18
Female Pelvic Floor Dysfunction

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18.1 Introduction

Pelvic floor dysfunction (PFD) is a term applied to a wide variety of clinical conditions including urinary incontinence (UI), pelvic organ prolapse (POP), defecatory dysfunction, sensory and emptying abnormalities of the lower urinary tract, sexual dysfunction and several chronic pain syndromes.

This chapter briefly reviews the definitions, pathophysiology, clinical features and the traditional imaging modalities of UI and POP. The chapter is structured to be problem oriented: examples of cases with PFD will be presented together with a newly developed MR imaging analytic approach.

18.2 Anatomical considerations

Pelvic floor

- 'Pelvic Floor' is used broadly to include all the structures supporting the abdominal and pelvic cavity (Fig. 18.1)
- Conceptually, it is useful to divide the pelvic floor anatomy artificially into passive and active structures.
  - Passive structures
    - The pelvic bones
    - Supportive connective tissue of the pelvis which consist of ligaments and endopelvic fascia.

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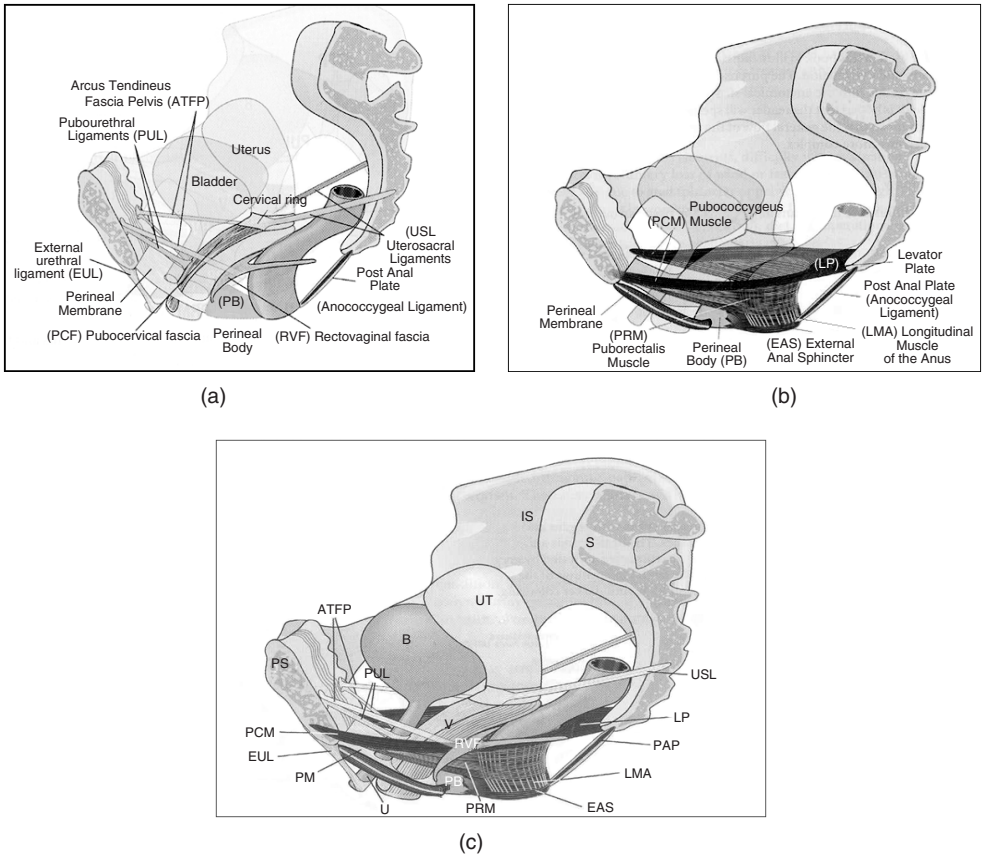

Figure 18.1 Diagram of the pelvis. (a) Pelvic organs, the ligamentous and membranous structures are indicated by gray color. (b) Muscles are marked with striation. (c) The relationship of the pelvic muscles to organs, ligaments and fascia is shown (Reproduced by permission of Springer).

- Active support structures
  - Pelvic floor muscles with its neurologic 'wiring' that result in sustained (tonic) and intermittent voluntary muscle contractions during activity.

- These passive and active components of the pelvic floor function as integrated multilayer system from superior to inferior consist of four principle layers:

- The endopelvic fascia; include the parametrium and paracolpium giving support to the uterus and upper vagina. The paracolpium that attach the upper vagina to the pelvic walls has two portions.
  - Level I (the upper portion) consists of relatively long sheet of tissue that suspends the vagina to the pelvic wall.
  - Level II attaches the mid portion of the vagina more directly to arcus tendineus fascia pelvis (ATFP) at the lateral pelvic wall.

- The pelvic diaphragm including the levator ani and the coccygeus muscles, both acts as a shelf supporting the pelvic organs.
- The perineal membrane (urogenital diaphragm),is triangular in shape and spans the anterior pelvic outlet. Trilaminar structure with the deep transverse perineal muscle sandwiched between the superior and inferior fascia.
- The superficial layer, (External Genital Muscles) comprising the superficial transverse perineal muscle, bulbospongiosus and ischiocavernous muscles.

- From a functional point of view it is useful to divide the pelvic organ support system into the urethral supporting system, the vaginal supporting system and the anal sphincter complex. The later will not be described as defecatory dysfunction is beyond the scope of this chapter.
  - Urethral supporting structures consist of:
    - The ventral and dorsal urethral supporting ligaments
    - The endopelvic fascia that support the middle and proximal urethra known as (level III fascial support)
    - The puborectalis muscle.
  - Vaginal supporting structures include:
    - Level I and II endopelvic vaginal fascia
    - The iliococcygeus muscle.

18.3 Pathophysiology of pelvic floor dysfunction

- Stress urinary incontinence (SUI) can be due to:
  - Structural defects in the urethral supporting structures.
  - A poorly functioning urethral sphincter muscle, termed ‘intrinsic sphincter deficiency’ (ISD).
- Pelvic organs prolapse (POP):
  - Weakness of the levator ani may cause widening of the levator hiatus, and descent of the central portion of the pelvic diaphragm. The resultant loss of support to the pelvic organs places tension on the pelvic fascial support system.
  - Excessive tension results in breaks, separations, and attenuation of the pelvic fascial support system. Cystocele, rectocele, and uterine prolapse are caused by specific defect in one of the vaginal support levels.

18.4 Clinical features

Urinary incontinence (UI)

Subtypes include stress (SUI) which is the most common, urge (UUI) and mixed (MUI).

- The main symptom of SUI is the involuntary leakage of urine on effort, sneezing or coughing.
- A urinary diary for pad use, UI episodes and urinary frequency is important in patient’s assessment.

- A cotton swab test to identify bladder neck hypermobility.
- Full bladder cough stress test to elicit the sign of SUI.
- Testing for urinary tract infection.

Urodynamic studies

- Correlation between urodynamic findings and symptoms of UI is generally poor particularly in patients with symptoms of mixed UI.
- Medium-fill cystometry
  - It differentiate SUI from urge incontinence.
  - A rise in the intravesical pressure is consistent with a bladder detrusor muscle contraction, which implies detrusor instability or urge incontinence.
- Abdominal leak point pressure
  - It can identify SUI owing to intrinsic urethral sphincter deficiency.
  - At different volume intervals during filing cystometry, the patient is asked to strain until leakage is observed and the pressure within the bladder is measured.
  - Valsalva leak point pressure (VLPP) of less than 60 cm H_20 at a volume of 150 filling correlates with intrinsic sphincter deficiency (ISD).

Pelvic organ prolapse (POP)

POP includes anterior vaginal prolapse (cystocele), apical or uterine prolapse, posterior vaginal prolapse which include (enterocele, rectocele, and perineal descent but does not include rectal prolapse). Refer to Table 18.1 for POP quantitation.

Cystocele

- Mild cystocele is asymptomatic but can be associated with SUI.
- Marked cystocele is commonly symptomatic and can be associated with:
  - Vaginal bulging

Table 18.1 Pelvic Organ Prolapse Quantification (POPQ)

Stage 0	No prolapse is demonstrated.
Stage I	The most distal portion of the prolapse is more than 1 cm above the level of the hymen.
Stage II	The most distal portion of the prolapse is 1 cm or less proximal to or distal to the plane of the hymen
Stage III	The most distal portion of the prolapse is more than 1 cm below the plane of the hymen but protrudes no further than 2 cm less than the total vaginal length in centimeters.
Stage IV	Essentially complete eversion of the total length of the lower genital tract is demonstrated.

- Dyspareunia
- Urinary tract infection
- Obstructive voiding symptoms
- Urinary retention

Uterine prolapse

- Mild uterine prolapse is usually asymptomatic but higher grades can present with:
  - A vaginal mass
  - Dyspareunia
  - Urinary retention
  - Stretching of the uterosacral ligaments may lead to low back pain
  - Obstructive uropathy due to ureteral obstruction
  - Difficult defecation is experienced by one-third of patients.

Enterocele

- *Simple enterocele* exists when there is no associated vault prolapse and the cuff of the vagina is well supported.
- *Complex enterocele* is associated with vault prolapse and tend to coexist with other forms of the anterior or posterior vaginal wall.
- Symptomatic enterocele may cause
  - Vaginal pressure
  - Dyspareunia
  - Dragging sensation in the pelvis as well as pelvic pressure
  - Stretching of the mesentery with straining can cause pain in the lower abdomen or back
  - Patients may complain of severe constipation, feeling of incomplete evacuation or symptoms of bowel obstruction.

Rectocele

- A rectocele may be present in up to 80% of asymptomatic patients.
- Symptoms include vaginal pressure, vaginal mass and dyspareunia.
- Difficult emptying of the rectum, tenesmus, and rectal splinting.

Difficulties in clinical assessment and management of patients with POP

- It is frequently difficult to different a high grade cystocele from an enterocele, a vaginal vault prolapse or a high rectocele by physical examination.
- A high grade cystocele may mask SUI; results of anti-incontinence procedure are usually improved by restoring the normal pelvic floor anatomy.

- Repair of cystocele without attention to the rest of the pelvic floor may predispose the patient to an increased incidence of enterocele, rectocele or uterine prolapse after the operation.
- Due to vaginal overcrowding, an enterocele is often missed on physical examination. In addition, physical examination cannot reliably distinguish the content of an enterocele.
- The size of the uterus and the presence of concomitant uterine or ovarian pathology determine if a vaginal or abdominal hysterectomy is performed at time of the prolapse repair.
- Clinical findings may not correlate with symptoms. These patients may have a degree of descent sufficient to cause symptoms but because they have a deep pelvis, the extent of the prolapse is not appreciated by clinical examination.

Recommendations

- It is essential that concomitant vaginal wall prolapse to be diagnosed prior to repairing cystocele or prior to incontinence surgery.
- It is sometimes necessary to reduce the enterocele to examine adequately the rest of the vaginal canal and rule out any associated cystocele or rectocele.
- Imaging, particularly MRI, is crucial in assessment of POP.

18.5 Imaging of pelvic floor dysfunction

Urinary incontinence (UI)

Cystourethrogram (CUG)

- The diagnostic criteria for SUI include:
  - The bladder neck and proximal urethra open and descend more than 2 cm in relation to symphysis pubis during straining (Fig. 18.2).
  - Posterior vericourethral angle (PVUA) beyond 100° during straining.
  - Angle of urethral inclination more than 30° from the longitudinal axis of the body.
  - Limitations
    - It provides only a silhouette view of the contrast agent-filled organ with little, if any information about the organ composition, surrounding soft tissue, or associated PFD.
    - There are controversies about the value of the PVUA as an indicator of SUI being of extremely variable value among continent and incontinent women.

Transvaginal ultrasound (TVUS)

Change in bladder position in relation to the symphysis pubis during stress maneuvers in patients with SUI include:

- Postero-inferior rotation of the urethrovesical junction.
- Opening of the bladder neck, urethra leading to urinary leakage.

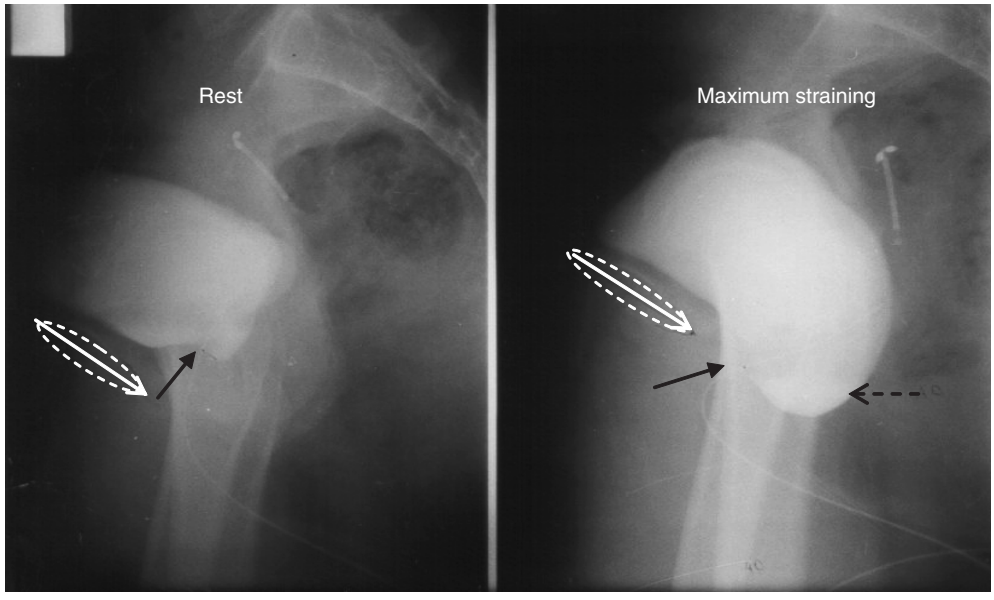

Figure 18.2 Cystourethrogram (CUG) of a 35-year-old patient with stress urinary incontinence (SUI). The bladder neck (BN) (solid arrow) is labeled by a soft guide wire placed inside the Foley's catheter; the symphysis pubis, outlined by the dotted line. At rest, the BN is seen above the level of the symphysis pubis. During straining, the BN is below the level of the pubococcygeal line (PCL) with an associated moderate cystocele (dashed arrow).

- Limitations
  - During endocavitary scanning, there is always the problem that the probe is stenting the vagina and limiting the movement of the bladder neck.
  - The examination is operator-dependent.
  - It does not provide adequate visualization of soft tissue planes.

MR imaging

- Provides detailed anatomic information on the status of the urethral supporting elements due to the high inherent soft tissue contrast. Details are provided with MRI of POP.

Pelvic organ prolapse (POP)

Dynamic contrast cystocolpoproctography

- Requires opacification of the pelvic organs (bladder, vagina, small bowel and rectum).
- The study can be done with all organs opacified or in phases with each organ opacified individually prior to each straining phase (Fig. 18.3).
- The diagnostic criteria include:
  - Prolapse of pelvic organs is defined radiologically by reference to the pubococcygeal line (PCL), which extends from the inferior margin of the pubic symphysis to the sacrococcygeal junction.

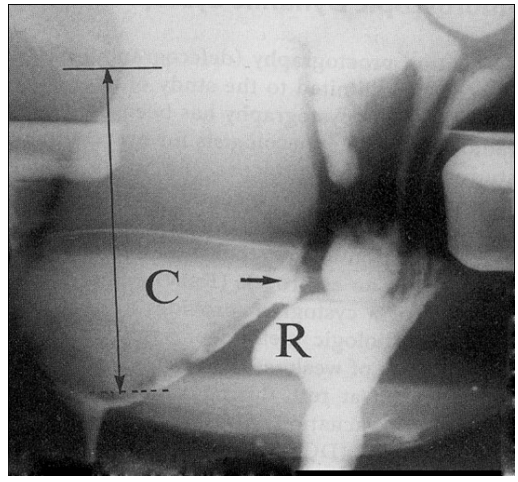

Figure 18.3 Cystoproctogram image taken during evacuation shows a very large cystocele (C). The uninterrupted line represents the pubococcygeal line (PCL), the dotted line indicates the bladder base and the arrowed line indicates the depth of the cystocele below the PCL. There is a rectocele (R) but its size is minimized by the pressure from the large cystocele. The arrow indicate the uppermost point of the vagina.

- A cystocele, enterocele or sigmoidocele, and vaginal vault prolapse are defined by extension of the bladder base, small bowel or sigmoid colon, and vaginal apex respectively below this reference line.
- Prolapse of any of these organs is graded as small if there is organ descent up to 3 cm below the PCL, moderate if this extension measures between 3–6 cm, and large if descent is greater than 6 cm.
- Anterior rectocele is defined as anterior rectal wall bulge, the depth of bulge is measured from line extended upward from the anterior wall of anal canal. Lateral and posterior rectocele may also occur.
- Rectocele is graded as small if its depth is less than 2 cm, moderate between 2–4 cm and large if it measures more than 4 cm.
- Limitations
  - Time consuming
  - Exposes the patient to a significant amount of ionizing radiation
  - It may fail to detect enterocele in 20% of patients with this condition.

Perineal ultrasound

- In dynamic transperineal ultrasound the probe is placed on the perineum, scanning is performed in the sagittal and coronal planes with the movement of the pelvic floor observed during straining and squeezing.
- This study has a considerable potential as simple, cheap and non-invasive technique.
- Its relationship to other imaging methods and reliability await further assessment.
- During straining cystocele, enteroceles and rectocele may become apparent.

18.6 Magnetic resonance (MR) imaging

- MRI has been effectively used to evaluate pelvic floor disorders, with very good reported sensitivity, specificity and positive predictive value.
- An MRI analytic approach that defines the most predominant pelvic supporting system defects to which the treatment can be directed is described below.
- This analytic approach gives new insight into the diagnosis of these complex pathologies. Based on this insight, a defect-specific approach for management could be applied and thus can allow an individually tailored surgical technique to be employed.
- All data obtained from MRI are presented in a schematic form (Table 18.2) for easier comprehension by the clinicians.
- A diagnostic algorithm is suggested in Figure 18.4.

Table 18.2 A proposed form for magnetic resonance (MR) reporting. Data reproduced from Radiology, August 2008: Volume 248: Number 2, 528–530

I. Location and type of prolapse:

Location	Type	
(1) Anterior compartment:	a] Bladder neck descent:	Grade:
	b] Bladder base descent:	Grade:
(2) Middle compartment:	a] Uterine descent:	Grade:
	b] Enterocele/Peritoneocele:	Grade:
(3) Posterior compartment:	a] Anorectal junction descent:	Grade:
	b] Rectocele:	Grade:

II. Defects in the pelvic organ support system:

Urethral supporting structures

a] Ligament/s:	Type of injury	Side:
b] Fascia level III:		
c] Puborectails:	Type of injury and/or weakness:	Side:

Vaginal supporting structures

a] Vaginal fascia level I and II:	Side:
b] Iliococcygeus: Type of injury and/or weakness	Side

III. Measurements of supporting structures:

H Line: M Line: Levator plate angle:
Width of levator hiatus:
Iliococcygeus angle:

Opinion

The predominant defect(s):
For SUI : Ligaments: Fascia: Muscles:
For POP: Fascia: Muscles:

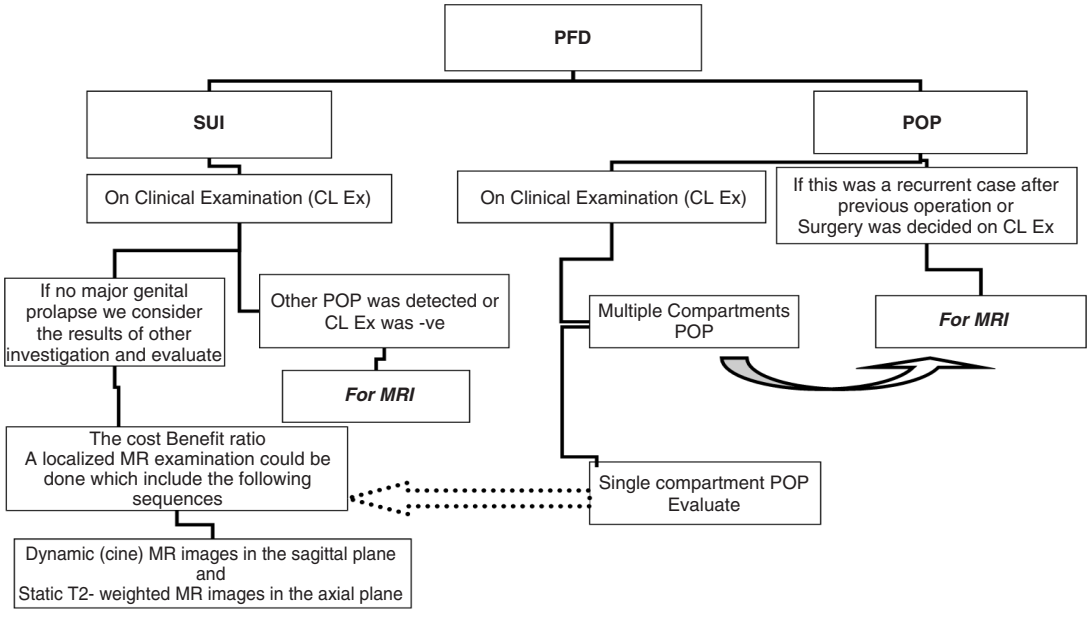

Figure 18.4 A diagnostic algorithm for MR imaging of patients with pelvic floor dysfunction.

Imaging protocol

- MR imaging is performed with the patient supine, using a pelvic phased-array coil and high magnetic filed strength.
  - Patient preparation
    - No oral or intravenous contrast agent is administered.
    - All patients should have a cleansing rectal enema (using warm water) the night before the MR examination.
    - The examination is performed while the urinary bladder is comfortably full. The patient is routinely asked to micturate 2 h before the examination.
    - The rectum is opacified with 90 to 120 cc of ultrasound gel.
  - Imaging parameters for static images
    - Static images of the pelvis are acquired in three planes using T2-weighted turbo spin-echo (TSE) sequences (TR/TE, 5000/132; field of view [FOV], 240–260 mm; slice thickness, 5 mm; gap, 0.7 mm; number of signals acquired [NSA], 2; flip angle, 90°; matrix, 512 × 512; acquisition time, 3.12 min for each sequence).
  - Imaging parameters for dynamic (cine) images
    - Dynamic sequences are performed in the sagittal, axial, and coronal planes, using BFFE sequence (TR/TE, 5.0/1.6 ms; FOV, 300 mm; slice thickness, 6–7 mm; gap, 0.7 mm).
    - In each plane five slices during six phases are acquired; each phase takes 10 s. These six phases are acquired (1) with the patient at rest, (2) during contraction of the pelvic floor (the patient was instructed to squeeze the buttocks as if trying to prevent

the escape of urine), (3) during mild straining, (4) during moderate straining, (5) during maximum straining, and (6) during a repeated maximum straining sequence to ensure a maximal Valsalva maneuver (the patient was instructed to bear down as much as she could, as though she were constipated and trying to defecate).

Analysis of static MR images

- ***The urethral supporting system*** (Fig. 18.5)
  - In the axial plane, the urethral ligament abnormalities are classified into:
    - distortion, when internal architectural changes with waviness of the ligaments are seen
    - defect, defined by discontinuity of the ligament with visualization of the torn parts.
  - Level III fascial defect is recognized by the drooping moustache sign which is formed by the fat in the prevesical space against the bilateral sagging of the detached lower third of the anterior vaginal wall from the arcus tendineus fascia pelvis (ATFP).
  - Puborectalis muscle defect is recognized through disruption of the normal symmetrical appearance of the muscle slings or of its attachment to the symphysis pubis.
- ***The vaginal supporting system*** (Fig. 18.6)
  - Level I & II endopelvic fascial vaginal defect are visualized as sagging of the fluid-filled posterior urinary bladder wall into the bilaterally detached vaginal supporting fascia from the lateral pelvic wall (saddlebags sign).Central defect is also indicated by sagging of the central part of the urinary bladder posterior wall.
  - The iliococcygeus muscle is assessed for loss of the normal symmetrical appearance of its muscle slings or defect and/or disruption of its attachment to the obturator internus muscle.

Analysis of dynamic MR images

- ***Sagittal plane***
  - In the sagittal plane the pubococcygeal line (PCL) is used as the reference line. This line extended from the inferior border of the symphysis pubis anteriorly to the tip of coccyx posteriorly.
  - The descent of the bladder neck, bladder base, uterus and anorectal junction below the PCL is recorded.
  - SUI is recorded when loss of urine through the urethra is visualized at maximum straining (however, absence of urine loss during MR imaging does not preclude the patient complaints).
  - Other measurements in the sagittal plane (Fig. 18.6) during maximum straining include:
    - the H-line (extends from the inferior aspect of pubic symphysis to the anorectal junction)
    - the M-line (dropped as perpendicular line from PCL to the posterior aspect of the H-Line)
    - the levator plate angle, enclosed between the levator pate and the PCL.

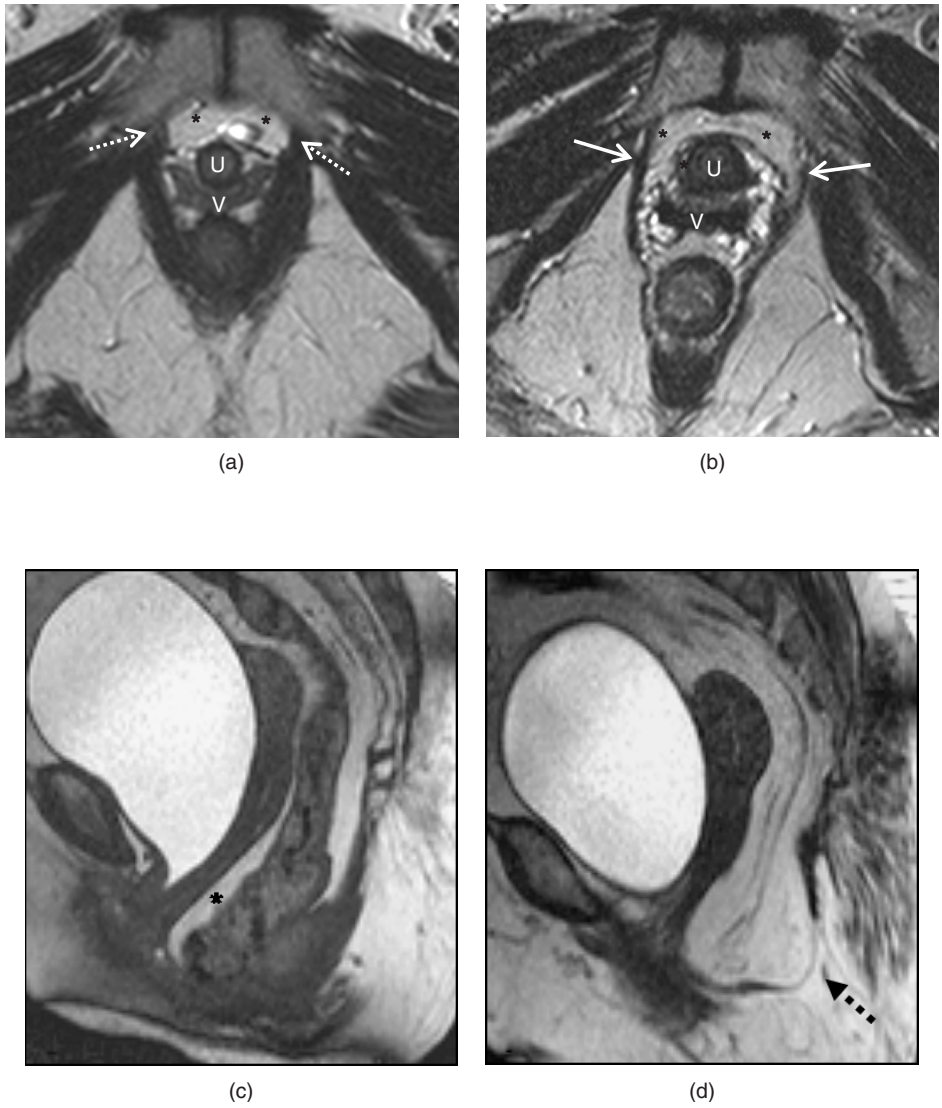

Figure 18.5 Normal and patterns of defect of urethral supporting structures at MR imaging [T2-weighted Turbo Spin Echo (TSE) MR images (TR/TE 5000/132) at the level of the proximal urethra (U), vagina (V)]. (a) Axial image obtained from a 27-year-old healthy continent volunteer shows normal level III endoplevic fascial support (**); dashed arrows, point to the attachment of the puborectalis slings to the pubic bone. (b) Axial image obtained from a 55-year-old patient with grade II SUI shows the typical MR imaging appearance of 'the drooping moustache sign', (**); thinning of the puborectalis muscle slings (arrows) more on the left side. (c,d) Dynamic balanced fast field echo (BFFE) MR images (TR/TE 9/4) (c) mid-sagittal, (d) parasagittal at maximum straining, peritoneocele (*), absence of small bowel content and the focal area of localized thinning and bulge of the iliococcygeus muscle (dashed arrow) are shown.

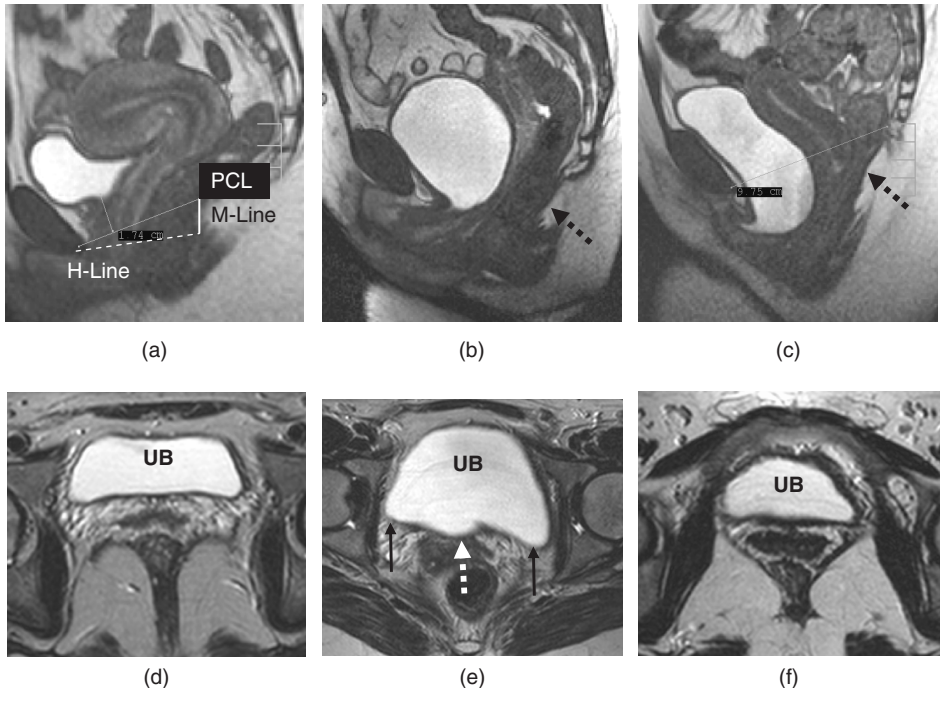

Figure 18.6 Normal plus patterns of defect of the vaginal supporting structures and how to correlate between static and dynamic MR images [Dynamic mid-sagittal balanced fast field echo BFFE (TR/T 9/4)] (a) Image obtained in a 30-year-old- healthy volunteer with no pelvic organ descent below the pubococcygeal line (PCL). (b,c) Images obtained in two patients with pelvic floor dysfunction, both images show cystocele with different grades and sagging of the levator plate (arrows) more advanced in C with uterine descent. It is not possible from these midline images to see the specific differentiating structural defects for each cystocele. (d,e,f) The corresponding axial T2-weighted turbo spin echo (TSE) MR images (5000/132) at level II endopelvic fascial support; (d) shows normal fascial support indicated by the straight posterior wall of the urine filled urinary bladder (UB); (e) shows fascial defects: bilateral paravaginal (saddlebags sign) more on the left side (solid arrows) and central defect (white arrow); (f) shows no gross evidence of fascial defect. Correlation between static and dynamic MR imaging findings reveals that in images B&E, POP is due to the more advanced fascial defect compared with the moderate sagging of the levator plate; while in C&F, the excessive sagging of levator plate relative to the fascial defect indicates that levator muscle weakness is the predominant defect responsible for POP. This analytic approach allows a defect- specific approach to disease management and surgical technique.

- ***Axial and coronal planes***
  - In the axial and coronal planes (Fig. 18.7), the width of the levator hiatus (enclosed between the puborectalis muscle slings) and the iliococcygeus angle were measured, respectively, at rest and during maximum straining.

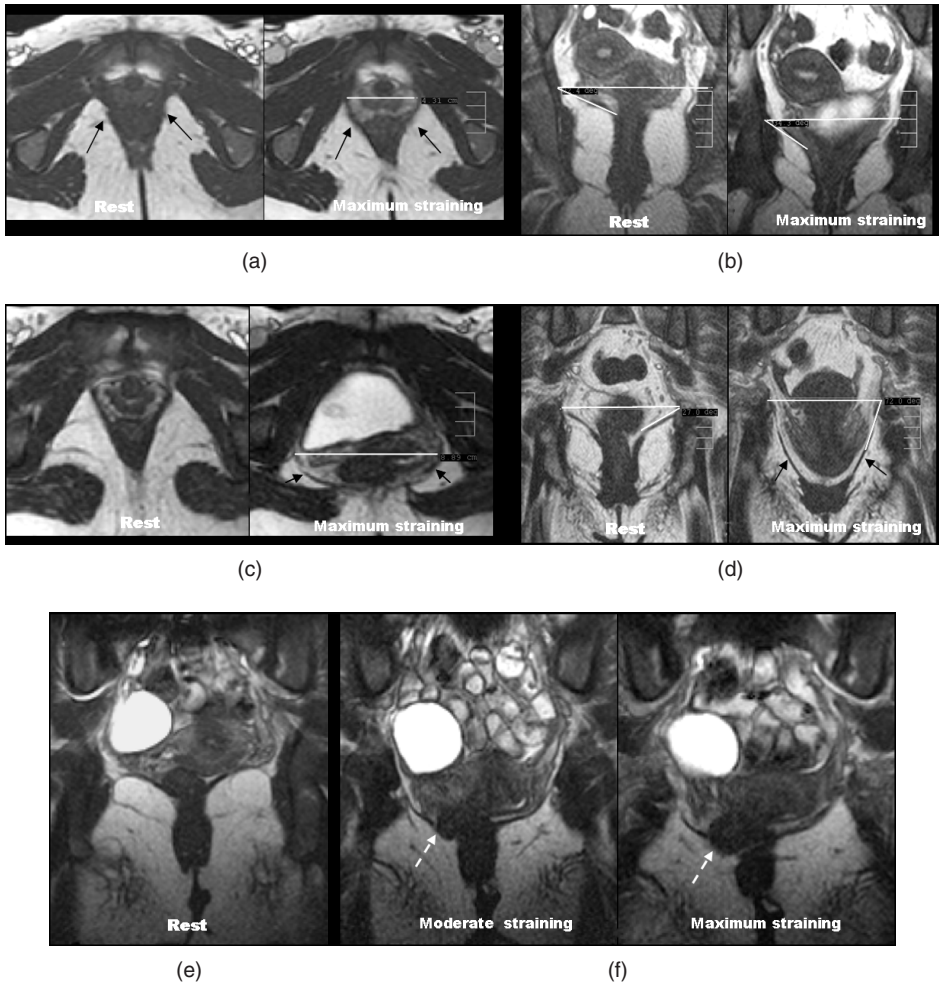

Figure 18.7 Patterns of pelvic floor muscle weakness and defect [Dynamic balanced fast field echo BFFE (TR/TE 9/4)] (a), axial (b) coronal images obtained in a 28-year-old healthy volunteer show normal width of the levator hiatus(WLH) (straight line) measuring 4.3 cm at maximum straining; arrows, point to the puborectalis (PR) slings in A, iliococcygeus angle(IL A) measured 34.3^0 (enclosed between the joined lines in B). (c) axial (d) coronal images obtained in a 54-year-old female patient with SUI, and POP show weakness of the pelvic floor muscle indicated by ballooning of the PR muscle (arrows in C); WLH measuring 9 cm; excessive downward vertical descent of the iliococcygeus muscle (arrows in D) with the IL A reaching 72^0. (e,f) Coronal images obtained in a 25-year-old patient with POP; with progressive straining a right levator defect is seen containing the rectum (dashed arrows).

- The mean and SD of the H-line is 5.8 cm $\pm$ −0.5; the M-line 1.3 ± 0.5; the levator plate angle $11.7^\circ \pm 4.8^\circ$, the width of the levator hiatus 4.5 cm $\pm$ 0.7 and the iliococcygeus angle $33.4^\circ \pm 8.2^\circ$ measured in healthy volunteers with no symptoms of lower genitourinary abnormalities at maximum straining. These measurements were proved

to be of value in identification of pelvic floor laxity and quantification of the degree of the weakness. They are also useful for follow-up assessment.

Correlation between static and dynamic MR images

- Static and dynamic MR images in the same patient are analyzed simultaneously and findings obtained are correlated to determine the most marked type of pelvic supporting system defects This defect is reported as the predominant defect.
- Based on this approach it was possible to differentiate whether POP was due to defects in the endopelvic fascia, levator muscle weakness (Fig. 18.6), or due to abnormalities in both the endopelvic fascia and levator muscles.
- SUI was found to be associated with structural defects in the urethral supporting elements and not with bladder neck descent.
- This imaging correlation converts static and dynamic MR imaging from two types of images that record abnormalities separately, into an integrated system that can more precisely delineate the underlying anatomic defect responsible for symptoms in patients with pelvic floor dysfunction (even allowing differentiation of the underlying anatomic defect when any two patients have the same symptoms).

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