapse is uterosacral suspension. In severe cases, a sacral colpopexy with mesh might be added.

### Rectocele, Sigmoidocele, and Enterocele

Caudal inclination of the levator plate is an indicator of loss of posterior muscular support. Angulation of greater than  $10^\circ$  is indicative of significant posterior weakness (21). On sagittal MR images obtained during pelvic strain, descent and anterior bulging of the rectum indicates a rectocele (Fig 6). Descent of small bowel loops more than 2 cm into the rectovaginal space indicates tearing of the rectovaginal fascia. Many physicians believe that small bowel loops resting on the sigmoid colon or rectum give patients the feeling of incomplete evacuation and lead to repetitive and unproductive straining. On axial images, loops of sigmoid or small bowel can be seen insinuated between the rectum and vagina.

Treatment for enterocele is a culdoplasty. All posterior fascial defects adjacent to the sigmoid and rectum require posterior colporrhaphy for adequate repair.

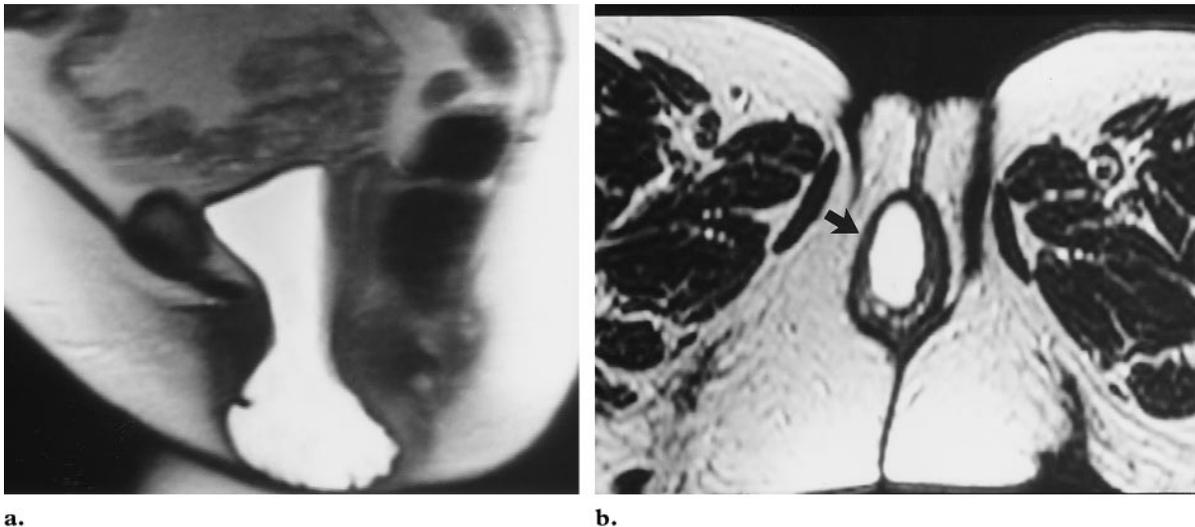
### Reporting MR Imaging Findings

The radiology report should detail the location and number of compartments that demonstrate laxity and the measured descent of the bladder, vagina, and rectum. In some cases, the damage to the pelvic floor may be so severe that all three compartments are involved. This is called global pelvic floor weakness (Fig 7) (26). The presence or absence of enterocele and rectocele should be noted. The location of muscle tears and inferred fascial tears should also be specified.

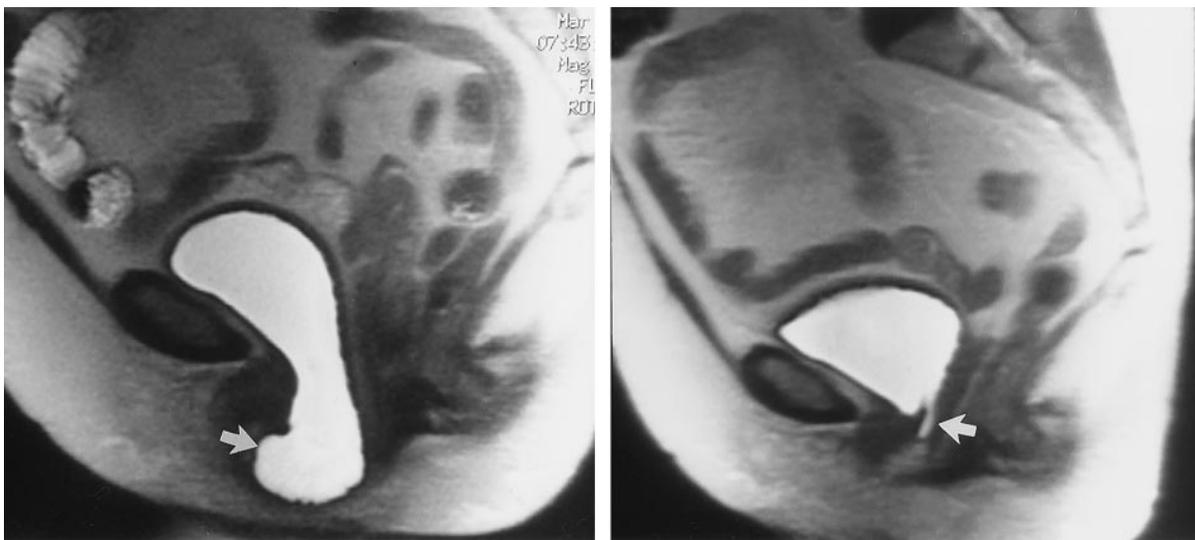
Supporting measurements such as those of the H line, M line, and angle of the levator plate can be reported as desired by the radiologist and referring surgeon. These measurements may be useful for quantification of descent and for comparison with future images in patients who return for evaluation of recurrent symptoms.

### Postoperative Imaging

Although not usually clinically necessary, postoperative imaging can be done to assess pelvic floor integrity in the postoperative patient with persistent or recurrent symptoms. The reparative surgical procedures use few clips, and metallic artifacts are not usually a problem. Many women have been imaged successfully less than 2 months after the initial surgical procedure (27) (Fig 8).



**a.** **b.**  
**Figure 7.** Pelvic pressure and protrusion of tissue through the pelvic floor in a 68-year-old woman. **(a)** Sagittal T2-weighted image (2,200/96) of the patient during pelvic strain shows global pelvic floor weakness with a severe cystocele and more moderate descent of the uterus and rectum. **(b)** Axial T2-weighted image (4,400/112) shows the bladder protruding through the labia (arrow).



**a.** **b.**  
**Figure 8.** Cystocele and vaginal vault prolapse in a 74-year-old woman. **(a)** Sagittal T2-weighted image (2,200/96) of the patient during pelvic strain shows a very large cystocele (arrow). **(b)** Sagittal image obtained with the same parameters after surgical repair of the prolapse shows a very small residual fascial defect containing a small cystocele (arrow).

### Advanced Imaging Techniques

The MR imaging protocol described above is all that is required for preoperative evaluation of the symptomatic patient with pelvic floor weakness. Several authors have described the use of upright imaging in an open-configuration MR imaging unit (28–30). Although this technique does maximize the evidence of all weakness, it rarely helps

identify new defects or changes the therapeutic approach. Three-dimensional imaging has also been explored as a tool for determining levator ani volume in an attempt to select patients for either conservative therapy or surgery (31). At present, it remains a research technique.

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