Dynamic Magnetic Resonance Imaging of Pelvic Floor Pathologies

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Learning Objectives

- To identify pelvic floor descent within the three-compartment model and to get familiar with the proposed grading system
- To identify the different pathologic conditions of the anorectal region according to the finding in MR defecography
- To know MR imaging findings of pelvic floor dysfunction in patients with dyssynergic defecation

51.1 Introduction and Definitions of Pelvic Floor Dysfunction

Pelvic floor dysfunction is a common problem affecting preferably postmenopausal, multiparous women, resulting in reduced quality of life and a frequent need for surgical treatments [1, 2]. In addition to age, risk factors for pelvic floor insufficiency are multiparity, menopause, and obesity [3]. Clinical symptoms of pelvic floor dysfunction vary widely and are usually determined by the pelvic organ or compartment most affected. However, clinical symptoms are often nonspecific and range from constipation to incontinence. A complex variety of pelvic floor distortions can present in one patient that range from stretching, denervation atrophy, insertion detachment, and a combination of pelvic floor relaxation and organ prolapse [4]. Identification of all pelvic floor structures is mandatory for an effective therapy as dysfunction of one compartment often does not present solitary and affects the whole functional entity of the pelvic floor. Given the complexity and the interdependence of the pelvic floor compartments, an effective workup and therapy strategy require a multidisciplinary team including urogynecologists, urologists, gastroenterologists, proctologists, and radiologists.

Pelvic floor dysfunction or weakness encompasses a spectrum of functional disorders that result from alteration of soft tissue structures such as ligaments, fasciae, or muscles supporting the pelvic organs. It leads to pelvic organ prolapse in case of insufficiency of the suspensory structures and associated functional disturbance of the pelvic organs involved such as the bladder (e.g., urinary incontinence and/or voiding dysfunction), the vagina and uterus (sexual dysfunctions), or the rectum (obstructed defecation syndrome or fecal incontinence) [1]. A general weakness of the pelvic floor leads to the so-called pelvic floor relaxation with prolapse of multiple pelvic organs and combined symptoms. A missing relaxation of the puborectalis muscle or discoordinated pelvic floor movement can lead to functional outlet obstruction described as dyssynergic defecation [5].

51.2 Indications of Dynamic Pelvic Floor MRI

To date the most common indications for dynamic pelvic floor MRI or MR defecography (MRD) are rectal outlet obstruction, rectocele, recurrent pelvic organ prolapse, enterocele, and dyssynergic defecation [6]. Other less frequent indications include: stress urinary incontinence, peritoneocele, fecal incontinence, pelvic pain/perineal pain, and descending perineal syndrome [6]. Prior to MRI a full patients' history should be taken and regardless of the leading symptom all patients should undergo the same preparation and protocol [6]. Findings reported at dynamic MRI of the pelvic floor are valuable for selecting patients who are candidates for surgical treatment and for choosing the appropriate surgery. The results of dynamic MRI of the pelvic floor can change the initial surgical plan in 41% of patients with pelvic floor disorders [7] and in 67% of patients with fecal incontinence [8].

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51.3 Anterior Compartment

The anterior compartment contains the bladder and urethra. Frequent dysfunctions of the anterior compartment are stress urinary incontinence (SUI) [9, 10] and overactive bladder which is likely induced by bladder outlet obstruction [9]. Bladder outlet obstruction is most commonly caused by surgical repair of SUI or by urethral hypermobility, cystocele with kinking of the bladder outlet, outlet compression of the bladder by a prolapsing uterus, or rectocele [11].

SUI is caused by urethral hypermobility (80–90% of patients) [12] or intrinsic sphincter dysfunction (10–20% of patients) [4]. Urethral hypermobility is caused by a defect in the urethral support system, e.g., due to vaginal delivery, hysterectomy, or after surgical cystocele repair.

A cystocele develops due to tears in the endopelvic fascia and is defined as abnormal descent of the bladder at rest or under stress (at straining and during defecation) [13]. Cystocele is defined as a bladder base descent below the border of the pubic symphysis and represents organ prolapse of the anterior pelvic compartment through its respective hiatus. In dynamic pelvic floor MRI or MR defecography (MRD) a cystocele is diagnosed on dynamic sequences when the inferior border of the bladder descends >1 cm below the pubococcygeal line (PCL) [9] (Fig. 51.1). A severe cystocele can mask symptoms of SUI as the urethra becomes kinked at the bladder neck and through bulging of the anterior vaginal wall patients can present with dyspareunia [4]. On MRD cystoceles are measured from the bladder base perpendicularly to the PCL and are graded according to their size as small (<3 cm below the PCL), moderate (3–6 cm below the PCL), and large (>6 cm below the PCL) [14]. Using the HMO system, cystoceles are graded based on the distance of the bladder base relative to the H line as follows: grade 0 (no prolapse), bladder base above the H line; grade 1 (mild or small cystocele), bladder base 0–2 cm below the H line; grade 2 (moderate), bladder base 2–4 cm below the H line; and grade 3 (severe or large cystocele), bladder base 4 cm or more below the H line [9] (Fig. 51.2).

Recommendations for Practice

- The measurements to assess pelvic floor descent are performed in the images with greatest straining effort, which are displayed side by side with the rest images.
- Avoid overdistension of the urinary bladder as it is associated with underestimation of pelvic organ prolapse and may obscure findings in other compartments.
- Enteroceles are best detected at the end of the defecation phase as a consequence of the increased intra-abdominal pressure.
- Functional abnormalities such as loss of urine during straining should also be reported (Fig. 51.1) as well as incidental findings of the pelvic floor soft tissue structures.

51.4 Middle Compartment

The middle compartment contains the uterus and vagina and therefore is only present in female patients. Uterine and vaginal vault prolapse caused by levator ani trauma (e.g., after vaginal childbirth) or damage to the supporting connective tissue due to aging or congenital collagen defects may cause nonspecific complains. A variety of symptoms are described that range from pelvic pain and pressure to urinary or fecal incontinence as well as dyspareunia [13]. The most common cause of pelvic floor dysfunction arising in the middle compartment is explained with an avulsion of the pubovisceral muscle at its inferior aspect after vaginal delivery [15]. Complete tear of the

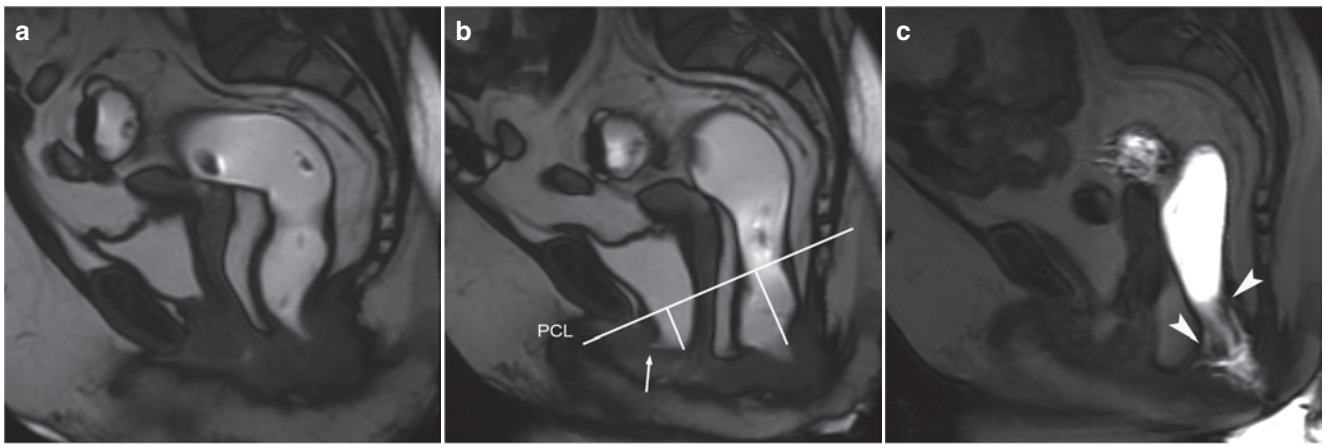

Fig. 51.1 54-year old female patient with urinary incontinence and slight outlet obstruction. Midsagittal T2-weighted trueFISP MR image at rest (**a**) shows a normal position of the pelvic floor. At straining (**b**) a pathologic descent of the bladder (2.2 cm) and anorectal junction (3.8 cm) is seen with a horizontal orientation of the urethra (white arrow). During defecation (**c**) the urinary bladder is emptied unintentionally and an intrarectal intussusception develops (white arrowheads). *PCL* pubococcygeal line

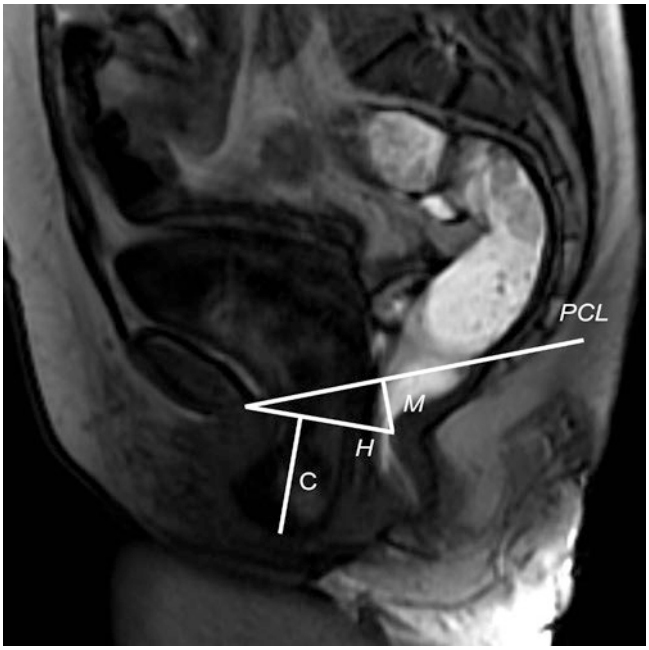

Fig. 51.2 64-year old female patient with a large cystocele. MR image obtained during defecation shows a large cystocele (C, white line) with the bladder base >4 cm below the H line according to the HMO-system. The H (5.5 cm) and M line (2 cm) are normal. *H* H line, *M* M line, *PCL* pubococcygeal line

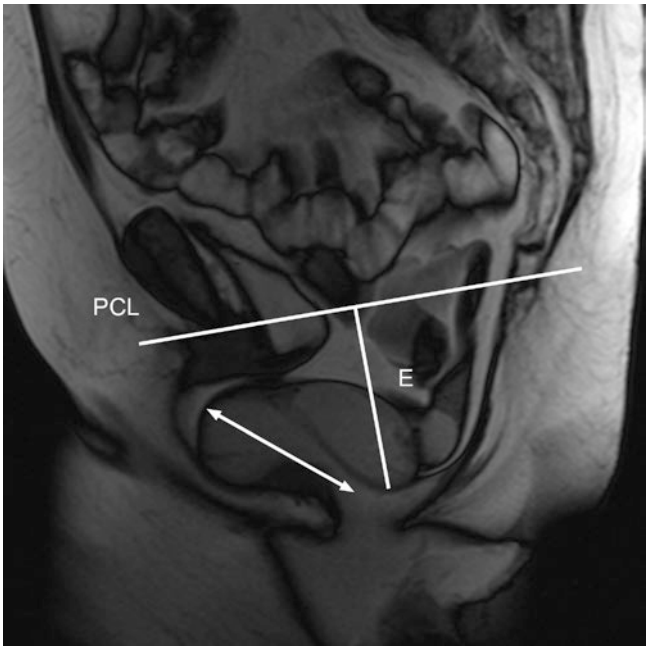

Fig. 51.3 76-year old female patient with an enterocele and anterior rectocele. Midsagittal T2-weighted trueFISP MR image during defecation shows protrusion of a moderate enterocele (5 cm) (E) into the extended perineum leading to compression of the distal rectum resulting in outlet obstruction. The large anterior rectocele shows retention of contrast medium due to compression by the enterocele. The extension of the anterior rectocele is measured as the maximum wall protrusion beyond the expected margin of the normal anterior rectal wall (white arrow). *PCL* pubococcygeal line, *E* enterocele

suspensory ligaments (uterosacral ligaments) causes uterine descent into the vaginal introitus and with severe uterine prolapse complete vaginal eversion can occur [16]. Patients may present with a vaginal mass in case of uterine prolapse and progressive ureteral obstruction can occur.

Vaginal prolapse is defined as descent of the vaginal vault below the PCL. In cases of uterine prolapse, 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. A vaginal vault or uterine prolapse is diagnosed if the vaginal vault or external cervical canal is located >1 cm below the PCL at rest or straining. For grading vaginal vault or uterine prolapse the same reference values are used as for grading of cystoceles. Vaginal vault prolapse is often associated with prolapse of other pelvic floor organs.

51.5 Posterior Compartment

51.5.1 Anorectal Descent

The landmark of the posterior compartment is the position of the anorectal junction with respect to the PCL [17]. On MRD anorectal descent is defined as an abnormal descent of the anorectal junction more than 3 cm below the PCL. A descent below the PCL between 3 and 6 cm is considered moderate and severe when greater than 6 cm (Fig. 51.1). It is often combined with an abnormal descent of the anterior and middle compartment [18]. The main cause for anorectal descent is excessive and repetitive straining leading to weakening of the pelvic floor musculature. Other conditions leading to weakening of the pelvic floor musculature are trauma due to vaginal delivery with pudendal nerve impairment as well as neuropathies of other etiologies.

51.5.2 Rectocele

A rectocele is a bulging of the anterior rectal wall and less frequently the posterior or lateral wall. Anterior rectocele is caused by weakening of the supporting rectovaginal fascia above the anal canal [19] (Fig. 51.3). Posterior rectoceles are rare and due to levator plate damage [20]. On clinical examination an anterior rectocele can be seen as an outpouching of the posterior vaginal wall with sensitivity between 30 and 80% [2, 21]. Most rectoceles only become apparent during defecation. Related symptoms include dyspareunia, sensation of incomplete evacuation, and constipation. For measuring an anterior rectocele the expected location of the anterior anorectal wall serves as posterior border of the rectocele in anterior posterior dimension. On MRD rectoceles are measured during maximal straining and evacuation. Small

rectoceles (<2 cm) are a very common finding in asymptomatic subjects, are more frequently found in women, and are considered normal [14, 22]. A bulge of 2–4 cm is considered moderate and >4 cm large; both are considered pathologic findings. Besides objective information about the size of a rectocele MRD displays the dynamics of its emptying and possibly entrapment of the rectal gel [17]. The retention of rectal gel may serve as a surrogate for retention of stool in the rectocele, which may lead to a sensation of incomplete evacuation. The clinical relevance of a rectocele is defined by size, retention of contrast material (Fig. 51.3), need for evacuation assistance, and symptoms.

51.5.3 Intussusception and Rectal Prolapse

Rectal prolapse is defined as an infolding of the rectal wall. An inner rectal pro-lapse (intussusception) is distinguished from an external rectal prolapse, corresponding to the widely used clinical term "rectal prolapse" [23].

51.5.3.1 Intussusception

Invagination or infolding of the rectal wall toward the anal canal during defecation is called intussusception. It can involve mucosal or mural components. Depending on the extension of the invagination the intussusception may remain in the rectum (intrarectal) (Figs. 51.1 and 51.4) or extent into the anal canal (intraanal intussusception). Patients with intraanal intussusception may experience incomplete defecation due to severe outlet obstruction. The intussusception can be seen anterior, posterior, or circumferential. Small invaginations of the rectal wall are considered normal during defecation, observed in nearly 80% of healthy subjects. However, an intussusception can be missed in pathologic conditions as it is commonly only visible at the end of the defecation phase. Therefore, the evacuation phase is mandatory to evaluate the full extent of pathologies [24]. The differentiation between a mucosal intussusception and a full-thickness intussusception is possible with dynamic pelvic MRI (Fig. 51.4), which is of clinical relevance, because the two different forms entail different treatment strategies [25, 26]. In up to 30% of patients with intussusception, associated anterior or middle pelvic floor compartment descent has been shown [21], underlining the importance of a complete pelvic floor evaluation.

51.5.3.2 External Rectal Prolapse

If parts of the rectal wall protrude through the anal canal outward, this condition is referred to as "rectal prolapse" (Fig. 51.5). Women are more commonly affected than men (6:1) with an incidence of 4:1000. Symptoms range from constipation, sensation of incomplete evacuation, fecal incontinence to rectal ulcerations with bleeding. Although it is a clinical diagnosis patients are referred to MRD to diagnose associated pathologies and for surgical planning.

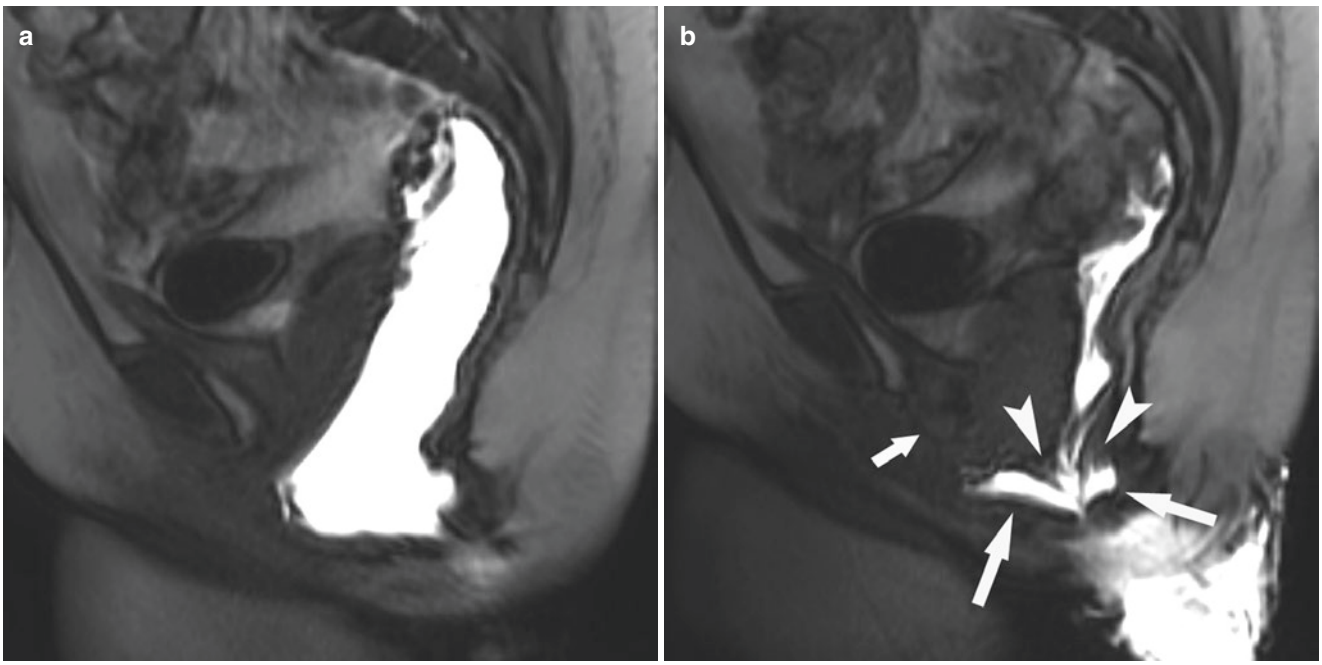

Fig. 51.4 41-year old female patient with full-thickness intrarectal intussusception. MR image (**a**) shows an anterior rectocele at the beginning of defecation. MR image (**b**) during defecation shows the development of a circumferential mural intussusception, which extends into the rectum (intraarectal, full-thickness intussusception) (arrowheads). Associated anterior and posterior rectoceles are seen (large arrows). In addition, a small cystocele evolves during defecation (small arrow)

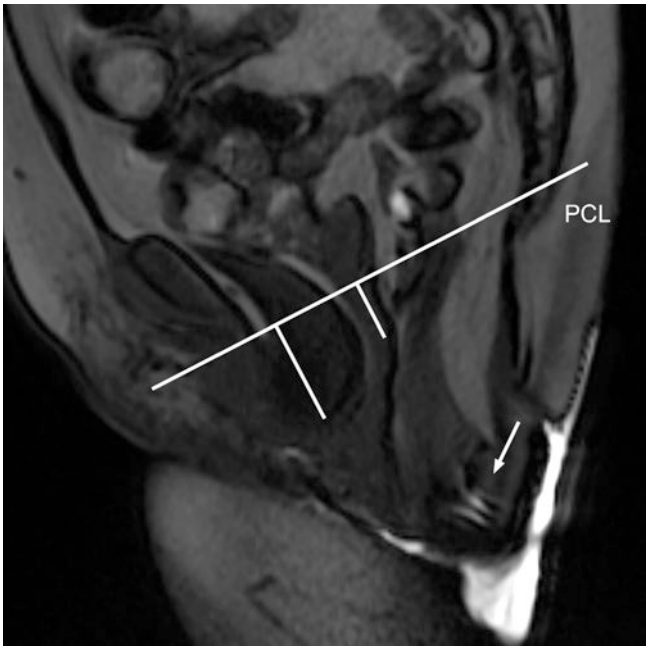

Fig. 51.5 63-year old female patient with external rectal prolapse. MR image obtained during defecation shows an external rectal prolapse (arrow) and an additional moderate anterior and small middle compartment descent. *PCL* pubococcygeal line

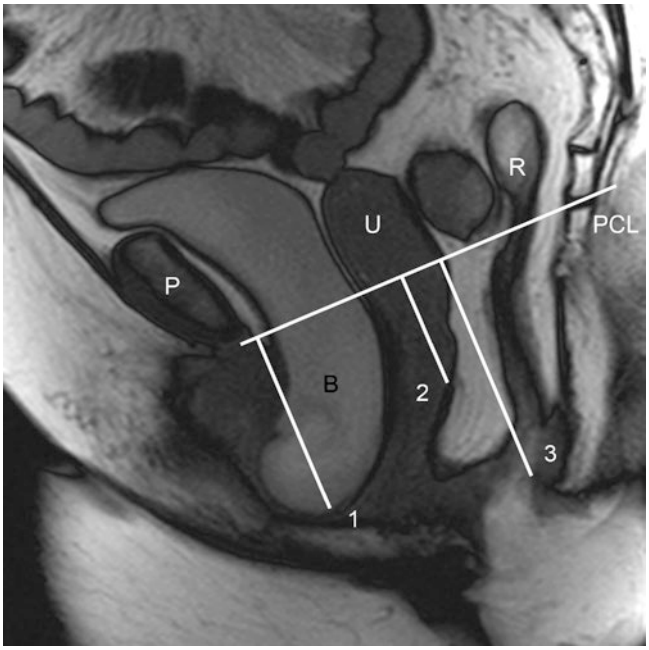

Fig. 51.6 78-year old female patient with descending perineum syndrom (pelvic floor relaxation). Midsagittal balanced steady state free precession T2-weighted MR image obtained during maximal straining shows a bulging of the whole pelvic floor with a large descent of the anterior compartment (*1*: 6.5 cm), small descent of the middle compartment (*2*: 2 cm) and a large descent of the posterior compartment (*3*: 7.5 cm). *B* bladder, *P* symphysis pubis, *PCL* pubococcygeal line, *R* rectum, *U* uterus

51.5.4 Enterocele

An enterocele is a generic term for herniation of the peritoneal sac, which contains omental fat (peritoneocele), small bowel (enterocele), or large bowel (sigmoidocele) which extents below the PCL into the rectovaginal or retrovisceral space (Fig. 51.3). Women are more frequently affected especially if they have a history of vaginal or abdominal hysterectomy as a hysterectomy causes a separation of the anterior (pubo-cervical) and posterior (rectovaginal) wall fascia. As a result of the widespread use of hysterectomy the incidence of enteroceles has markedly increased. In patients with pelvic floor disorders the prevalence ranges between 17 and 37% and they are frequently associated with rectoceles [17] (Fig. 51.3). As clinical examination misses 50% of enteroceles and therefore is insufficient for its detection, imaging in cases of suspicion is indispensable. MR imaging being superior to conventional cystocolpoproctography is the best suited imaging modality for diagnosis of enteroceles [27] and often allows the differentiation between peritoneocele, enterocele, and sigmoidocele. Enteroceles are often concomitant findings of other pelvic floor pathologies and are best detected at the end of the defecation phase. Especially in patients planned for surgical pelvic floor repair the additional diagnosis of an enterocele influences the surgical approach. Large enteroceles may follow the sacral curve and lead to compression of the ano-rectum, resulting in outlet obstruction. The distance from the most inferior point of the enterocele to the PCL line is measured in a perpendicular fashion in order to measure the size. Depending on the size enteroceles are graded as small (<3 mm), moderate (3–6 mm), and large (>6 mm) [14].

51.6 Pelvic Floor Relaxation

Pelvic floor relaxation (also known as descending perineal syndrome) is defined as a pathologic descent of the pelvic floor at rest or at straining caudal to the PCL (Fig. 51.6). Usually all three compartments of the pelvic floor are involved. It is initially characterized by perineal pain and constipation. Prolonged and excessive straining lead to denervation and thereby in the chronic stage the patients develop fecal incontinence [28]. Most commonly affected are women, aged 50 or older, with multiple vaginal deliveries, gynecological operations, and chronic constipation [29]. Although it can be already seen at rest, the maximus extension of the pelvic floor relaxation is seen at straining and defecation. The descent is defined as the maximum distance between the PCL and the lowest point of the anterior (bladder base), middle (vaginal vault), and posterior pelvic floor compartment (ARJ). A distance <3 cm below the PCL is graded as mild, 3–6 cm is moderate, and >6 cm is considered a large descensus.

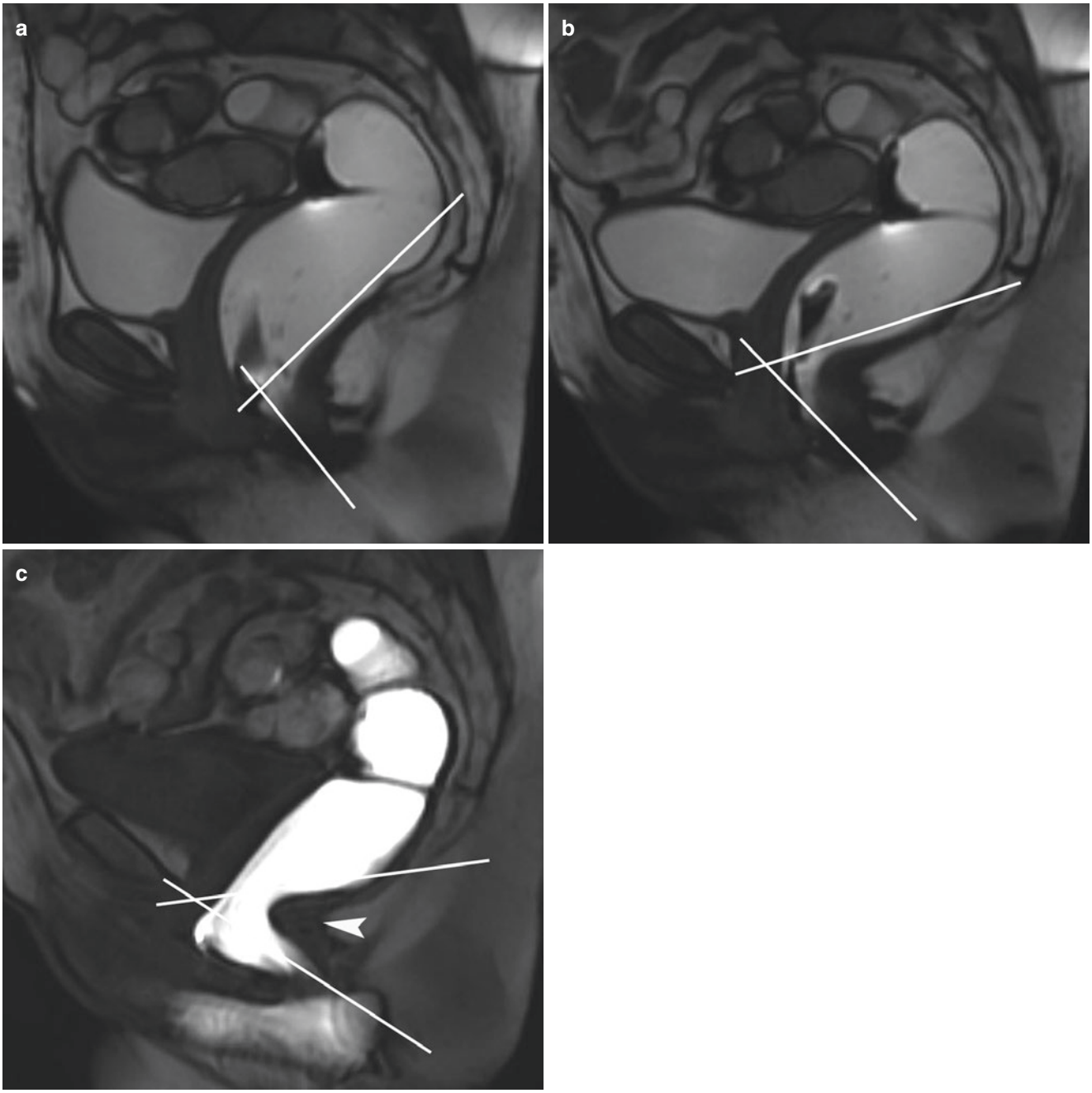

Fig. 51.7 60-year old female patient (s.p. hysterectomy and surgical repair of an enterocele) with clinical suspicion of dyssynergic defecation. On MR images obtained at rest (**a**) the anorectal angle measures 103°, whereas the anorectal angle during squeezing is 81° (**b**). During evacuation a pathologic decrease of the anorectal angle (48°) is seen (**c**). Paradoxical sphincter contraction is noted with impression of the dorsal anorectal wall during evacuation (arrowhead in **c**). The patient was able to evacuate only less than two thirds of the contrast agent

51.7 Dyssynergic Defecation

At rest the puborectalis muscle constantly pulls the rectum anteriorly to maintain the continence and relaxes during the evacuation phase. In patients with dyssynergic defecation during defecation no relaxation or a paradoxical contraction of the puborectalis muscle and/or anal sphincter is observed leading to functional outlet obstruction during defecation (Fig. 51.7). It typically causes chronic constipation and patients can present with a variety to symptoms including sensation of blockage, need for manually assisted defecation, and frequent use of enemas [30] as well as delay between opening of the anal canal and initiation of defecation [31]. Many other terms have been used in the literature

to describe this phenomenon such as anismus, spastic pelvic floor syndrome, and pelvic floor dyssynergia. The term "dyssynergic defecation" was proposed by an expert group [5] to correctly describe the failure of coordination of the abdominal and pelvic floor muscles involved in defecation [32]. How exactly dyssynergic defecation evolves is still unclear, but associations seem to exist between dyssynergic defecation and pelvic surgery, previous sexual abuse, anxiety, and psychologic stress [33]. As the diagnosis is extremely difficult, it is recommended to use a combination of diagnostic tests, imaging, and clinical history to properly diagnose dyssynergic defecation. Besides imaging, different physiological tests exist to investigate this functional disorder (e.g., balloon expulsion test, electromyography, anorectal manometry); however none can be used as a gold standard by itself as false-positive and false-negative results are common. Functional imaging with conventional defecography or MRD is considered to be a useful adjunct in establishing the diagnosis of dyssynergic defecation. In addition, MRD can be performed to rule out structural rectal abnormalities. Delayed initiation of evacuation and/or incomplete evacuation was shown to be highly predictive in patients with dyssynergic defecation as seen on conventional defecography [31, 34]. MRD has been shown to be a valuable alternative to evacuation proctography [14, 32, 35, 36]. Findings on MRD include lack of normal pelvic descent, inability to evacuate, paradoxical decrease of the anorectal angle during straining and evacuation, and a posterior prominent impression of the contracted puborectalis muscle on the anorectal junction (Fig. 51.7) [32, 37]. Impaired evacuation, which was defined by Halligan et al. [34] as an inability to evacuate two-thirds of the contrast enema within 30 s, is especially highly suggestive for the presence of dyssynergic defecation. In addition to morphologic and dynamic changes implying the diagnosis of dyssynergic defecation, MRD can be used for therapy monitoring as it can also assess changes in dynamics of the pelvic floor after biofeedback therapy [38].

51.8 Conclusion

By providing morphologic and functional information on pelvic floor structures and pathologies MRD and therefore the radiologist is gaining a central role in the workup of patients with pelvic floor disorders. Profound knowledge of pelvic floor anatomy, patients' history, clinical finding, as well as the ability to correctly depict pathologic condition of the pelvic floor on MRD are crucial to contribute to an accurate management of these patients. The use of guidelines helps to standardize MRD protocols and provide a systematic approach to report MRD findings for a better communication between the different specialists involved in the management.

Future Directions

- To focus on imaging of pelvic floor support structures and their defects, more than on pelvic organ prolapse, which is simply the effect of the structural defects
- To develop measurement systems, which allow the measurement of pelvic organ location in a three-dimensional space instead of midsagittal two-dimensional planes to improve diagnosis and surgical planning

Take-Home Messages

- Knowing normal pelvic floor anatomy and being able to recognize physiologic conditions of the pelvic floor is key for correct interpretation of MRD finding and its pathologic conditions.
- The presence and degree of pelvic floor abnormalities may be underestimated if the evacuation phase is not performed. Therefore, the evacuation phase should be an integral part of every MRD protocol.
- MRD offers the possibility of a comprehensive evaluation of pelvic floor dysfunction most often being a combination of pathologies of more than one pelvic floor compartment.

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