Dynamic MR imaging of the pelvic floor dysfunction: a pictorial review

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Learning objectives

- To discuss the imaging protocol and procedure details,
- To describe the magnetic resonance (MR) features of pelvic organ prolapse, incontinence and outlet obstruction syndrome,
- To illustrate the postsurgical findings.
**Background**

Disorders of the pelvic floor such as defecation dysfunction and pelvic organ prolapse are increasingly being recognized as a common health problem, primarily affecting adult parous women. Around 15% of women are affected by some pelvic floor disorder [1]. They present with various symptoms such as constipation, fecal or urinary incontinence, dyspareunia, feeling of incomplete emptying, pelvic pain and gross organ protrusion [1, 2]. MR imaging of the pelvic floor is often requested for obstructed defecation syndrome (ODS) which encompasses the symptoms of outlet obstruction to the passage of stool or incomplete rectal evacuation [1].

The pelvic floor in women is divided in three compartments: the anterior compartment (urinary bladder and urethra), the middle compartment (vagina and cervix) and the posterior compartment (rectum). Patients attend gynecologists, urologists and proctologists for pelvic floor disorders [2].

Basic diagnostic approach for these disorders is physical examination with inspection and palpation, rectoscopy and proctoscopy, along with urodynamics, anorectal manometry and endosonography [3]. Radiological examination can give additional information. Traditional imaging methods in assessment of pelvic floor weakness include evacuation proctography and voiding urodynamics, but they don't allow simultaneous assessment of all pelvic floor compartments and provide limited anatomic information. Furthermore, these methods require multiple examinations with significant radiation exposure. Abnormalities in all three pelvic compartments are frequently associated in various degrees and combinations. In the case of a single compartment surgical correction, the recurrence of symptoms is 10-30% due to problems related to compartment that was not initially corrected [1].

MR imaging of the pelvic floor has first been introduced in 1991 by Yang et al and Kruyt et al [4]. With advances in technology, new machines and sequences, that allow better signal to noise ratio and fast acquisition times, dynamic MRI of the pelvic floor can be performed [3]. It consists of imaging patient at rest, during squeezing, straining and defecation and enables the concomitant assessment of all three compartments and relationship of pelvic organs. It is increasingly being used for studying pelvic floor dysfunction due to absence of ionizing radiation, high contrast soft-tissue resolution and multiplanar imaging capabilities [1]. Because accurate preoperative diagnose is necessary to select patients who are candidates for operation and to choose appropriate surgical approach, MR should be routinely used in preoperative planning before pelvic floor surgery.

**MR imaging protocol:**
In our center, we perform the study in 1.5 T MR unit (Philips, Achieva) in supine position, with torso phased-array coil placed around the pelvis.

The MR imaging protocol requires no bowel preparation. Before the examination patients is asked to void. Around 100-150 mL of the ultrasound gel (which has high signal intensity with T2-weighted sequences) is instilled via a small-caliber catheter-tip syringe into the rectum. We didn’t use the endovaginal coil as it is invasive and may distort the pelvic/vaginal tissue and the field of view is too small [3]. Patients are placed in supine position with knees bent and supported lightly by a pillow with legs somewhat apart.

MR study protocol starts with obtaining scout images to identify a midline sagittal section. The examination proceeds with sequences for visualization of pelvic floor anatomy: T2-weighted turbo spin echo sequences (repetition time [msec]/echo time [msec], 8975/90, 50x20-cm field of view, 240x240 matrix, 40 sections with a 5-mm section thickness, 3-4 minute imaging time) are performed in sagittal, axial and coronal plane and T1-weighted turbo spin echo sequences (repetition time [msec]/echo time [msec], 618/10, 50x20-cm field of view, 480x480 matrix, 40 sections with a 5-mm section thickness,) are performed in axial plane. For the dynamic MRI of the pelvic floor balanced fat sat turbo field echo (B-TFE) breath hold images (3.5/1.8, 55x23-cm field of view, 160x160 matrix, 5-mm section thickness) in sagittal plane are obtained during squeeze, strain and defecation.

The protocol can be completed in 20 min.

Anatomy:

Endopelvic fascia is a layer of connective tissue that provides important anterior and lateral passive support to the vagina, urinary bladder and urethra. The fascia around the vagina and uterus forms a sacrouterine or cardinal ligament that suspends and supports the vaginal vault and pulls it towards the rectum [2].

Pelvic diaphragm consists of levator ani muscle that has three important components: the ileococcygeus, pubococcygeus and puborectalis muscle. The pubococcygeus muscle posteriorly fuses to form a midline raphe, called the levator plate. The puborectalis muscle originates from the pubic symphysis and forms a sling around rectum at anorectal junction. It aligns with the external anal sphincter [2].

Urogenital diaphragm is composed of connective tissue and the deep transverse perineal muscles. The perineal body is the important anchoring structure for the muscles and ligaments of the urogenital diaphragm: rectovaginal fascia, (condensation of the
endopelvic fascia), external anal sphincter and superficial and deep transverse muscles [2] (Fig 1).

**Fig. 1:** Normal male (a, b) and female (c) pelvic anatomy, T2 weighted turbo spin echo image in midsagittal (a, c) and axial (b) plane showing urinary bladder, vagina, uterus, and rectum. Urethra (U) is located anteriorly and has a bull's eye configuration on axial T2W images, with central hyperintense mucosa. Vagina is located in the middle of the pelvis, between the urethra and the rectum. Rectum lies posteriorly and cranially to the transverse perineal muscles. Perineal body (star) in women lies within the anovaginal septum, in men is located posteriorly to the spongious and cavernous bodies. Urogenital septum (rhomb) and levator plate (arrow) are also indicated. On axial images, puborectal muscles (arrowheads) are shown forming a sling around the rectum (R).

**References:** Department of radiology, General hospital Novo mesto - Novo mesto/SI

**Interpretation**

MR of the dynamic pelvic floor are interpreted according to Yang et al. and using the HMO system [H-line, M-line and organ prolapse] [5].
Fig. 2: Midsagittal B-TFE image obtained at rest shows normal findings. PCL is drawn from the inferior border of the pubic symphysis to the last coccygeal joint. The M line is drawn perpendicular from the PCL to the posterior wall of the rectum at the level of anorectal junction. The H line is drawn from the inferior pubic symphysis to the lowest aspect of M line (Ref. 5).

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The pubococcygeal line (PCL) according to is the line, representing the level of the pelvic floor (Fig 2). Two additional lines can be measured: the H-line (puborectal hiatus line) represents the anteroposterior hiatal dimension, allowing the grading of the maximal widening of the pelvis sling during straining. The M-line (muscular pelvic floor relaxation)
measures the pelvic floor descent from the PCL line during straining. The O classification (organ prolapse) characterizes the degree of prolapse [5].

Pelvic floor relaxation and pelvic organ prolapse are related and often coexistent pathologic conditions but they need to be differentiated. Elongation of the H and M lines is the indication of pelvic floor relaxation and it includes levator plate widening and descent of the levator hiatus (Table 2) [2]. The H line and M line in normal women measured approximately 5 and 2 cm, respectively [1, 2].

Table 1
Grading of the pelvic floor relaxation

<table>
<thead>
<tr>
<th>Grade</th>
<th>Hiatal enlargement (cm) (H line)</th>
<th>Pelvic floor descent (cm) (M line)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (normal)</td>
<td>&lt;6</td>
<td>0-2</td>
</tr>
<tr>
<td>1 (mild)</td>
<td>6-8</td>
<td>2-4</td>
</tr>
<tr>
<td>2 (moderate)</td>
<td>8-10</td>
<td>4-6</td>
</tr>
<tr>
<td>3 (severe)</td>
<td>#10</td>
<td>#6</td>
</tr>
</tbody>
</table>

Pelvic organ prolapse is considered if protrusion of the organ during straining is seen beneath the PCL line. It constitutes the final O component of the HMO grading system (Table 2). On static images the position of the urinary bladder neck, cervix, and anorectal junction are detected and are used as the landmarks for measuring the pelvic organ prolapse. The distance (vertical lines) from the PCL to the landmarks should be measured on images while patient is at rest and during straining [1, 6, 7]. The pelvic organ prolapse can involve the urethra (urethrocele), urinary bladder (cystocele), vaginal vault (vaginal vault prolapse), uterus (uterine prolapse), rectum (rectocele), small bowel (enterocele) or bulging of the rectum wall anterior to the transverse perineal muscle of more than 2 cm can be seen (anterior rectocele) [1].

Table 2
Grading of the pelvic organ prolapse

<table>
<thead>
<tr>
<th>Grade</th>
<th>Organ location (cm) relative to PCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (none)</td>
<td>Above</td>
</tr>
<tr>
<td>1 (minimal)</td>
<td>1-3</td>
</tr>
<tr>
<td>2 (moderate)</td>
<td>3-6</td>
</tr>
<tr>
<td>3 (severe)</td>
<td>#6</td>
</tr>
</tbody>
</table>
Anorectal junction is the point where the distal part of rectum meets the anal canal. Anorectal angle (ARA) (Fig 3) is defined as the angle 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 [1].

**Fig. 3:** Measurement of anorectal angle on dynamic MRI of the pelvic floor, midsagittal T2-weighted turbo spin echo images at rest (a), B-TFE images during squeezing (b) and straining (c). The anorectal angle is normally between 108 and 127 degrees at rest. It changes during squeezing and straining, as the puborectal muscle contracts and relaxes by 15-20 degrees (Ref 1).

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Findings and procedure details

Pathologic conditions are divided topographically.

**Anterior compartment:**

*Cystocele and urethral hypermobility:*

Cystocele is defined as the urinary bladder descent below the PCL [2, 6, 7] (Fig 3c, 4b, 5c). It is due to the tear in the pubocervical fascia that may be located in central part of the fascia, in the lateral part (paravaginal) or a combination of both [2]. In women presenting with stress urinary incontinence, which is due to urethral sphincter deficiency, the support from the anterior vaginal wall is diminished. The distal two thirds of urethra is inseparable from the anterior vaginal wall [3]. In these cases, on the dynamic MR of the pelvic floor, we can observe the descent of the urinary bladder neck. If the urinary bladder prolapse is severe, the urethers may become entrapped in the muscles of the pelvic floor resulting in hydronephrosis [2]. Treatment ranges from nonsurgical interventions such as pessary in mild cases of cystocele to surgical procedures (e.g. retropubic urethropexy) in more severe cases to restore the original position [1, 6].

Urethral hypermobility is a condition in which the posterior wall of the urinary bladder descends more than the anterior wall, causing the downward and clockwise urinary bladder rotation and the rotation of the urethral axis into a horizontal position [2] (Fig 3c). It indicates loss of intrinsic urethral sphincter integrity [1].

Urethral funnelling is a condition where dilatation of the proximal urethral lumen and apparent shortening of the urethra occurs. It is a nonspecific finding indicating intrinsic urethral sphincter integrity in an incontinent women as it can be observed even in continent women [1]. On midsagittal images, it is important to separately assess the urethra and the urinary bladder, as the high grade cystocele may mask urethral hypermobility [2]. Urethral hypermobility requires pubovaginal sling procedure to provide midurethral support and avoid subsequent stress incontinence [1, 2, 6].

**Middle compartment**

*Uterine and vaginal vault prolapse*

Uterine and vaginal vault prolapse are defects of the middle compartment. Vaginal or cervical prolapse is defined as the vaginal vault descends below the PCL line [1] (Fig 3c). It is due to the laxity of the uterosacral ligaments and muscle damage that allow the...
cervix to move anteriorly, resulting in progressive uterine retroversion and subsequent prolapse. On axial images, vagina loses the typical H shape, is displaced inferiorly and on dynamic images distal portion moves anteriorly. On coronal images, the iliococcygeus muscle is flat or convex downwardly [2].

Vaginal prolapse in the patients that have undergone hysterectomy is termed "apical prolapse" (Fig 4b, 5c, 7). It is due to defect in the superior vaginal support (pubocervical and rectovaginal part of the endopelvic fascia). In these women, the support of the vaginal vault is provided by paracolpium and the vaginal apex should remain at least 1 cm above the PCL line during straining [3].

Mild vaginal vault prolapses can be managed with pelvic floor exercise. In more severe cases, reattachment of vaginal vault to the sacrospinous ligament, ileococcygeus muscle or uterosacral ligaments are needed (uterosacral suspension) [2, 6]. Uterine prolapse are usually treated with hysterectomy [2].

**Posterior compartment**

*Enterocele, peritoneocele and sigmoidocele.*

Small bowel and peritoneal mesenteric structures can herniate downward along the ventral rectal wall into the rectovaginal space (cul-de-sac) or posterior perineum passing more than one third of the vagina [1, 2]. Depending on the content (small intestine, omental fat or sigmoid colon) it is called enterocele, peritoneocele or sigmoidocele. Enterocele may be simple or complex, depending on presence of vaginal vault prolapse, which is important for the surgical planning [2]. These conditions occur when the perineal body is damaged, due to episiotomy during childbirth, separation of the perineal body or disruption of the rectovaginal fascia or iliococcygeus muscle [1]. Surgical repair aims to obliterate the cul-de-sac and is called culdoplasty [1]. Another operation, the sacrocolpopexy, lifts the vagina to its normal position and attaches it by a mesh to the sacrum [7].

Patients who have undergone hysterectomy are particularly prone to vaginal prolapse. Vaginal descent creates wide rectovaginal space, predisposing patients to enterocele and peritoneocele [1]. Large cystocele may mask coexisting enterocele or rectocele because of tight space in the pelvic floor [3].

*Rectocele*

Rectocele is characterised by the prolapse of the rectum through the hiatus or bulging of the anterior wall in the posterior vaginal wall (Fig 3b, 3c, 4, 5, 6, 7). Less frequently there is bulging of the posterior or lateral rectal wall. It results from the defects in the prerectal and pararectal fascia (endopelvic) or rectovaginal septum [2].
Rectal invagination or intussusception is considered when a full thickness rectal wall prolapse is seen. The intussusception may remain internal (in that case it is classified as intrarectal), may extent into the anal canal (intraanal) or pass the anal sphincter (extraanal or extrarectal) which is most often called rectal prolapse. Low-grade intussusception is defined when rectal mucosa infolding is seen, but not extending intraanal. High-grade intussusception or prolapse is full-thickness rectal wall prolapse that penetrates the anal canal [1, 8]. Simple intussusception may be treated with simple transanal excision of the prolapsing mucosa, while full-thickness rectal invagination requires rectopexy alone or in combination with colporrhaphy or levatoplasty [1, 7]

Anterior rectocele is the most common pathology in the posterior compartment. It is considered when rectal wall bulges into the posterior vaginal wall more than 2 cm beyond the expected margin of the normal anterior rectal wall, which is distance measured between the anal canal to the tip of the rectocele (Fig 3, 4, 5). It can be easily identified on the midsagittal image. Anterior 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 more than 4 cm. It is important to correlate imaging findings with symptoms as low to mild-grade rectocele may be asymptomatic [1]. Surgical treatment involves rectovaginal fascia repair or posterior fixation of the rectum with possible sigmoid or rectal resection [2]

Rectoceles are often accompanied by other pelvic floor disorders, such as enterocele or intussusception [2]. In these patients, Douglas obliteration surgery with rectocele and intussusception correction should be considered [7] (Fig 6).

**Descending perineal syndrome**

Descending perineal syndrome is defined as the hiatus widening and pelvic floor descent, H and M-line increase more than 5 and 2 cm respectively. This is due to progressive weakening and relaxation of the pelvic floor supporting structures. The underlying cause is the dysfunction of the perineal body or a levator plate descent. The midline raphe of the iliococcygeus muscle is easily identified on the midsagittal image. During the dynamic MR examination it should remain parallel to the PCL line. Caudal angulation with respect to the PCL is indicative of pelvic floor weakness. Focal asymmetry of the levator ani muscle may also occur and is best imaged in coronal plane. As the pelvic floor descends, so do the pelvic organs above it [1, 2].

**Spastic pelvic floor syndrome:**

Spastic pelvic floor syndrome is a functional abnormality that is observed in some constipated patients. When performing dynamic study, during progressive straining no
physiological relaxation of the puborectal muscle occurs, instead inappropriate and paradoxical contraction of the pelvic floor muscles is observed [8]. There is a long time interval between opening of the anal canal and start of defecation, therefore the evacuation is prolonged and sometimes incomplete. Moreover, hypertrophic puborectal muscle can be seen on axial images. The syndrome is also called pelvic floor uncoordination or anismus. The etiology is unclear but could be due to abnormal muscle activity or psychological factors [1].

**Fig. 4:** Cystocele, vaginal vault prolapse, anterior rectocele and rectal prolapse in a 61-years-old woman, with symptoms of obstructions, who has undergone vaginal hysterectomy: midsagittal B-TFE image at rest (a) shows position of anorectal junction 4.8 cm below the PCL line indicating moderate rectal prolapse. Corresponding
defecation image (b) shows severe rectal prolapse, minimal cystocele, vaginal vault prolapse and an anterior rectocele (star) of more than 2 cm. Midsagittal B-TFE image at rest (c) shows normal ARA of 117 degrees. Image during straining shows almost no change in ARA measurements, during defecation (d) ARA measures 110 degrees indicating weakness and disorder of puborectal muscles.

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Fig. 5: Cystocele, rectocele and anterior rectocele in a 60-year-old women with symptoms of ODS who has undergone hysterectomy: midsagittal T2-weighted turbo spin echo at rest (a) shows minimal rectal prolapse and elongated H and M lines. Midsagittal B-TFE images obtained during straining (b) and defecation (c) show further elongation of H and M line (7.7 and 3.2 cm respectively), minimal cystocele, anterior rectocele (star) and a severe rectocele.

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**Fig. 6:** 44 year old women with symptoms of obstructions: dynamic fluoroscopic defecography (a, b) revealed rectal prolapse, anterior rectocele (arrow), intussusception (arrowhead) and enterocele (star). Patients has undergone rectopexy according to Wells. Midsagittal B-TFE image obtained at rest (c) shows normal position of the urinary bladder and uterus. Small rectal prolapse is already evident. During defecation (d) severe rectal prolapse is seen, along with relapsing anterior rectocele. H and M line are elongated indicating pelvic organ descent. No enterocele is evident.

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Fig. 7: Rectocele in a 50-year-old women. Midsagittal B-TFE image obtained during straining shows minimal cystocele and moderate rectocele.

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Conclusion

Pelvic floor dysfunction syndrome is a common clinical problem. Dynamic MRI of the pelvic floor is mandatory in patients whom conservative management was unsuccessful and who need surgery to determine the extent of the pathology and to choose appropriate surgical procedure. It is also a comfortable method for the patients for the study of pelvic floor disorders. Unfortunately pelvic floor disorders are not completely understood. Dynamic MRI of the pelvic floor has a big research potential to understand the pathophysiology of these disorders.
References


