Dynamic MR Imaging of the Pelvic Floor: a Pictorial Review

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Abbreviations: FIESTA = fast imaging employing steady-state acquisition, FISP = fast imaging with steady-state precession, ODS = obstructed defecation syndrome, PCL = pubococcygeal line

Abstract

Pelvic floor dysfunctions involving some or all pelvic viscera are complex conditions that occur frequently and primarily affect adult women. Because abnormalities of the three pelvic compartments are frequently associated, a complete survey of the entire pelvis is necessary for optimal patient management, especially before surgical correction is attempted. With the increasing use of magnetic resonance (MR) imaging in assessing functional disorders of the pelvic floor, familiarity with normal imaging findings and features of pathologic conditions are important for radiologists. Dynamic MR imaging of the pelvic floor is an excellent tool for assessing functional disorders of the pelvic floor such as pelvic organ prolapse, outlet obstruction, and incontinence. Findings reported at dynamic MR imaging of the pelvic floor are valuable for selecting patients who are candidates for surgical treatment and for choosing the appropriate surgical approach. This pictorial essay reviews MR imaging findings of pelvic organ prolapse, fecal incontinence, and obstructed defecation.

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Introduction

Functional disorders of the pelvic floor such as pelvic organ prolapse and defecatory dysfunction represent a common health problem, especially in women. It is estimated that more than 15% of multiparous women (1) are affected by some sort of pelvic disorder and that 10%–20% of patients seek medical care in gastrointestinal clinics for evacuation dysfunction (2). These conditions often significantly affect the quality of life and result in a variety of symptoms. The pelvic floor in women is divided into three compartments: the anterior compartment (bladder and urethra), middle compartment (vagina and uterus), and posterior, or anorectal, compartment (3). The spectrum of dysfunction of the pelvic floor depends on the compartment involved and includes incontinence, constipation, and prolapse, occurring in varying combinations. Constipated patients with functional anorectal abnormalities complain of fecal evacuation difficulties in terms of incomplete evacuation, excessive straining, and need for manually assisted evacuation.

Clinical examination either underestimates or results in misdiagnosis of the site of prolapse in 45%–90% of patients (4), and it is not reliable for assessing evacuation abnormalities. Furthermore, pelvic floor weakness is usually generalized, so the various pelvic floor compartments should be evaluated simultaneously (4,5). In fact, although surgical correction of single-compartment prolapse is possible (eg, colposuspension for cystocele, hysterectomy or suspension for uterine prolapse), symptoms recur in 10%–30% of patients, and the cause of recurrence often involves compartments that were not repaired initially (6). Besides, surgical correction of obstructed defecation abnormalities, such as rectocele or rectal prolapse (eg, stapled transanal rectal resection) may be modified if general pelvic floor prolapse is involved (7). Consequently, the treatment of pelvic floor dysfunction is becoming increasingly dependent on preoperative imaging (8).

Dynamic imaging (imaging obtained at rest, during squeezing, straining, and defecation) has a central role in the diagnosis of pelvic floor dysfunction, and it is crucial when choosing a conservative versus
a surgical treatment (9). Dynamic cystoproctography is still the reference imaging technique for assessing functional pelvic organ abnormalities, despite requiring separate opacification of the bladder, vagina, and rectum and being time-consuming and invasive. Moreover, irradiation of younger patients must be considered, and pelvic floor musculature is not visualized. Magnetic resonance (MR) imaging has an increasing role in assessing pelvic floor dysfunction because of its multiplanar imaging capability, the intrinsic soft-tissue contrast it provides, and the absence of ionizing radiation. These features are specifically suitable for those patients with multicompartiment involvement and for those who have undergone previous repairs.

This pictorial essay shows dynamic MR imaging findings in pelvic floor disorders such as prolapse, obstructed defecation, and fecal incontinence.

**MR Imaging Technique**

Dynamic MR defecography consists of imaging patients during squeezing, straining, and defecation. Two methods are used, depending on the configuration of the MR unit. The patient can be either supine in a closed-magnet system or sitting in an open-magnet system. The open-magnet system allows image acquisition with the patient upright. The primary advantages of imaging the patient in a sitting position is maximizing the evidence of pelvic floor weakness due to gravity and permitting physiologic movement of the anorectum during defecation. However, in the detection of clinically relevant pelvic floor abnormalities, there is no substantial difference between imaging patients in a sitting or in a supine position (10). In conventional 1.5-T units, dynamic imaging is performed with the patient in a supine position. Although it is not the physiologic defecatory position, it has been shown to be perfectly satisfactory for evaluating pelvic floor weakness (11–14).

Images in all cases presented here were obtained with the patient in a supine position in a conventional 1.5-T magnet.

In previously published articles (10–32), the examination technique varied both for preparation and imaging sequence parameters. Since pelvic floor imaging is a dynamic form of imaging, aiming to evaluate the evacuation phase, rectal filling is mandatory. Authors have used different filling media,
such as sonographic gel, mashed potatoes (variably mixed with a gadolinium compound, according to
the signal intensity intended to obtain in the T1- or T2 weighted sequences used), or air. For practical
reasons—availability, cost, and cleanness—we use 200 mL of sonographic gel (which has high signal
intensity with T2-weighted sequences). Gel is introduced into the rectum via a short flexible tube
while the patient lies in the lateral decubitus position on the scanner table before being moved into the
gantry. Warm gel might be used as well to reduce patient discomfort. Owing to the high intrinsic soft-
tissue contrast of MR imaging, it is not necessary to opacify bowel loops, bladder, and vagina.
However, anterior and middle-compartment dysfunction (eg, vaginal vault eversion and prolapse) are
better assessed when the bladder is distended. In our institution, patients are asked not to void the
bladder in the hour before the examination, and the vagina is filled with 50 mL of sonographic gel to
increase the conspicuity of any abnormal finding involving these structures. The MR imaging protocol
requires no oral or intravenous contrast agents, and bowel preparation is not necessary either. Because
the patient’s cooperation is of major importance to achieve a satisfactory examination, explanation is
crucial during the preparatory phase, since defecating in the supine position could be difficult for
some patients. Covering the gantry with a plastic sheet helps overcome the patient’s embarrassment
and allows easier cleaning after the examination. A multicoil array, either pelvic or torso, is wrapped
around the inferior portion of the pelvis, and the patient is placed in the supine position.
With a rapid T1-weighted large-field-of-view localizer sequence, scout images are obtained to identify
a midline sagittal section; this section should encompass the symphysis, bladder neck, vagina, rectum,
and coccyx. The examination proceeds with sequences for imaging pelvic anatomy and any muscle
defects, such as thinning and tears. For this purpose, T2-weighted thin-section sequences (repetition
time [msec]/echo time [msec], 3700/102, 23 × 23-cm field of view, 384 × 224 matrix, 25 sections with
a 5-mm section thickness, 3–4-minute imaging time) are performed in axial, sagittal, and coronal
planes.
Dynamic imaging is performed by using a steady-state sequence (FIESTA [fast imaging employing
steady-state acquisition], true FISP [fast imaging with steady-state precession], or balanced FFE [fast
field echo]) (4.8/2.4, 40 × 40-cm field of view, 224 × 288 matrix, 8-mm section thickness), acquiring one section per second in the midsagittal plane at rest, during maximal sphincter contraction, straining, and defecation. This kind of sequence has the advantage of combining high intrinsic signal intensity and temporal resolution. High-performance 1.5-T magnets and gradients provide an image update every 1 second. Images are also analyzed in cine loop mode. If defecation is quick, 40–50 repetitions are usually sufficient to cover the time of examination. However, at least 80–120 repetitions should be acquired to ensure that slow or difficult evacuation is covered. The first three or four images are obtained with the patient at absolute rest, and the last three or four images are obtained at the end of defecation to reassess the position of the pelvic organs after evacuation. The examination is completed in 10–15 minutes.

Normal Anatomy and Imaging Findings

The pelvic floor is a complex structure made of passive and active supports, respectively fasciae and muscles. The endopelvic fascia is a layer of connective tissue that attaches the uterus and vagina to the pelvic side walls. Its anterior aspect, the pubocervical fascia, extends from the anterior vaginal wall to the pubis and supports the bladder. A tear in the anterior portion of the endopelvic fascia (pubocervical fascia) results in bladder descent or a cystocele (33,34), while a tear in the posterior aspect (rectovaginal fascia) results in an anterior rectocele or enterocele (35). The central tendon of the perineum, also called the perineal body, is another passive structure into which many structures insert, such as the external anal sphincter, the endopelvic fascia, the deep and superficial transverse muscles of the perineum (urogenital diaphragm), and the puborectalis muscle (36). The perineal body in men is located posterior to the spongious and cavernous bodies; in women it lies within the anovaginal septum, between vaginal introitus and anal canal.

The other main soft-tissue component of the pelvic floor is the levator ani muscle, which consists of three different muscle groups: the ileococcygeus, pubococcygeus, and puborectalis muscles. The ileococcygeus and pubococcygeus muscles are horizontal sheetlike structures that arise, respectively,
from the junction of the arcus tendineus fascia pelvis and the fascia of the internal obturator muscle
and from the pubic bone, and then fan out to insert at the pelvic sidewall on the tendinous arch. This
configuration is nicely assessed in the coronal plane (Fig 1), which is helpful for demonstrating
normal thickness and symmetry of the fibers. Posteriorly, the fibers fuse anterior to the coccyx to form
a midline raphe, the levator plate (35). The puborectalis muscle, which is part of the anal sphincter,
arises from the body of the pubic bone and forms a sling around the rectum, aligning with the external
anal sphincter. This sling shape is easily imaged in the axial plane (Fig 1).
**Figure 1.** Multiplanar T2 weighted images in a 32-year-old normal volunteer woman. (a) The ileococcygeus and the pubococcygeus muscles (white arrows) are seen in the coronal plane, closely aligning with puborectal muscle fibers of the anal sphincter (black arrowheads), and having a horizontal orientation. (b, c) Posteriorly, the fibres fuse anterior to the coccyx to form a midline structure (arrow), the levator plate, seen in the (b) coronal and (c) sagittal planes. The perineal body (*) is located between the vaginal introitus and anal canal. (d) Axial view shows the puborectalis muscle (white arrowheads) arising from the body of the pubic bone and forming a sling around the rectum, aligning with the external anal sphincter.

These muscles have slow-twitch fibers that continuously contract and provide tone to the pelvic floor, against the stress that comes from gravity and intraabdominal pressure. Contraction of the levator ani muscle closes the urogenital hiatus and compresses the urethra, vagina, and anorectal junction in the direction of the pubic bone. Neuromuscular damage, occurring primarily during vaginal delivery, diminishes the levator ani’s capability of providing adequate pelvic support; in addition, lifting heavy objects, chronic straining at defecation, and chronic obstructive pulmonary disease raise abdominal pressure and may result in pelvic organs prolapse (37). Hysterectomy also contributes by weakening pelvic supports (38).

The anorectal junction is defined as the point of taper of the distal part of the rectum as it meets the anal canal, corresponding to the posterior impression of the transition between puborectal muscle and levator plate, and represents the point of reference for posterior compartment descent. The anorectal junction is the apex of the anorectal angle, which is defined as the angle between the
posterior border of the distal part of the rectum and the central axis of the anal canal (Fig 2) [15]. The anorectal angle normally measures between 108° and 127° at rest (16,33) and changes as the puborectalis muscle contracts or relaxes. Normally, the anorectal angle closes between rest and squeezing and opens between rest and defecation by about 15°–20° (11,16).
Figure 2. Drawings illustrate the puborectalis muscle originating from the pubic symphysis and surrounding anorectal junction during (a) rest, (b) squeezing, and (c) straining. The anorectal angle (indicated by dark area) is between the two lines, one at the posterior wall of the distal part of the rectum and the other representing the central axis of the anal canal. The angle becomes more acute during squeezing for the contraction of the puborectalis muscle, which shortens and brings the anorectal junction higher and nearer to the pubic symphysis. During straining and defecation, the anorectal angle becomes more obtuse for relaxation of the puborectalis muscle.

The radiologist should begin interpretation of the sagittal MR images by drawing the pubococcygeal line (PCL) from the inferior border of the pubic symphysis to the last coccygeal joint (15,16,32,33,35). The PCL represents the level of the pelvic floor and is the landmark for measuring organ prolapse (Fig 3). The distance from the PCL to the bladder neck, cervix, and anorectal junction, respectively, should be measured on images obtained when the patient is at rest and during maximal pelvic strain. This line is reproducible, independent of pelvic tilt, and includes the pubic bone and
coccyx, which are attachments for the pelvic floor (13–16,35). In healthy volunteers, there is minimal movement of the pelvic organs with respect to the PCL (Fig 3), even during maximal strain (15).

Figure 3. Sagittal FIESTA images obtained (a) at rest and (b) during straining and defecation in a 50-year-old normal volunteer woman. The PCL is drawn from the inferior border of the pubic symphysis to the last coccygeal joint. The H line is drawn from the inferior border of the pubic symphysis to the posterior wall of the rectum at the level of the anorectal junction. The M line is drawn perpendicularly from the PCL to the most posterior aspect of the H line. Images show normal positions of the bladder base (black arrow), the vaginal vault (white arrow), and anorectal junction (*) with respect to the PCL both at rest and during defecation. Defecation shows widening of the anorectal angle and minimal lowering of the bladder base, vaginal vault and anorectal junction relative to the initial positions; as a consequence M line is elongated. Note that the urethral axis (black dotted line) remains vertical during straining and defecation.
Next, the H line and M line are measured (Figs 3, 4). The H line corresponds to the anteroposterior width of the levator hiatus and is drawn from the inferior border of the pubic symphysis to the posterior wall of the rectum at the level of the anorectal junction. The M line is a vertical line drawn perpendicularly from the PCL to the most posterior aspect of the H line and represents the vertical descent of the levator hiatus (21,35). Normally, the H and M lines should not exceed 5 cm and 2 cm in length, respectively (39). Lesions of the pelvic muscolofascial support result in widening of the hiatus and descent of the levator plate. Thus, the H and M lines tend to elongate with pelvic floor relaxation, representing levator hiatal widening and levator plate descent, respectively (21).

### Figure 4, Movie 1

Pelvic organ prolapse and fecal incontinence in a 71-year-old woman. Sagittal FIESTA images obtained (a) at rest and (b) during straining and evacuation. At rest, positions of the
bladder base and cervix are normal. The anal sphincter is open at rest, with leakage of endorectal material and an abnormally low position of the anorectal junction (note elongated H and M lines). The evacuation phase shows a large cystocele and severe descending perineal syndrome, with further elongation of the H and M lines and positions of all pelvic organs below the PCL. The descending bladder bulges into the vagina and is responsible for complete eversion of the anterior vaginal wall (white arrow). The uterus prolapses into the vaginal lumen, and endovaginal contrast medium is displaced and fills the posterior vaginal fornix (black arrow). A small anterior rectocele is also present (*).

In healthy patients, the anorectal angle closes during squeezing and the anorectal junction can rise 1–2 cm from the rest position. During straining and defecation, the anorectal angle becomes more obtuse, the anal canal opens and shortens and the rectum is rapidly evacuated. Finally, the anal canal closes and the anorectal junction and anorectal angle return to their pre-evacuation positions (15,34–35).

Pathologic Conditions

Constipation and pelvic organ prolapse are the most common reasons for requesting dynamic MR imaging of the pelvic floor, although urinary and anal incontinence are frequent indications as well. Correct assessment of causes of constipation includes evaluation of the presence of obstructed defecation syndrome (ODS). This is a particular condition of stipsis in which outlet obstruction to the passage of stools or incomplete rectal evacuation occurs. ODS is conventionally investigated by defecography to assess for rectocele, rectal invagination, or prolapse and peritoneocele. ODS is mostly associated with pelvic organ prolapse. Only patients in whom an obstructive lesion (eg, rectal tumor) or slow colonic transit has been ruled out should undergo evacuation imaging to assess for functional defecatory disorders (36).
Classification of pelvic floor abnormalities has been topographic. This classification is mostly artificial and reflects historical boundaries between the different specialties involved. In fact, pelvic floor dysfunction is often generalized so that abnormalities of the anterior and middle compartments are frequently observed even in patients with ODS (4). An examination of 50 healthy volunteers suggested that criteria for abnormality derived from conventional proctographic examinations are generally applicable to MR imaging (15).

Prolapse severity can be easily graded according to the “rule of three”: prolapse of an organ below the PCL by 3 cm or less is mild, between 3 and 6 cm is moderate, and more than 6 cm is severe (14–16).

**Anterior Compartment Abnormalities**

Anterior compartment abnormalities include cystocele and urethral hypermobility. Cystocele is bladder base descent below the border of the pubic symphysis. At MR imaging, a cystocele is diagnosed when the bladder base descends more than 1 cm below the PCL. Cystoceles occur when there is tearing or stretching of the pubocervical fascia. This abnormality can develop in the menopausal period, owing to the drop in the estrogen level that normally helps maintain the tone of muscles and ligaments supporting the bladder (33). Cystocele severity is graded with respect to the position of the bladder base below the PCL, as follows: small if the bladder base extends less than 3 cm below the PCL, moderate if the extension is between 3 and 6 cm, and large if it is 6 cm or more (40). In cystoceles, the bladder base occupies part of the width of the levator hiatus, thus displacing the uterus and anorectal junction posteriorly and inferiorly. As a consequence, the H and M lines are elongated on MR images, exceeding 5 cm and 2 cm, respectively (35) (Fig 4, Movie 1). 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. Cystoceles can manifest with stress incontinence. In cases in which there is loss of urethral sphincter and fascial support, an increase of abdominal pressure allows rotation of the urethral axis into the
horizontal plane. This condition is called urethral hypermobility and indicates loss of intrinsic urethral sphincter integrity (Fig 5, Movie 2). Denervation and/or muscular or fascial defects secondary to aging, vaginal delivery, pregnancy, and obesity (36) are the most important causes of urethral hypermobility. Dynamic MR imaging is able to depict urethral hypermobility, which is important because it requires a pubovaginal sling procedure to repair (41), while retropubic urethropexy is the surgical procedure used in cases of uncomplicated stress incontinence.

5.

**Figure 5, Movie 2.** Constipation and urinary incontinence in a 39-year-old woman. Sagittal FIESTA image obtained during defecation and Valsalva maneuver shows a rotation of the urethral axis. The urethral sphincter has opened, and the urethra appears shortened, horizontal, and dilated (white arrow). In this defecation phase, severe lowering of the anorectal junction, intrarectal full-thickness invagination (black arrow), and a small anterior rectocele (arrowhead) are also seen.

Urethral funnelling, an abnormality in which there is dilation of the proximal urethral lumen and apparent shortening of the urethra, can also be observed. This finding may indicate intrinsic urethral sphincter incompetence in incontinent women (42,43). However funnelling is a nonspecific sign of incontinence, since it can be observed in continent women as well.
In other cases, prolapse of the bladder base may be responsible for kinking of the urethrovescical junction (Fig 6, Movie 3), which is a potential cause of urinary retention. This condition can be associated with or mask symptoms of incontinence and may lead to urinary stasis and infections.

Figure 6, Movie 3. Stress urinary incontinence, feeling of incomplete bladder voiding, and ODS in 56-year-old woman. Sagittal FIESTA image obtained during defecation shows a large cystocele and little leakage of urine, with kinking of the vesical floor with respect to the urethral sphincter (black arrow). These findings can explain the symptom of urine retention. The vagina is filled with sonographic gel (arrowheads). The large cystocele exerts the following effects: The vaginal axis has become horizontal, the vaginal apex is abnormally located below the PCL, and the anterior wall is everted. An intraanal full-thickness rectal invagination is also evident (white arrow). The site of wall infolding is at the level of the anal canal, thus obstructing stool passage during rectal voiding.

*Middle Compartment Abnormalities*

Middle compartment abnormalities are represented by uterine or vaginal vault prolapse. Uterine and vaginal support structures are the uterosacral ligaments (which suspend the uterus and upper vagina from the presacral fascia), the pubocervical fascia (which attaches the lateral part of the vagina to the pelvic sidewalls), and the rectovaginal fascia (which attaches the posterior part of the vagina to
perineal body). A paravaginal fascia defect can be suspected when the vagina loses its “H” shape on axial images (Fig 7).

7.

**Figure 7.** Hysterectomy and pelvic organ prolapse in a 66-year-old woman with a history of four vaginal deliveries. T2-weighted axial plane image (same level as in Fig 1d) shows detachment of the right aspect of the puborectalis muscle from the parasympyseal area and deformation of the right vaginal fornix (arrow), secondary to a paravaginal fascia defect. The vaginal lumen is filled with sonographic gel.

Vaginal or cervical prolapse is defined as descent of the vaginal vault or cervix below the PCL (Fig 4–6, **Movies 1–3**) (10). The degree of prolapse is graded as mild if the vaginal vault or cervix extends less than 3 cm below the PCL, moderate if it extends between 3 and 6 cm, and severe if it extends 6 cm or more below the PCL. In cases of uterine prolapse the cervix is located abnormally low through the vagina, which may thus appear shortened. In complete uterine prolapse, the vaginal walls are everted and the uterus is visible as a bulging mass outside the external genitalia (Fig 8, **Movie 4**). 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 6, **Movie 3**).
Figure 8, Movie 4. Severe uterine prolapse in a 41-year-old woman. Sagittal FIESTA images obtained (a) at rest and during (b) straining and (c) defecation show that during straining and defecation the uterus moves downward inside the vagina and the cervix exits the vaginal introitus (white arrow). H and M lines are abnormally elongated. The vagina appears shortened and everted; this finding is associated with the change in cervix-fundus angulation and flexion. Urethral funnelling
without hypermobility (arrowhead) and severe (7 cm) posterior compartment descent (black arrow) are also seen.

In cases of hysterectomy, superior defects in the vaginal supports can cause vaginal descent, infolding of the vaginal apex, or complete eversion of the mucosa. Abnormal descent of the vagina can create a wider potential space for the peritoneal cul de sac to descend through or can cause a traction effect on it (36), resulting in a peritoneocele (Fig 9, Movie 5).

Figure 9, Movie 5. Pelvic floor prolapse after hysterectomy in a 72-year-old woman. Sagittal FIESTA images obtained (a) at rest and (b) during defecation. Severe vaginal prolapse is seen. Vaginal walls are completely everted (arrowhead), and the perineal space is massively occupied by a
large enterocele containing a large amount of peritoneal fat (black arrow) and small-bowel loops (white arrows).

**Posterior Compartment Abnormalities**

*Rectocele.*—Rectocele is a condition characterized by abnormal bulging of the rectal wall due to inadequate support and laxity of the endopelvic fascia above the anal canal (Fig 10, Movie 6). Rectoceles are measured as the depth of wall protrusion beyond the expected margin of the normal anorectal wall, and they are clinically significant when the bulge exceeds 2 cm during evacuation (11–16). Rectoceles are graded as small if they measure less than 2 cm, moderate if they measure from 2 to 4 cm, and large if they measure 4 cm or more (13). Rectoceles usually involve the anterior wall but may rarely occur posteriorly (Fig 11). Anterior rectoceles can stretch the perineal body and bulge into the vagina (Fig 10b). Identified factors that may increase the risk of developing a rectocele include vaginal delivery trauma, constipation with chronically increased intraabdominal pressure, hysterectomy, and aging (31). Rectoceles are common findings but become clinically relevant when symptoms occur, as they are responsible for obstructed or incomplete evacuation (Fig 12, Movie 7), requiring vaginal or perineal digitations to empty the rectum. MR defecography provides information about the size and dynamics of rectocele emptying, retention of contrast medium within the rectocele, and coexistent abnormalities. Retention of contrast medium in the rectocele during rectal voiding is supporting evidence for this abnormality, and explains the symptoms of incomplete evacuation.
10a.

Figure 10, Movie 6. (a) Drawing illustrates anterior rectocele as an outpouching of the anterior rectal wall (arrow). (b) Sagittal FIESTA image obtained during defecation in a 45-year-old woman with a history of obstructed defecation shows the anterior rectal wall bulging (arrow), with stretching of the perineal body (*) and protrusion of the rectum into the vaginal lumen.

11.

Figure 11. ODS in a 41-year-old woman. Sagittal true-FISP image obtained during evacuation phase shows severe perineal descent, incomplete opening of the anal canal, and appearance of a small posterior rectocele (arrow).
Figure 12, Movie 7. History of incomplete evacuation in a 65-year-old woman. Sagittal FIESTA images obtained during defecation show (a) a large anterior rectocele (arrow), widely bulging into the vagina and protruding outside the introitus (arrowhead). During defecation the rectocele is filled with intrarectal sonographic gel and is unable to empty, even during maximal effort. (b) Note that the amount of sonographic gel filling the rectocele corresponds to the intrarectal residual at completed evacuation. The patient needed manual assistance (in particular vaginal digitations) to empty the rectum. Moderate prolapse in the anterior and middle compartments is associated.
Rectal invagination and prolapse.—Although mucosa alone may prolapse (Fig 13, Movie 8), invagination, or intussusception, is defined as a full-thickness rectal wall prolapse involving both the mucosa and muscular layer (Fig 14, Movie 9). This causes a mechanical obstruction to the passage of stool. 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 15), intraanal, or extraanal (Fig 16, Movie 10). Extraanal invagination is currently clinically termed rectal prolapse (44). Low-grade intussusception is defined as rectal mucosa infolding but not entering the anal canal, while high-grade intussusception is a full-thickness prolapse that penetrates the anal canal or impedes evacuation. The incidence of rectal prolapse is estimated approximately as four cases per 1000 people; in the adult population, the female-to-male ratio is 6:1 (45). Symptoms of extraanal prolapse also include rectal ulceration with bleeding and incontinence.

For the diagnosis of intussusception, the sensitivity of MR defecography has been reported to be 70% relative to evacuation proctography (18). The clinical relevance of missed findings at MR imaging has been further reported to be of little importance (10,24,36). In fact, the frequency of low-grade intussusception (not obstructing the passage of stool) is high even in the asymptomatic population (36). The differences between results also relate to the difficulty of standardizing procedures and to the fact that both the mobility of the rectum and the degree of straining during evacuation are likely to affect the formation and degree of any intussusception (18). However, MR defecography has the potential advantage of clearly distinguishing between rectal mucosal intussusception and rectal full-thickness intussusception, a difference that can only be inferred at conventional defecography and which is relevant in that the treatment for the two conditions is different. Simple mucosal prolapse may be treated with transanal excision of the prolapsing mucosa, whereas a rectopexy might be required for full-thickness rectal invagination (46). Moreover, additional information regarding anterior- or middle-compartment prolapse provided by MR imaging could affect the final surgical plan, since it has been demonstrated that up to 30% of patients with intussusception have associated abnormal descent in the anterior and middle compartments (16).
13.

**Figure 13, Movie 8.** Perineal prolapse and feeling of incomplete evacuation in a 68-year-old woman. Sagittal steady state (FIESTA) image obtained at late evacuating phase shows abnormal thickening and redundant infolding of the mucosal layer in the posterior and anterior rectal wall (arrowheads). Mucosal infolding occupies rectal lumen and obstructs normal passage of stools. Anterior and middle compartment prolapse is associated.

14.

**Figure 14, Movie 9.** Feeling of incomplete evacuation in a 57-year-old woman. Sagittal FIESTA image shows an intrarectal invagination (arrows) during defecation. The invagination obstructs the rectal lumen and is responsible for intrarectal residue after defecation. A cystocele (black arrowhead) and cervical prolapse (white arrowhead) are associated.
15. **Figure 15.** 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.
Extraanal invagination (rectal prolapse) and fecal incontinence in a 63-year-old woman. The patient had undergone hysterectomy 25 years previously. Sagittal true-FISP images show that at rest position (a), an abnormally open anal canal is present with leakage of contrast material (arrow). Progressive straining and defecation (b, c) result in a wider opening of the anal canal and infolding of the anterior rectal wall inside the anal canal (white arrow), finally with a full-thickness extraanal rectal prolapse. (d) A moderate cystocele (arrowhead) and vaginal vault descent (black arrow) are associated.
**Enterocele.**—Enterocele is a herniation of the pelvic peritoneal sac into the rectogenital space, the rectovaginal septum in women, passing below the proximal one-third of the vagina. It may contain fat, called peritoneoceles (Figs 17, 18; Movie 11), small bowel (Figs 19–21, Movies 12-14), or sigmoid colon. Enteroceles are graded small, moderate, or large if they extend 3 cm, 3–6 cm, or more than 6 cm, respectively, below the PCL. As opposed to conventional defecography, MR imaging can easily help identify the content of the peritoneal cul-de-sac, fat or bowel loops. Moreover, unlike with conventional proctography, bowel loops are easily identified on MR images without the need for selective opacification. MR imaging criteria for enterocele diagnosis include the presence of bowel between the vagina and rectum, bowel below the PCL, widening of the rectovaginal space, and abnormal deepening of the cul-de-sac (11–16). Patients who have undergone hysterectomy are primarily at risk of developing an enterocele because an interruption of the continuity of the pubocervical and rectovaginal parts of the endopelvic fascia has occurred. Since a filled rectum does not allow sufficient space for small bowel to descend into the pelvis, enterocele usually occurs at the end of evacuation as a consequence of increased intraabdominal pressure (Fig 19, Movie 12). A spontaneous irreducible enterocele is also called a perineal hernia (Fig 20, Movie 13). An enterocele may result in compression of the distal part of the anorectum and finally in incomplete evacuation due to outlet obstruction (Fig 21, Movie 14). The feeling of incomplete evacuation might be caused by bowel loops resting on the sigmoid colon and lead to repetitive and unproducting straining (35). Stretching or tearing of the mesentery can also cause pain in the lower abdomen or back (Fig 18, Movie 11) (43). Large enteroceles can also cause a bulge in the introitus, but clinical examination alone has shortcomings in identifying the content of the hernia. Indeed, in presurgical assessment of pelvic organ prolapse, an undetected enterocele may result in progressive symptoms and need for repeat surgery (8). Descent of small-bowel loops more than 2 cm into the rectovaginal space indicates a torn rectovaginal fascia that should be treated with culdoplasty (35). MR imaging is an accurate modality for evaluating enterocele because of its ability to help identify the content of the peritoneal
sac, to assess the role of the content in the dynamics of evacuation obstruction, and to survey the entire pelvis simultaneously.

Figure 17. ODS in a 66-year-old woman. Sagittal FIESTA images obtained (a) at rest and (b) defecation show a peritoneal cul-de-sac (white arrow) herniating into the rectovaginal space, resulting in a large fat-containing enterocele (peritoneocele). A large anterior rectocele is associated (black arrow).
Figure 18, Movie 11. Pelvic floor prolapse and painful defecation in a 59-year-old woman. Sagittal FIESTA image obtained during evacuation phase shows a moderate peritoneocele (black arrowhead), with stretching of mesenteric vessels in the peritoneal hernia (white arrowheads).
**Figure 19, Movie 12.** Pelvic organ prolapse after hysterectomy in a 64-year-old woman. Sagittal FIESTA images obtained at (a) early and (b) late defecation show a large rectocele (white arrow) occupying and widening the rectovaginal space, with the peritoneal cul de sac normally positioned (black arrow). At late defecation, when the rectocele is voided, space is now sufficient for the peritoneal sac to descend, and the rectovaginal space is occupied by a large enterocele (arrowheads).

20a.

20b.

**Figure 20, Movie 13.** Perineal descent and ODS in a 68-year-old woman. Sagittal FIESTA images show a severe three-compartmental prolapse (a) during defecation, with cystocele (white arrowhead) and severe enterocele associated (white arrow); note the distal intrarectal invagination (black arrowhead). (b) At completed defecation, the bladder base (arrowhead) and the anorectal junction (*) return to the rest position, but the enterocele in not reduced (arrow).
Figure 21, Movie 14. (ODS in a 65-year-old woman. The patient underwent hysterectomy 18 years previously for uterine prolapse. (a–c) Sagittal true-FISP images obtained during progressive defecatory effort show the appearance of an anterior rectocele (*) and a large enterocele (arrow).
During its descent, the peritoneal sac closes the rectal lumen and prevents complete evacuation of the rectocele and the proximal rectum. A cystocele (white arrowhead) and vaginal vault prolapse (black arrowhead) are associated.

*Descending perineal syndrome.*—In descending perineal syndrome, the pelvic muscles lose tone, resulting in excessive descent of the entire pelvic floor at rest or during evacuation (Fig 22, Movie 19). Pudendal nerve injury, due to delivery trauma or neuropathy, and chronic straining at defecation are underlying causes of descending perineal syndrome. Patients may have a dysfunction affecting the perineal body or levator ani musculature, so that diffuse bulging or focal asymmetry of the levator ani muscle can occur, best imaged in the coronal plane. On dynamic images, perineal descent can be quantified by measuring the descent of the anorectal junction from the PCL, considered abnormal if exceeding 2.5 cm (15,16). Since the width of the pelvic hiatus is greater in descending perineal syndrome, the H and M lines will be longer as well. A caudal angulation of the levator plate will also be evident (35). In descending perineal syndrome, a decreased elevation of the pelvic floor at maximal contraction can be observed (44). This syndrome can involve not only the posterior but, frequently, the anterior and middle compartments. The syndrome is associated with a feeling of incomplete evacuation, which leads to increased straining during evacuation and consequent additional neuropathic injury that may result in incontinence.
22e.

**Figure 22, Movie 15.** Severe three-compartment descent in a 62-year-old woman. Sagittal FIESTA images obtained (a) at rest, (b) during squeezing, and (c) during defecation. (a) At rest, the bladder and uterus are in the correct positions with respect to the PCL (white line), while the anorectal junction (arrowhead) is abnormally below the PCL, with elongation of the H and M lines. (b) During squeezing, the anorectal junction (arrowhead) fails to rise with respect to the PCL. (c) At defecation, the bladder base, cervix and anorectal junction are abnormally below the PCL. The H and M lines are abnormally elongated, and the levator plate is directed vertically (arrow). Note that the posterior wall of the bladder descends along an arc, initially moving posteriorly and inferiorly to deform the anterior wall of the vagina and then bulging forward as it exits the introitus. (d) Coronal and (e) axial thin-section T2-weighted images show an extremely thin left levator ani muscle (arrows) and discontinuity in the left anterior aspect of the puborectalis muscle (arrowhead).

**Spastic pelvic floor syndrome.**—Spastic pelvic floor syndrome is a functional abnormality that affects some constipated patients who experience evacuation failure associated with involuntary, inappropriate, and paradoxical contraction of striated pelvic floor musculature (Fig 23, Movie 16). This syndrome is also called pelvic floor uncoordination or anismus. The etiology of this condition is unclear and can include both abnormal muscle activity and psychologic or cognitive factors (36). Increased pressure at rest and during defecation is shown with anorectal manometry, while pathologic signals are evident at electromyography (44).
Figure 23, Movie 16. ODS in a 51-year-old man. (a, b) Sagittal FIESTA images obtained (a) at rest and (b) during strain. At strain, the anorectal angle (ARA) paradoxically closes and the anal sphincter fails to open, due to inappropriate contraction of the puborectalis muscle, which conforms to spastic pelvic floor syndrome. Note the small bowel loops pushing on the bladder roof in b (arrow) owing to increased intraabdominal pressure during the Valsalva maneuver. (c) Axial thin-section T2-weighted
image obtained below the pubic symphysis shows thickened puborectalis muscle and external anal phincter (arrowheads).

MR imaging clearly shows lack of descent of the pelvic floor during defecation and paradoxical contraction of the puborectalis muscle with failure of the anorectal angle 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. The most appropriate findings on which to base the diagnosis of anismus are prolonged and incomplete evacuation (8) and a long interval between opening of the anal canal and start of defecation (36). An anterior rectocele below the contracted puborectalis muscle can also be associated with this syndrome (Fig 24, Movie 17) (33).
24c.

**Figure 24, Movie 17.** History of outlet obstruction syndrome symptoms, in particular excessive straining and incomplete evacuation, in a 68-year-old woman. Sagittal FIESTA images obtained (a) at rest and (b, c) during progressive straining show failed normal opening of the anorectal angle, with persistent impression of the puborectalis muscle on the posterior rectal wall (arrowhead in b, c). Anal sphincter does not open completely, and progressive overdistention of the rectal ampulla occurs, resulting in an anterior rectocele (arrow in b, c). As a result, rectal voiding is pathologically slow and incomplete.

**Anal incontinence.**—Anal incontinence is common, especially in women, with a prevalence increasing with age, and has a considerable economic impact (47). Patients can present with either fecal leakage they are unaware of, suggesting an internal sphincter abnormality, or with urge incontinence, indicating external sphincter damage. The most common cause of incontinence is vaginal delivery that causes direct sphincter laceration or indirect damage to sphincter innervation. Other causes include iatrogenic damage (as a complication of anal surgery) or neuropathy. Imaging of fecal incontinence relies on endoanal MR imaging or ultrasonography of the anal sphincter, with the aim of detecting sphincter tear or atrophy and thus selecting patients likely to benefit from surgical repair (47). Anal canal manometry is also important for determining whether sphincter function is normal, although it is unable to help differentiate traumatic damage from atrophy. MR defecography findings such as inability to hold an enema, anorectal angle changes of less
than 10°, pelvic floor descent, intussusception, and rectocele (Figs 4, 16; Movies 1, 10) may change the surgical approach for surgery candidates for treatment of incontinence (17). A recent study reported that MR defecography findings led to changes in surgical approach in 67% of patients who were candidates for treatment of fecal incontinence with some form of surgery (17). In particular, if a simple sphincter repair was planned, the evidence of a rectocele or enterocele modified the treatment to sphincteroplasty and anterior levatorplasty. Even patients with constipation may complain of fecal incontinence (eg, overflow incontinence or postdefecation leakage). In these patients, MR defecography is helpful for demonstrating the causes of associated outlet obstruction. Therefore, in the workup of anal incontinence, it is useful to perform a morphologic endoanal study with dynamic MR imaging of the evacuating phase.

**Summary**

Pelvic floor dysfunctions are frequent but complex conditions that can involve some or all pelvic viscera. As abnormalities of the three pelvic compartments are frequently associated, a complete survey of the entire pelvis is necessary before surgical repair. Dynamic MR imaging of the pelvic floor is an excellent modality for assessing functional disorders of the pelvic floor in cases of pelvic organ prolapse, outlet obstruction, and incontinence. 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.
References


