High-field (3T) magnetic resonance defecography with functional assessment of the evacuation phase: A pictorial essay

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Learning objectives

1. To review and describe the anatomy and the pathology of the pelvic floor

2. To describe the adequate technique of dynamic high-field MRI (3T) in assessing pelvic floor disorder

3. To provide an overview of the most common pathologies occurring during the evacuation phase, especially in comparison with results of conventional defecography

Background

1. Definition and epidemiology

- The pelvic floor is a complex system of active and passive components providing pelvic support, continence and relaxation during urination and defecation.
- Dysfunction of pelvic floor is a very common disease affecting up to 50% of women older than 50 years. In the general population, 10% of the women will undergo surgery with a high rate of recurrence (up to 30%) [1].
- Pelvic floor abnormalities have a significant impact on the quality of life resulting in a variety of symptoms such as incontinence (fecal or urinary), constipation, pelvic pain and prolapse of pelvic organs.
- Etiology of pelvic floor dysfunction is generally multifactorial. The risk factors for pelvic floor weakness are commonly advancing age, vaginal parity, multiparity, obesity, hysterectomy, menopause, and more rarely neuropathy, collagen-related disorders and iatrogen injury [2].
- Anatomical and functional assessment of pelvic floor disorders is essential for the planning of the surgical approach and strategy.
- Clinical evaluation frequently underestimates the extent of pelvic floor dysfunction.
- Fluoroscopic defecography is a well established method for diagnosing anorectal disorders. HOWEVER, it is a ionizing radiation examination and is less suitable for the evaluation of complex pelvic floor disorders.
- Dynamic high-field magnetic resonance (MR) defecography including the evacuation phase is a promising tool for the assessment of functional pelvic disorders allowing for the evaluation of all the compartments of the pelvis without ionizing radiation exposure.

2. Anatomy of the pelvic floor

- The pelvic floor is divided in three compartments (FIG 1 on page )
  - Anterior, called "urinary compartment" (containing bladder and urethra)
- Middle, called "genital compartment" (containing uterus and vagina)
- Posterior, called "intestinal compartment" (containing sigmoid, rectum, anal canal and small intestine).

- The pelvic floor is a complex and multilayered anatomic and functional unit with fascias and ligaments providing passive support and muscles providing active support [3].
- There are three horizontal layers, from cranial to caudal: endopelvic fascia, pelvic diaphragm and urogenital diaphragm.
- The endopelvic fascia (FIG 2) on page is a delicate structure and cannot be constantly demonstrated with any surface phased-array coil. It provides passive support to the pelvic organs and is composed of:
  - parametrium (supporting uterus),
  - paracolpium (supporting vagina)
  - pubocervical fascia (supporting bladder and urethra)
  - recto-vaginal fascia (between rectum and vagina)
- It also contains several ligaments. The most important are uterosacral ligaments, cardinal ligaments and the arcus tendineus [3].
- The pelvic diaphragm, also called the levator ani complex, provides active support to the pelvic viscera and continence (at rest and during increased intra-abdominal pressure). The levator ani complex is composed of several muscles with two components providing the major support of pelvic organs:
  - Iliococcygeus muscle (FIG 3) on page (best seen in coronal T2 WI) and
  - Puborectalis muscle (FIG 3) on page (best seen in axial T2 WI).
- The right and left puborectalis muscle join behind the anorectal junction to form a muscular sling.
- The urogenital diaphragm, also called deep perineal space, lies inferior to the pelvic diaphragm and contains five muscles with two main components: Deep transverse perineal muscle and the external anal sphincter. Internal anal sphincter can be well visualized due to the high contrast and spatial resolution of the 3 Tesla MR unit (FIG 4) on page.

3. Pathology of the pelvic floor

- There are two different pathological entities:
  - Pelvic organ prolapse which corresponds to an abnormal protrusion of a pelvic organ through its respective hiatus and
  - Pelvic floor relaxation which results from the weakness of the active and passive pelvic floor support.

a) PELVIC ORGAN PROLAPSE (DEFINITION):

- Cystocele (FIG 5) on page: prolapse of the bladder in the anterior compartment.
- Bladder neck descent: prolapse of the bladder neck only.
- Rectocele (FIG 5) on page: prolapse of the rectum with bulging of the anterior rectal wall of more than 2 cm.
• **Vaginal vault prolapse (FIG 6) on page**: descent of the vaginal vault.
• **Prolapse of the uterus (FIG 6) on page**: descent of the vaginal fornices and uterus.
• **Peritoneocele**: protrusion of the pouch of Douglas through the rectovaginal space.
• **Enterocle/sigmoidocele (FIG 7) on page**: protrusion of small bowel/ sigmoid colon through the rectovaginal space.
• **Intussusception**: invagination of the rectal wall.

b) **PELVIC FLOOR RELAXATION (FIG 8) on page**

There are two components of pelvic floor relaxation: Pelvic floor descent and Pelvic floor widening [4]. Usually, these two pathologies simultaneously occur.

Images linked within the text of this section:

![Pelvic Floor Compartments](image)

**Fig.**: compartments of the pelvic floor
**Fig.:** pelvic fascia
Fig.: pelvic diaphragm
**Fig.:** anal sphincter complex
Fig.: pelvic organ prolapse
Fig.: pelvic organ prolapse
Fig.: pelvic organ prolapse
Fig.: pelvic floor relaxation
1. MR Technique

- **Since 1993,** MRI is being used for the assessment of pelvic floor dysfunction [5]. MR defecography 3 T is an "all in one " technique with many advantages **(FIG 9) on page** [6]. Patient's collaboration is crucial for a successful examination **(FIG 10) on page**. The bladder should be half-full. The rectum is filled with 100-150 ml of ultrasound gel and a towel is placed underneath the patient who is in a supine position. Then a surface phased array coil is placed. Imaging in our institution is performed using a 3 T MR unit with a standard protocole **(FIG 11, 12 on page, 13 on page, 14 on page, 15 on page).**

- The images will be analysed to provide a grading of the pelvic floor dysfunction according to the HMO SYSTEM (H line, M line, organ prolapse) **(FIG 16 on page, 17 on page, 18 on page)** [7, 8].

2. PATHOLOGIC FINDINGS

a) Morphologic findings of pelvic floor :

- Atrophy of the levator ani complex **(FIG 19) on page**
- Atrophy of the anal sphincter complex **(FIG 20) on page**

b) Dynamic findings of pelvic floor

- The dysfunction of the anal sphincter complex is assessed by means of T2 HASTE (rapid Half-Fourier) sequences during maximal strain and maximal contraction **(FIG 21 on page, 22 on page).**
- Relaxation of pelvic floor and pelvic organ prolapse is assessed by means of sagittal dynamic TrueFISP sequences during maximal strain and evacuation **(Video 1) on page**
- The grading of the pelvic floor relaxation **(FIG 23) on page** and the grading of the pelvic organ prolapse **(FIG 24 on page, 25 on page, 26 on page, 27 on page)** is performed on TrueFISP or T2 HASTE sagittal images during or at the end of the evacuation phase.
- Urinary **(Video 2) on page** and fecal incontinence **(Video 3) on page** can also be demonstrated using dynamic MRI.
- Several studies demonstrated no significant differences between measurements resulting from MR colpocystoproctography in the upright position compared to the supine one [10,11]. However, according to our daily experience, enterocele may be underestimated, or even missed on supine MRI **(FIG 28) on page**. In these cases, an open MR-unit permitting the patients to undergo the examination in sitting position could be useful [11].
MR defecography 3T
«all in one »

- No ionizing radiation, noninvasive
- Ability to assess all the pelvic compartments
- Ability to assess dynamically the pelvic floor
- High-resolution and high contrast technique
- «inconvenience» : examination in supine position BUT several studies have reported no significant difference with the upright position (6). However, in our experience enterocele can be missed or under-estimated

Fig.: advantages of the MR defecography 3T
MR Technique

Meeting the patient

- Patient cooperation is crucial for a successful examination
- Put the patient at ease (anxiety often high, embarrassment can be significant barrier)
- Ask about past significant medical problems, injuries and surgical procedures
- Explain the procedure and purpose

Fig.: meeting the patient
3 T - MR Technique

MR imaging sequences

- Imaging in our institution is performed using a 3 T MR unit

<table>
<thead>
<tr>
<th>Sequences</th>
<th>Slice thickness</th>
<th>Orientation</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2 spin echo</td>
<td>4 mm</td>
<td>Axial, coronal, sagittal</td>
<td>Rest</td>
</tr>
<tr>
<td>T2 HASTE (rapid Half-Fourier)</td>
<td>5 mm</td>
<td>Sagittal</td>
<td>Maximal contraction</td>
</tr>
<tr>
<td>True FISP dynamic</td>
<td>5 mm</td>
<td>Sagittal</td>
<td>Maximal strain</td>
</tr>
<tr>
<td>T2 HASTE</td>
<td>5 mm</td>
<td>Sagittal</td>
<td>Evacuation</td>
</tr>
</tbody>
</table>

Matrix size = 512 x 250 with 3 T (320 x 204 with 1.5 T)
Voxel size (mm) = 0.5x0.8x4 with 3 T (1x0.9x4 with 1.5 T)

Fig.: MR Technique
Fig.: MR Technique

**FIRST STEP**: T2 spin echo
Axial, coronal, sagittal at rest

**AIM**
- Morphology of the levator ani complex:
  - puborectalis muscle: the posterior sling must be visible on axial plane
  - iliococcygeus muscle describes a convex shape on coronal plane
- Morphology of the anal sphincter complex (internal and external anal sphincter)
- Search for others pelvic pathology
SECOND STEP: T2 HASTE sagittal at maximal contraction and maximal strain

**Aim:** To assess the function of the external anal sphincter

**Aim:** To assess the function of the internal anal sphincter

**Maximal Sphincter Contraction**

**Maximal Strain**

**Fig.:** MR Technique
THIRD STEP: True FISP dynamic SAGITTAL during evacuation phase

**AIM:**
Dynamic assessment of the pelvic floor:
- Pelvic organ prolapses
- Relaxation of the pelvic floor

Fig.: MR Technique
**FOURTH STEP: T2 HASTE SAGITTAL at the end of the evacuation phase**

**AIM:**
Used for the images analysis (interpretation and grading of pelvic floor dysfunction)

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**Fig.:** MR Technique
- **3 lines** will be drawn on the rapid half-Fourier T2-weighted image obtained after evacuation phase

- **Pubococcygeal line (PCL line)**: from the inferior margin of the pubic symphysis to the junction between first and second coccygeal segment

- **The puborectal hiatus (H line)**: from the inferior margin of the pubic symphysis to the convex posterior margin of the puborectalis muscle sling

- **M line**: extends perpendicularly from the PCL to the posterior end of the H line

**Fig.:** HMO SYSTEM
# GRADING OF PELVIC FLOOR RELAXATION

<table>
<thead>
<tr>
<th>GRADING</th>
<th>HIATAL ENLARGEMENT (H LINE)</th>
<th>PELVIC FLOOR DESCENT (M LINE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (normal)</td>
<td>&lt; 6 cm</td>
<td>0 - 2 cm</td>
</tr>
<tr>
<td>1 (mild)</td>
<td>6 - 8 cm</td>
<td>2 - 4 cm</td>
</tr>
<tr>
<td>2 (moderate)</td>
<td>8 - 10 cm</td>
<td>4 - 6 cm</td>
</tr>
<tr>
<td>3 (severe)</td>
<td>≥ 10 cm</td>
<td>≥ 6 cm</td>
</tr>
</tbody>
</table>

Pelvic floor relaxation is graded by measuring the enlargement of the uro-genital hiatus (H line) and the pelvic floor descent (M line).

**Fig.:** GRADING OF PELVIC FLOOR RELAXATION
**Fig.: GRADING OF PELVIC ORGAN PROLAPSE**

<table>
<thead>
<tr>
<th>GRADE</th>
<th>ORGAN DISTANCE RELATIVE TO THE H LINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (no prolapse)</td>
<td>Above</td>
</tr>
<tr>
<td>1 (mild or small)</td>
<td>0 – 2 cm below</td>
</tr>
<tr>
<td>2 (moderate)</td>
<td>2 – 4 cm below</td>
</tr>
<tr>
<td>3 (severe or large)</td>
<td>≥ 4 cm below</td>
</tr>
</tbody>
</table>

Pelvic organ prolapse is graded by calculating the distance of the organ (bladder, urethra, uterus, vagina, small bowel, sigmoid colon or peritoneum) relative to the puborectal hiatus (H line).
Morphologic findings of pelvic floor

ATROPHY OF LEVATOR ANI COMPLEX

Fig.: MORPHOLOGIC FINDINGS OF PELVIC FLOOR
Fig.: MORPHOLOGIC FINDINGS OF PELVIC FLOOR
Fig.: DYNAMIC FINDINGS OF PELVIC FLOOR
Fig.: DYNAMIC FINDINGS OF PELVIC FLOOR
Fig.: TruFisp dynamic sagittal during evacuation phase
Fig.: DYNAMIC FINDINGS OF PELVIC FLOOR
Fig.: DYNAMIC FINDINGS OF PELVIC FLOOR
**Fig.**: TruFisp dynamic sagittal during evacuation phase. In this case a significant rectocele is demonstrated during this phase.
**Fig.**: TruFISP dynamic sagittal during evacuation phase. Urinary incontinence is clearly demonstrated during this phase.
**Fig.**: TruFISP dynamic sagittal during maximal strain. Fecal incontinence is clearly demonstrated during this phase.
Fig.: DYNAMIC FINDINGS OF PELVIC FLOOR
Enterocoele missed on the MRI examination and well demonstrated on the colpoproctography.

**Fig.:** DYNAMIC FINDINGS OF PELVIC FLOOR
Fig.: DYNAMIC FINDINGS OF PELVIC FLOOR
Conclusion

- Anatomical and functional assessment of pelvic floor disorders is essential for the planning of the surgical approach and strategy.
- MRI is a simple and no ionizing radiation technique permitting morphologic and dynamic assessment of all the compartments of the pelvic floor.
- The better signal-to-noise ratio provided by 3T MR unit compared to 1.5 T MR unit allows for higher spatial resolution with consecutive detailed demonstration of pelvic floor anatomy and pathology.

Personal Information

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References