Dynamic MR Imaging of Pelvic Floor Dysfunction

Genevieve L. Bennett, M.D.
Assistant Professor of Radiology and OB/GYN
NYU Langone Medical Center

U Penn Cape Cod July 2016
Pelvic Floor Dysfunction

- Weakening of pelvic floor support structures, prolapse of pelvic organs
- Affects up to 37% of women in US
- 11% lifetime risk need for surgical repair
- Pelvic pain, pressure, urinary/fecal incontinence, obstructed defecation
- Multifactorial in etiology- vaginal birth and advancing age
- > 30% of women with 3 or more deliveries report pelvic floor disorder
- Up to 1/3 of women may require re-operation
Objectives

- Current role of dynamic MRI in evaluation of pelvic floor dysfunction
  - Pelvic floor anatomy
  - MRI Technique
  - Image analysis/interpretation
  - Abnormal findings in each compartment
  - Limitations
Pelvic Floor Dysfunction: Evaluation

- Clinical History
- Physical exam- POP-Q staging
- Imaging most useful in setting of complex, multicompartment disorders
- Fluoroscopic techniques- do not allow direct visualization of pelvic floor support structures, assess each compartment individually, invasive, ionizing radiation
- Ultrasound (3D)-operator dependent, small FOV, limitations in dynamic assessment (evacuation)
Dynamic MRI Evaluation of the Pelvic Floor

- 1\textsuperscript{st} described by Yang et al 1991
- Fast MR scanning techniques - improved temporal resolution
- 3 compartments evaluated simultaneously in dynamic fashion
- Direct visualization of pelvic organs and support structures (pelvic floor muscles)
- Functional assessment
- No radiation
- No patient preparation

\textit{Tricompartmental prolapse}
American College of Radiology  
ACR Appropriateness Criteria®

**Clinical Condition:** Pelvic Floor Dysfunction  
**Variant 1:** Protruding/bulging vaginal mass, chronic pelvic pressure/discomfort, clinically suspected pelvic organ prolapse.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray fluoroscopic cystocolpoproctography</td>
<td>9</td>
<td>Oral contrast can be administered to opacify the small bowel and detect enteroceles.</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>MR defecography with rectal contrast</td>
<td>9</td>
<td>Imaging patient in the seated position is preferred, if possible.</td>
<td>O</td>
</tr>
<tr>
<td>US pelvis transperineal</td>
<td>8</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>MRI pelvis dynamic with rectal contrast</td>
<td>7</td>
<td>Dynamic refers to imaging the patient during rest and strain maneuvers. Encourage adequate Valsalva effort by patient. Avoid overdistended bladder. Lack of rectal contrast may result in suboptimal study. Vaginal contrast may also be given.</td>
<td>O</td>
</tr>
<tr>
<td>X-ray fluoroscopic defecography</td>
<td>5</td>
<td>Lack of intraluminal contrast in the bladder, bowel, and vagina limits assessment of entire pelvic floor.</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>US pelvis transvaginal</td>
<td>3</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>US pelvis transrectal</td>
<td>2</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>US pelvis transabdominal</td>
<td>2</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>MRI pelvis with endorectal coil</td>
<td>2</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>CT pelvis without IV contrast</td>
<td>1</td>
<td></td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>CT pelvis with IV contrast</td>
<td>1</td>
<td></td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>CT pelvis without and with IV contrast</td>
<td>1</td>
<td></td>
<td>🌟🌟🌟🌟</td>
</tr>
</tbody>
</table>

**Rating Scale:** 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate  
*Relative Radiation Level
Pelvic Floor Dysfunction: Anatomy

- 3 pelvic compartments: *anterior, middle, posterior*

- In many patients, all 3 compartments are involved
Pelvic Floor Support: Passive support

- Pelvic bones and connective tissues
  - Endopelvic fascia - envelopes the pelvic organs and anchors them to the pelvic sidewall

- Arcus tendineus - lateral reflection - site of attachment of the levator ani muscles
Pelvic Floor Support: Active support

- Pelvic floor muscles
- Levator ani muscle complex-major muscle of the pelvic diaphragm
  - Iliococcygeus
  - Pubococcygeus
  - Puborectalis
- Pelvic floor hiatus
- Posterior levator plate
MRI Technique

- Most often performed in closed magnet in supine position
- May be performed with patient seated in open magnet
  - In an upright configuration, degree of prolapse may be greater, but no additional affected compartments identified (Fielding, et al 1996)
  - Both methods equally effective in identifying clinically relevant abnormalities (Bertschinger, et al 2002)
- Phased array coil-positioned lower than for routine pelvic MRI
- Urinary bladder reasonably full
- No IV contrast, endoluminal contrast if defecography
MRI Technique

- Dynamic and static imaging
- High resolution static T2 weighted images in 3 planes
  - Evaluation of pelvic organs at rest and pelvic floor musculature
- Dynamic evaluation: performed during fast strain or defecation (midline sag)
  - Steady state sequences (trueFISP, FIESTA)-allow for near real-time continuous imaging
  - T2 weighted SSFSE or HASTE

Normal

trueFISP

Tricompartmental prolapse
MRI of pelvic floor dysfunction: dynamic true fast imaging with steady-state precession versus HASTE


- True FISP sequence allowed detection of greater degrees of prolapse in all 3 pelvic compartments compared with the HASTE sequence
MR Defecography

- Endoluminal opacification of vagina and rectum
- US gel widely available
- Dynamic imaging during evacuation
- Improved evaluation of posterior compartment ensures adequate strain
Dynamic MR Defecography: Assessment of the Usefulness of the Defecation Phase

- Added value of true defecation phase in 83 patients with pelvic floor abnormalities referred for pelvic floor MR
- More accurate estimation of presence and degree of pelvic floor abnormalities in all 3 compartments
- Defecation phase identified more cases of
  - Undetected rectoceles > 2cm 36.5%
  - Enteroceles 40%
  - Rectal intussusception 25.9%
- Should this be performed routinely for all dynamic pelvic floor studies?
Image Interpretation
Pubococygeal Line: defines level of levator plate

- Pubococygeal line (PCL) - inferior margin of pubic symphysis to the last coccygeal joint (Yang, 1991)
- Measure distance of each pelvic organ to the line
- Normal: minimal descent, ARJ within 2.5 cm

Rule of 3:
- Mild: 1 to <3 cm descent
- Moderate: 3-6 cm descent
- Severe: > 6 cm descent
More closely approximates landmarks for clinical staging (vaginal hymen)

- Grading:
  - 0 - No compartment descent
  - 1 - Compartment descent to 1 cm proximal to MPL
  - 2 - Compartment descent between 1 cm proximal and 1 cm distal to MPL
  - 3 - Compartment descent between 1 cm distal to MPL and 2 cm < total vaginal length
  - 4 - Compartment descent from 2 cm < total vaginal length to complete prolapse
Magnetic resonance imaging of pelvic organ prolapse: comparing pubococcygeal and midpubic lines with clinical staging

Woodfield, CA et al Int Urogynecol J 2009; 20:695

- Compared prolapse during Valsalva using both PCL and MPL with POP-Q scoring in 20 patients
- Both PCL and MPL had fair agreement with clinical staging in anterior compartment
- MPL - fair agreement in middle and posterior compartments.
- PCL - poor agreement for middle and posterior compartments.
- Neither line had better than fair agreement with clinical staging
- Tendency to overstage with MRI
HMO classification (Z. Barbaric)

- Quantification of degree of pelvic organ prolapse and pelvic floor relaxation
- **H line** - width of the levator hiatus
- **M-line** - indicates pelvic floor dysfunction
- **O line** - degree of pelvic organ prolapse

*From Fielding, J. R. Radiographics 2002; 22: 295*
Anterior Compartment Prolapse

- Cystocele - most common abnormality
- Descent of bladder base below the PCL or inferior margin of pubic bone
- Stress urinary incontinence or incomplete emptying
Cystocele
Urethral Hypermobility: Rotation of the urethra from the vertical axis by more than 30°

Rest

Stress urinary incontinence - loss of intrinsic urethral sphincter integrity
Middle Compartment Prolapse

- Uterine prolapse: descent of the anterior lip of the cervix or vaginal apex below the PCL
- If severe, may have complete eversion of the vagina
- Vagina oriented in horizontal axis
Middle Compartment Prolapse
Enterocoele (peritoneocele, sigmoidocele)

- Herniation of peritoneal sac into rectovaginal or rectovesical space
- Variable contents
- Increased risk after hysterectomy
- May contribute to symptoms of obstructed defecation
- On PE, may simulate anterior rectocele
- Conventional defecography may fail to visualize in up to 20%
Peritoneocele
Posterior Compartment:
Obstructed defecation syndrome (ODS)

- Chronic constipation: difficult, incomplete evacuation, excessive straining, pain, bleeding, need for manually assisted evacuation
- Functional and anatomic factors
  - Most frequent anatomic defects: rectocele, rectal intussusception
- Often prolapse in other pelvic compartments
- Variable management
- Several surgical approaches when conservative measures fail
  - Transabdominal, transperineal, transvaginal
  - STARR procedure-stapled transanal rectal resection
Descending Perineal Syndrome

- Anorectal junction descent (> 2.5 cm): indication of pelvic floor relaxation
- Incomplete evacuation
- Pudendal nerve damage, obstetric trauma or chronic straining
Spastic Pelvic Floor Syndrome
*Paradoxical contraction of the puborectalis muscles*

- Evaluation of ARA
- Normal at rest 100-115°
- Normal ARA with defecation more obtuse by > 10-15°
- Abnormal if ARA decreases with defecation
- Prolonged evacuation and incomplete contrast evacuation
Rectocele

- Abnormal bulging of rectal wall (anterior)
- Weakness of posterior vaginal wall (obstetric trauma or chronic straining)
  - Depth of wall protrusion extending beyond the expected margin of the rectal wall (> 2cm)
- Staging:
  - < 2 cm small
  - 2 – 4 cm moderate
  - > 4 cm large

Small rectoceles may be observed in asymptomatic women
MR Defecography: Anterior Rectocele

- Ensures adequate strain and increased abdominal pressure (*exam is performed supine*)
- Retention of contrast medium and incomplete evacuation supports dx of clinically significant rectocele
- Size, location, degree of emptying better evaluated
Rectal Intussusception

- Internal rectal prolapse
- Rectal wall invaginations that descend towards the anal canal
- Mucosa vs full-thickness
  - Low grade - intra rectal
  - High grade - intra anal
- MRI sensitivity of 70% compared to evacuation proctography (mucosa only vs full thickness) (Dvorkin 2004)
- Up to 30% may have abnormalities in anterior and posterior compartment
Rectal Intussusception
Rectal Prolapse

- Rectal wall protrudes partially or completely through the anal orifice

- Should not be used to described ARJ descent

- Clinical diagnosis but MRI may detect other abnormalities and aid surgical planning

19 to 35% of patient with ODS have an enterocele
Comparison of supine magnetic resonance imaging with and without rectal contrast to fluoroscopic cystocolpoproctography for the diagnosis of pelvic organ prolapse


- Compared supine MRI and CCP studies in 82 patients
- 35 MRI exams with rectal contrast, 47 noncontrast
- MRI with rectal contrast vs CCP: no significant difference between cystoceles, vaginal prolapse, or anterior rectoceles. More enteroceles on CCP (36% vs 19%)
- MRI without rectal contrast vs CCP: more cystoceles, vaginal prolapse, enteroceles and anterior rectoceles on CCP
MR Defecography findings in 40 patients with ODS


- MR defecography added information in 27.5% of patients over clinical exam
- Increased diagnosis of rectocele, anorectal junction descent, intussusception, cystocele and enterocele in women and dyskinesia in men
- 90% of patients had more than one finding, 40% had 3 findings, 29% had four or more findings
- Surgical treatment performed in 25 patients and after findings at MRI, approach changed from transperineal to transabdominal in 6 patients
**Clinical Condition:** Pelvic Floor Dysfunction

**Variant 4:** Defecatory dysfunction. Straining during defecation, difficulty initiating defecation, incomplete evacuation, or splinting or digital maneuvers to defecate.

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray fluoroscopic defecography</td>
<td>9</td>
<td>MR defecography is equivalent to x-ray fluoroscopic defecography if patient is imaged in the seated position in a vertically configured MR scanner. Rectal evacuation is suboptimally assessed when patient is supine.</td>
</tr>
<tr>
<td>MR defecography with rectal contrast</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>X-ray fluoroscopic cystocolpoproctography</td>
<td>7</td>
<td>Oral contrast can be administered to opacify the small bowel and detect enteroceles.</td>
</tr>
<tr>
<td>MRI pelvis dynamic with rectal contrast</td>
<td>5</td>
<td>Dynamic refers to imaging the patient during rest and strain maneuvers. Encourage adequate Valsalva effort by patient. Lack of rectal contrast will result in a suboptimal study.</td>
</tr>
<tr>
<td>US pelvis transperineal</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MRI pelvis with endorectal coil</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>US pelvis transvaginal</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>US pelvis transrectal</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>US pelvis transabdominal</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>CT pelvis without IV contrast</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>CT pelvis with IV contrast</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>CT pelvis without and with IV contrast</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Rating Scale:** 1, 2, 3 Usually not appropriate; 4, 5, 6 May be appropriate; 7, 8, 9 Usually appropriate

*Relative Radiation Level*
Muscular Pelvic floor Weakness: Levator Plate Angle

Normal: should parallel the PCL
Caudal inclination >10° indicates loss of posterior muscle support
Muscular Pelvic Floor: evaluate for weakness and defects

- Normal
- Ballooning out of levators
- Hernia
Postoperative Evaluation: Recurrent Symptoms

s/p sacrocolpopexy with mesh
Coexisting Pelvic Pathology: large uterine fibroid
Reporting MRI Findings

- Reporting template
- Develop in consultation with referring clinicians
- Choose consistent method for quantifying degree of pelvic organ prolapse and pelvic floor relaxation
- Report findings of prolapse in each pelvic compartment, abnormalities at evacuation, defects in pelvic floor muscles and any additional pelvic abnormalities
Dynamic MRI: Limitations

- Not every patient is candidate for MRI
- Physiologic effects of gravity not evaluated in supine position
- Some cases of intussusception may only be detected during fluoroscopy in upright position
- Inadequate straining – evacuation phase helps to overcome this
- Mild prolapse may be observed in asymptomatic patients, of uncertain significance
- Correlation with patient symptoms and physical exam should always be performed
Prevalence of pelvic organ prolapse detected at dynamic MRI in women without history of pelvic floor dysfunction: comparison of two reference lines


- 60 women with symptoms unrelated to pelvic floor dysfunction who underwent dynamic MRI
- MR studies retrospectively evaluated
- Prolapse was found in all 3 compartments, greatest degree in posterior compartment
- The MPL consistently yielded greater frequency of prolapse than the PCL
- Essential to correlate MR findings with clinical history and PE findings
Dynamic MRI: Limitations

- Lack of universally accepted standardized imaging protocol and grading system
- Variability among readers for determining measurements
- Training session with targeted training with clear agreement regarding landmarks is helpful \( (\text{Lockhart et al 2008}) \)
MRI for pelvic floor dysfunction: can the strain phase be eliminated?

*Bhan SN et al Abdom Radiol 2016; 41: 215-20*

- The evacuation phase identified all abnormalities identified on the strain phase and also identified both additional and more pronounced abnormalities.
- The strain phase is redundant and can be eliminated.
DYNAMIC MR IMAGING OF THE PELVIC FLOOR: TIPS FOR SUCCESS

- Obtain a patient history
  - Clinical symptoms
  - Prior surgeries/repair
- Precise instructions to the patient
- Appropriate positioning of coil
- Repeat imaging sequences if inadequate strain or important anatomic landmarks not included in FOV (monitor the case!!)
- Defecation phase
Future Research

- Further comparative studies with surgical findings
- Greater consensus regarding protocol and methods of image analysis
- Impact of MRI on treatment strategy and improving surgical outcome
- Research tool to gain insight into the anatomy of the pelvic floor and pathophysicsiology of pelvic floor dysfunction
- Added value of functional information to anatomical information
MRI of the Urethra in Women With Lower Urinary Tract Symptoms: Spectrum of Findings at Static and Dynamic Imaging

Genevieve L. Bennett¹
Elizabeth M. Hecht¹
Teerath Peter Tanpitukpongse¹
James S. Babb¹
Bachir Taouli¹
Samson Wong¹
Nirit Rosenblum²
Jamie A. Kanofsky²

OBJECTIVE. The purpose of our study was to determine the findings at both static and dynamic MRI in women with a clinically suspected urethral abnormality.

MATERIALS AND METHODS. MRI of the urethra was performed in 84 women with lower urinary tract symptoms using multiplanar T2-weighted turbo spin-echo and unenhanced and contrast-enhanced gradient-echo sequences. A dynamic true fast imaging with steady-state free precession sequence was performed during straining in the sagittal plane. Images were evaluated by two radiologists for urethral pathology and pelvic organ prolapse. MRI findings were correlated with clinical symptoms using the Fisher’s exact and Mann-Whitney tests.

RESULTS. Urethral abnormalities were found in 10 of 84 patients (11.9%), including two urethral diverticula, five Skene’s gland cysts or abscesses, and three periurethral cysts. Thirty-three patients (39.3%) were diagnosed with pelvic organ prolapse, of whom 29 (87.9%) were diagnosed exclusively on dynamic imaging. In 29 of 33 patients with prolapse (87.9%), the urethra was structurally normal. MRI showed 13 cystoceles and 17 cases of urethral hypermobility not detected on physical examination. Patients with a greater number of vaginal deliveries, stress urinary incontinence, frequency of voiding, and voiding difficulty were statistically more likely to have anterior compartment prolapse (p < 0.05).
26 yo woman rule out urethral diverticulum
MRI evaluation of urethral diverticula and differential diagnosis in symptomatic women

Dwarkasing, R.S., Dinkelaar, W., Hop, W.C.J., Steensma, A.B., Dohle, G.R., Krestin, G.P. 
AJR 2011; 197: 676-682

- 60 patients referred to MRI for suspected urethral diverticulum due to various lower urinary tract sx
- 20 (33%) had a diverticulum and 28 (47%) had an alternative diagnosis with 13 (46%) visualized at MRI
- 12 patients (20%) no abnormality found at MRI or clinical follow-up
- Functional disorders of the pelvic floor and supporting ligaments of the bladder base and urethra may account for sx in these patients
- Advocate role for dynamic MRI for complete imaging evaluation of these patients
Conclusions

- Dynamic MR may replace other conventional imaging methods for evaluation of pelvic floor
- Well-tolerated by patients and evaluates all 3 compartments as well as pelvic support structures in a dynamic fashion
- Evolving technique (optimal protocol, grading)
- Develop in conjunction with referring clinical service
- Important role in patient management
Additional References

- Attenberger UI et al. The value of dynamic magnetic resonance imaging in interdisciplinary treatment of pelvic floor dysfunction. Abdom Imaging 2015; 40: 2242-7