2 2D/3D Endovaginal and Endoanal Instrumentation and Techniques

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Learning Objectives

1. Understand the pelvic floor ultrasound instrumentation and techniques
2. Appreciate the capabilities and limitations of ultrasound equipment
3. Become familiarized with systems for performing meaningful 2D/3D endovaginal and endoanal ultrasound imaging and techniques
4. Learn how to use pelvic floor ultrasonography to make accurate and comprehensive diagnoses and guide therapeutic decisions

2.1 Introduction

Varying pelvic floor disorders require varying degrees of imaging for proper management. The pelvic floor is a complex structure functionally and anatomically. Muscles, nerves, and connective tissue all play a role in its proper functioning. Therefore, many factors, including birth-related trauma and age, play a role in pelvic floor dysfunctions. Despite much progress in the diagnosis of pelvic floor dysfunction, general practitioners in women's health are often not fully aware of the potential of pelvic floor ultrasonography. Although physical examination, cystoscopy, and urodynamics are main stays of pelvic floor diagnosis, cheap, simple, noninvasive 2D, 3D, or 4D office ultrasound is not in widespread use. It can be important to view all compartments of the pelvic floor in order to (1) find the causes of dysfunction, (2) plan treatment, and (3) evaluate outcomes. More and more clinical studies are reporting the value of a thorough pelvic floor ultrasound examination that includes endovaginal and endoanal as well as transperineal imaging. The benefits of high-resolution 3D imaging of pelvic floor structures are also being increasingly recognized. Ultrasound allows fast, multicompartmental assessment, facilitating optimal patient throughput. It allows for high-resolution assessment of the morphology and function of the different parts of the pelvic floor. It facilitates observation of the entire pelvic floor with minimal disruption to the natural condition of the structures. Preoperative evaluation may reveal more in-depth information about the nature of incontinence. It may help the practitioner visualize the position and mobility of the bladder neck and urethra, in combination with maneuvers like squeeze and Valsalva. To evaluate prolapse, cystocele, rectocele, and enterocele, postoperative evaluation may help ensure that corrective devices, such as tension-free vaginal tape (TVT) or mesh implants, are properly placed. The value of anal sphincter ultrasonography to

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Fig. 2.1 A Pro Focus UltraView scanner

Table 2.1 UltraView specifications

Imaging modes: B, M, color Doppler, power Doppler, pulsed wave Doppler, tissue harmonic, contrast imaging
Features and options: vector flow imaging (VFI), 3D professional, 360° probe support, DICOM, HistoScanning™, remote control, 3 array connectors
Display: 19″ LCD flat monitor
Dimensions (*approx*): system height, 1,475–1,565 mm/58–62 in.; width, 525 mm/21 in.; depth, 765 mm/30 in.
Weight: 70 kg/154 lb

detect and evaluate anal sphincter tears and perianal fistulas is well established [1].

2.2 2D Transperineal and 3D Endovaginal and Endoanal Ultrasound Imaging

A fair amount of information can be obtained with an abdominal 2D concave probe that is placed on the perineum [2]. Additional information can be obtained by endovaginal and endoanal imaging. Analogic's BK Pro Focus UltraView (Fig. 2.1, Table 2.1) and Flex Focus are suited for this purpose. These systems offer high performance with efficiency and speed, a high-resolution

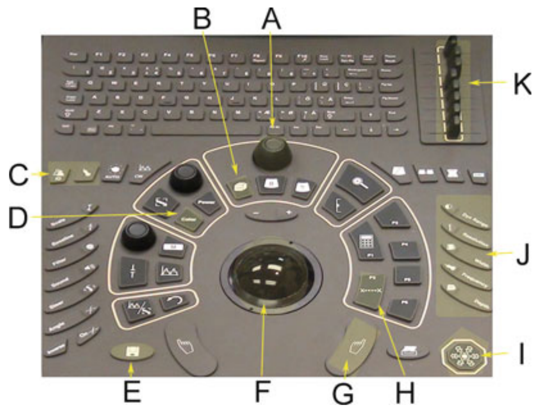

Fig. 2.2 The Pro Focus UltraView 2202 console. A: The general toggle control which amplifies or mutes the signal all across the screen. B: The most important button. Once your machine has your desired setting, the 3D button starts and stops scanning. C: For ID input and probe selection, D: for color Doppler, E: save button saves a video clip of specified duration or if the screen is frozen, an image is captured. F: Your mouse, G: the mouse click, H: for distance measurements, I: freeze button, J: buttons used for changing the depth of scanning, frequency, width, resolution, and range, K: the toggle buttons control selective amplification or muting of signals on the screen © SHOBEIRI 2013

Fig. 2.3 A Flex Focus machine

19″ monitor, and a sensitive color Doppler with superb spatial resolution and sensitivity. The UltraView system (Fig. 2.2) has all the features

Table 2.2 Flex Focus specifications

Imaging modes: B, M, color Doppler, PW Doppler, tissue harmonic
Features and options: 3D 360° probe, DICOM, BK power pack
Display: 19″ LCD flat monitor
Dimensions (*approx*): system height, 1,350–1,602 mm/53–63 in.; keyboard height, 745–1,055 mm/29–41.5 in.; body width, 350 mm/14 in.; depth, 610 mm/24 in.
Weight: 49 kg/108 lb (excluding probes and printer), 7 kg/15 lb (imaging unit only)

Fig. 2.4 8802 probe

such as HistoScanning™ capabilities, while Flex Focus (Fig. 2.3, Table 2.2) has a small footprint—fits in the tightest spaces—4 h plug-free imaging, innovative and easy to use, smooth, sealed keyboard for easy cleaning and disinfection. The ultrasound machine comes with state-of-the-art probes. Although there are probes for multiple principles, there are only two or three probes needed for pelvic floor imaging. These probes offer innovative design for access to all areas, advanced puncture guides, convenient one-button control, and easy sterilization and disinfection.

2.2.1 The 2D Probes

Although any available 2–8 MHz abdominal probe can be used for scanning of the pelvic floor, the images in this book are from a BK 8802 probe unless specified otherwise (Fig. 2.4, Table 2.3).

Table 2.3 8802 probe specifications

8802 specifications	
Frequency range	4.3–6.0 MHz
Focal range (typical)	6–114 mm
Contact surface	52 × 8 mm
Disinfection	Immersion, sterile covers are available
Physical data (length × width)	100 × 60 mm
Weight (approx)	150 g (approx)

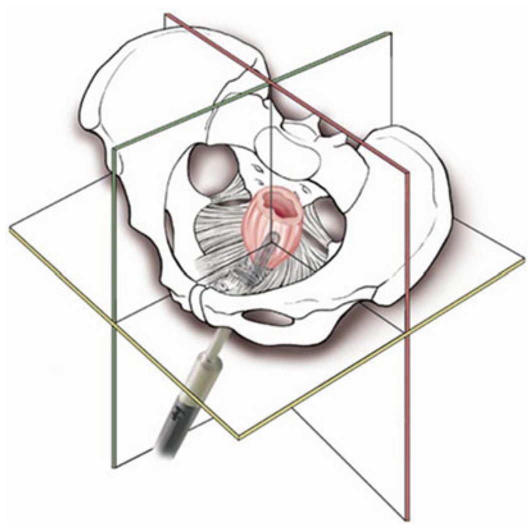

Fig. 2.5 *x*, *y*, *z* planes

2.2.2 The 3D Endocavitary High-Resolution Probes

High-resolution 3D allows the automatic acquisition and construction of high-resolution data volumes by synthesis of a high number of parallel transaxial or radial 2D images, ensuring that true dimensions in all three *x*, *y*, and *z* planes are equivalent. The constructed data cube technique provides accurate distance, area, angle, and volume measurements. The volume rendering technique resulting from high-resolution 3D provides accurate visualization of the deeper structures. High-resolution endovaginal or endoanal anatomy can be obtained in 30–60 s. The scanned data set is also highly reproducible, with limited operator dependency. The probe can visualize all rectal wall layers; evaluate the radial, longitudinal extension of sphincter tears; and measure detailed pelvic floor architecture in all *x*, *y*, and *z* planes accurately (Fig. 2.5).

Table 2.4 2052 endocavitary 360° probe specifications

2052 specifications	
Frequency range	6–16 MHz
Focal range (typical)	Up to 50 mm
Sector angle	360°
Disinfection	Immersion
Physical data	Length: 542 mm Shaft length: 270 mm Handle width: 38.4 mm Shaft width: 17 mm
Weight (approx)	850 g (approx)

Fig. 2.6 2052 probe

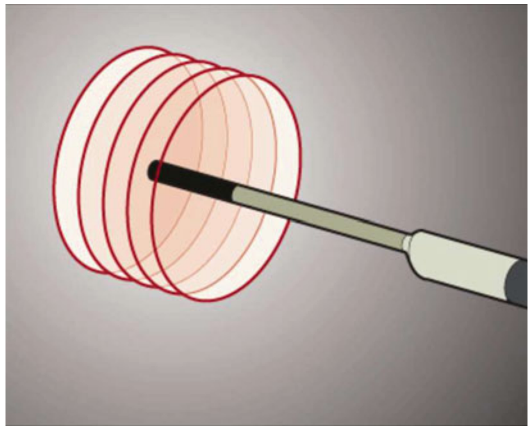

Fig. 2.7 2052 probe creates parallel axial images that are packaged to create a 3D volume

2052 Endocavitary 360° Probe

The 2052 probe (Table 2.4, Fig. 2.6) has an internal automated motorized system that allows an acquisition of 300 aligned transaxial 2D images over a distance of 60 mm every 0.2 mm in 60 s, without any movement of the probe within the cavity (Fig. 2.7). The probe has buttons on the handle that allows manual control of the probe (Fig. 2.8). The set of 2D images is instantaneously reconstructed into a high-resolution 3D image for real-time manipulation and volume rendering. The 3D volume can also be archived for offline analysis on the ultrasonographic system or on PC with the help of dedicated 3D Viewer software. The main limitation of this probe is the total length of the probe of 54 cm. Although the probe is also used by colorectal surgeons for staging of rectal tumors which necessitates the length, in pelvic floor imaging, the length may create anxiety for the patients. For pelvic floor imaging, the length requires keeping the hand in a stable position to avoid image distortion. From the methodological point of view, mechanical character of the probe does not allow to obtain the same resolution in all sections, only the axial section (the section of acquisition) has the best quality, and all other sections coming from post-processing of the 3D volume data set have lower resolution.

8848 Endocavitary Biplane Probe

Broad views of anterior and posterior compartments for functional and anatomical studies may be obtained using the 8848 probe (Table 2.5, Fig. 2.9). To obtain quick views of the anterior and posterior compartments, this probe can be rotated manually, but to obtain reproducible 180° 3D measurements, the 8848 probe can be installed on an external mover (Fig. 2.10). The probe has two buttons on the handle that allows for selection of axial or sagittal scanning. It provides detailed high-resolution biplane with 6.5 cm linear and convex views. One can obtain 3D volumes by manually rotating hand 180° when in sagittal mode or withdrawing the hand 6.5 cm when scanning the urethra or the rectum vaginally. However, these 3D volumes are not accurate if measurement

Fig. 2.8 The 2052 probe has two buttons on the handle anteriorly that allows manual pilot of the scanner elements within the probe. The button posteriorly activates the probe or freezes the image on the screen

Table 2.5 8848 180° probe specification

8848 specifications	
Frequency range	5–12 MHz
Focal range (typical)	3–60 mm
Frame rate/td>	>150
Disinfection	Immersion, STERIS SYSTEM 1*, STERIS SYSTEM 1E, STERRAD 50,100S and 200
Scanning modes	B,M, Doppler, BCFM, tissue harmonic imaging
Contact surface (overall)	Transverse: 127 mm^2, sagittal: 357 mm^2
Image field (expanded)	180°(transverse)
Weight (approx)	250 g

Fig. 2.10 The external mover elements for 8848 probe

Fig. 2.9 8848 probe

Table 2.6 8838 endocavitary 360° probe specification

2D frequency (MHz)	12–6
Doppler frequency (MHz)	7.5–6.5
Tissue harmonic imaging frequency (MHz)	10
Contrast imaging frequency (MHz)	4
Image field	65 mm wide acoustic surface able to rotate 360°
2D penetration depth (mm)	82–85
Footprint (mm)	65 × 5.5

of structures is the desired endpoint. To obtain consistent 3D volumes, a 3D mover needs to be utilized.

8838 Endocavitary 360° Probe

8838 is similar to 8848 probe, but all the mechanisms are internalized (Table 2.6, Fig. 2.11). The probe is world's first electronic probe for endovaginal and endoanal imaging with built-in high-resolution 3D capabilities. The probe has built-in linear array which rotates 360° inside the probe. The probe has no need for additional accessories or movers; no moving parts come in contact with the patient. The probe has capability for dynamic 2D (Fig. 2.12) and 3D scanning (Fig. 2.13). The probe has wide frequency range 12–6 MHz, with the same excellent imaging capabilities across all frequencies. Probe has a slim 16 mm (0.6) diameter for more comfortable patient imaging with an easy grip to hold and manipulate. Unlike 2052 probe's long profile which was designed with staging of colorectal cancers in mind, the 8838 is short and less threatening to the patients.

The 8838 probe allows an acquisition of radial 2D images without any movement of the probe within the cavity. The set of 2D images is instantaneously reconstructed into a high-resolution 3D image for real-time manipulation and volume rendering. The 3D volume can also be archived for offline analysis using BK PC software.

Fig. 2.11 8838 probe

Fig. 2.12 8838 set at scanning at 12:00 o'clock position for dynamic imaging of the bladder

Fig. 2.13 The 8838 probe elements move within the shaft radially to create a 3D data volume

2.2.3 BK 3D Viewer Software

The 3D volume can be used on the scanner, but the ease of use and functionality is better when the free software is installed on any PC (Fig. 2.14). The available functions are lined to the right, bottom, and the left side of the screen. One can scan any patient and export their data files to a CD, DVD, USB, external hard drive, or a server and then view them at any time, on any PC. This is akin to the virtual examination of the patient. The work can be saved and reproduced with ease. On the left side there is an "eye" icon where you can create "memory points." By clicking on the eye icon, you save the 3D view and find it easily

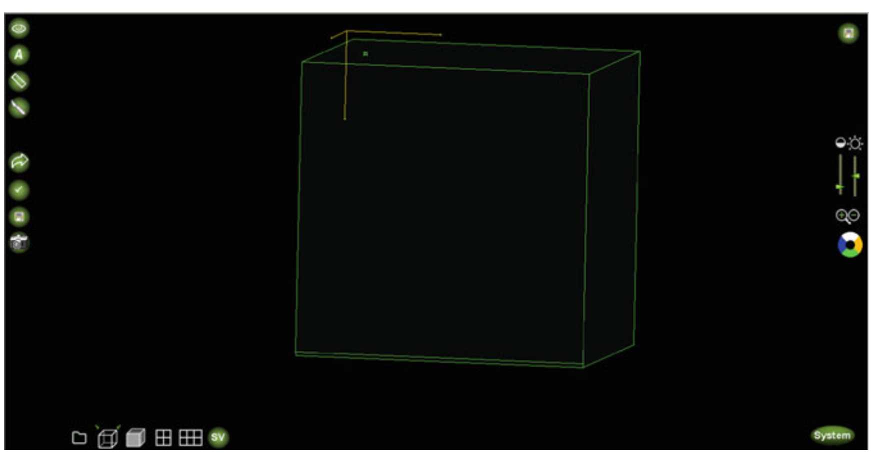

Fig. 2.14 The screen view of BK 3D software. The empty 3D wire frame is seen in the center with control icons all around it © SHOBEIRI 2013

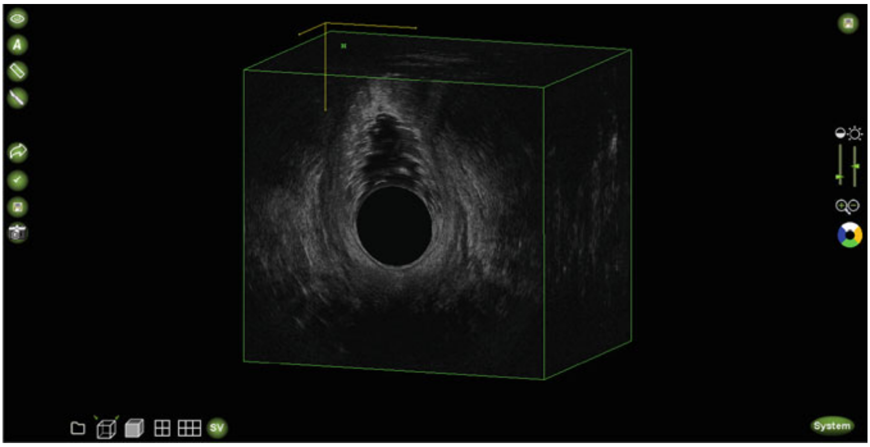

Fig. 2.15 The "eye icon" saves your screen shot and creates a menu of images of interest for future reference © SHOBEIRI 2013

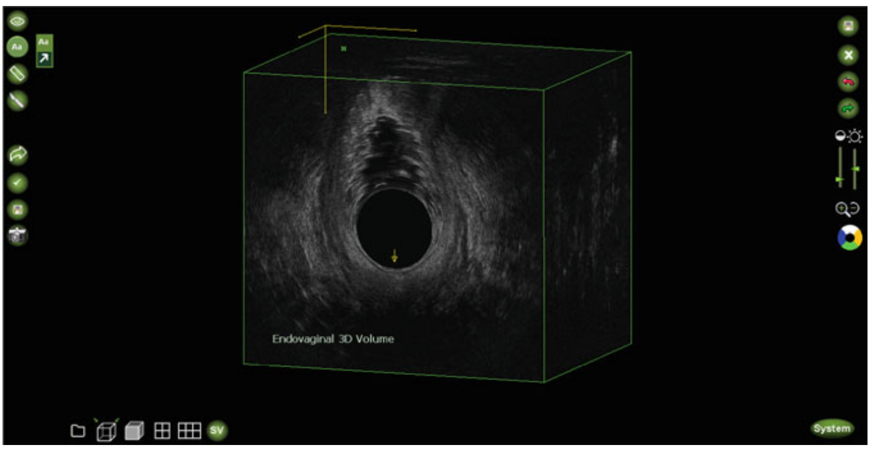

Fig. 2.16 The annotation and arrow icon allows for marking of the structures on the screen © SHOBEIRI 2013

for documentation or research purposes at a later time (Fig. 2.15). Below the "eye icon" is the annotation and arrow icon for writing and marking structures on the 3D volumes (Fig. 2.16). The third icon on the left is the measurement icon. You can obtain linear measurement, angle, area, and volume measurements. When in the measurement mode, additional icons appear on the upper right side that allows to undo or delete all your measurements (Fig. 2.17). The fourth icon on the upper left of the screen is the sculpting icon. One can cut the structures out (Fig. 2.18) or cut the inner structures (Fig. 2.19). Alternately, a structure could be isolated all together (Fig. 2.20). The next 4 icons on the middle left of the screen are for taking snapshots, including the wire frame, removing the personal data, and saving the volumes (Fig. 2.14). On the right side of the screen, there are two icons for adjusting the brightness and the hue. There is also an icon for changing the volume color to soft yellow, blue, or green (Fig. 2.21). On the bottom of the screen, there are icons for opening files, obtaining rendered views (Fig. 2.22). Volume render mode is a technique for the analysis of the information inside 3D volume by digital enhancing individual voxels. It is currently one of the most advanced and computer-intensive rendering algorithm available for computed tomography and can also be applied to high-resolution 3D US data volume.

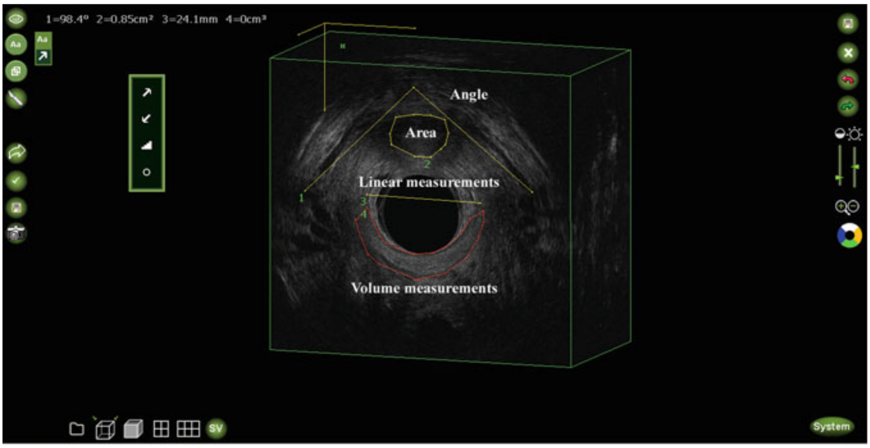

Fig. 2.17 The measurement icon allows very useful functions such as angle, area, linear, or area/volume measurements © SHOBEIRI 2013

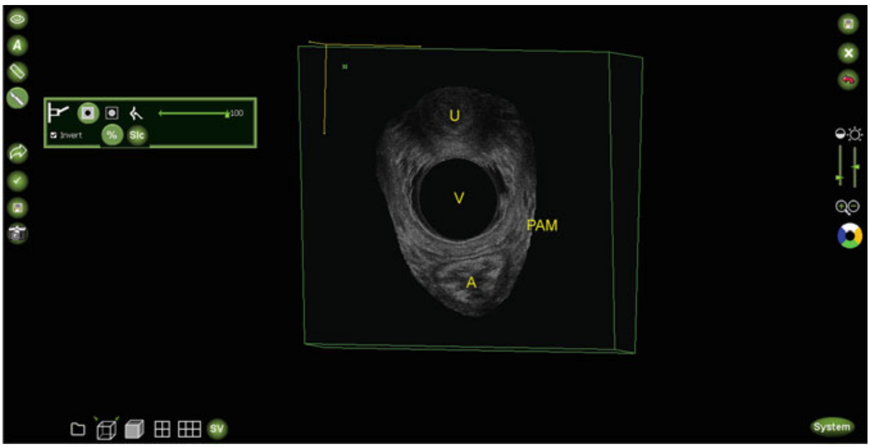

Fig. 2.18 The sculpting icon opens a window with multiple capabilities. Here the puboanalis muscle is isolated. *U* urethra, *V* vagina, *A* anus, *PAM* puboanalis muscle © SHOBEIRI 2013

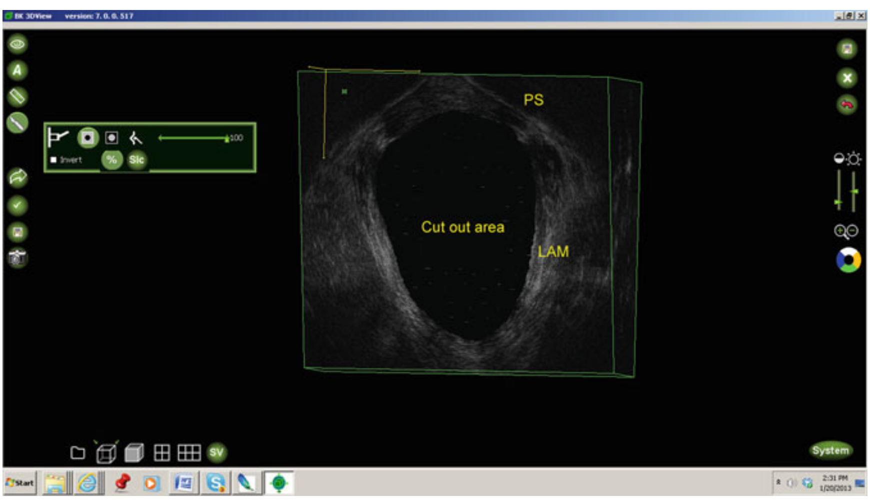

Fig. 2.19 The sculpting icon opens a window with multiple capabilities. Here the minimal levator hiatus is cut out leaving the surrounding levator ani muscles (LAM) © SHOBEIRI 2013

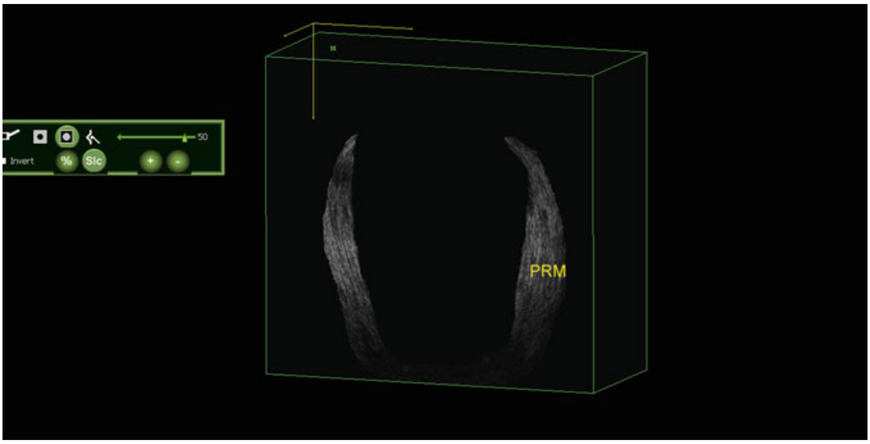

Fig. 2.20 The sculpting icon opens a window with multiple capabilities. Here everything but the puborectalis muscle (PRM) is cut out © SHOBEIRI 2013

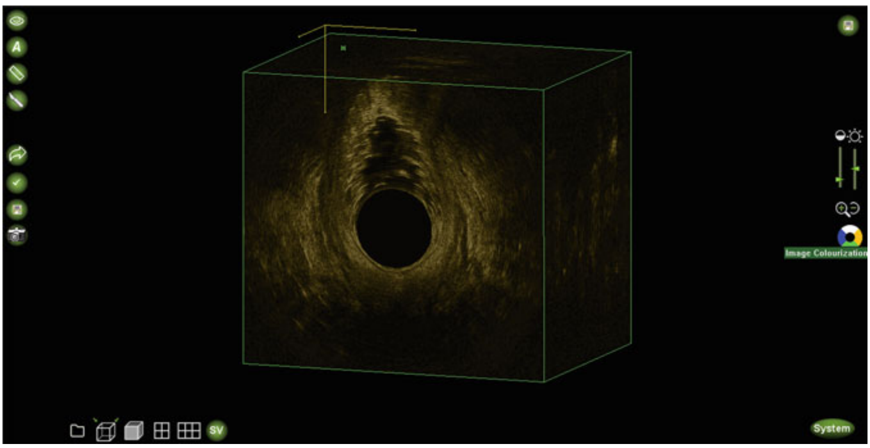

Fig. 2.21 The two icons on *upper right side* have toggle capabilities to adjust the brightness and the hue. The four-colored circle controls the desired color. Here the image is colored in *soft yellow* © SHOBEIRI 2013

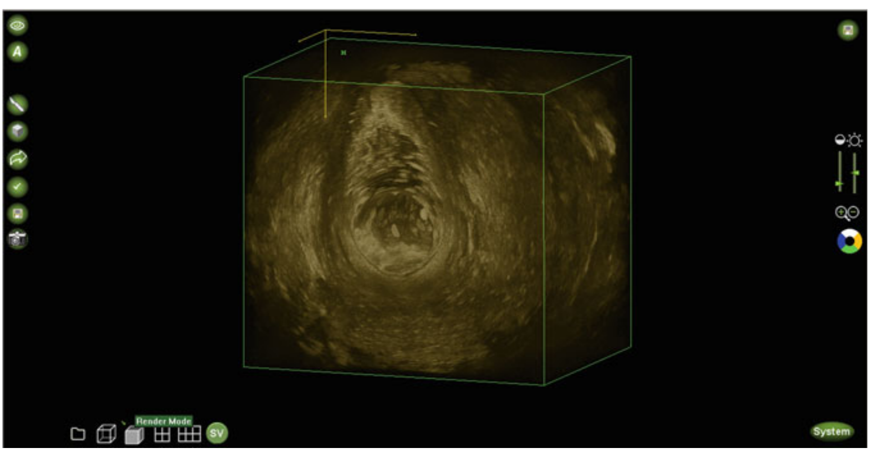

Fig. 2.22 The screen view of BK 3D software. The rendered endovaginal frame is seen in the center with control icons all around it. The icons on the *bottom left* of the screen from *left* to *right* are open file, normal view, rendered view, 4 shots, and 6 shots view © SHOBEIRI 2013

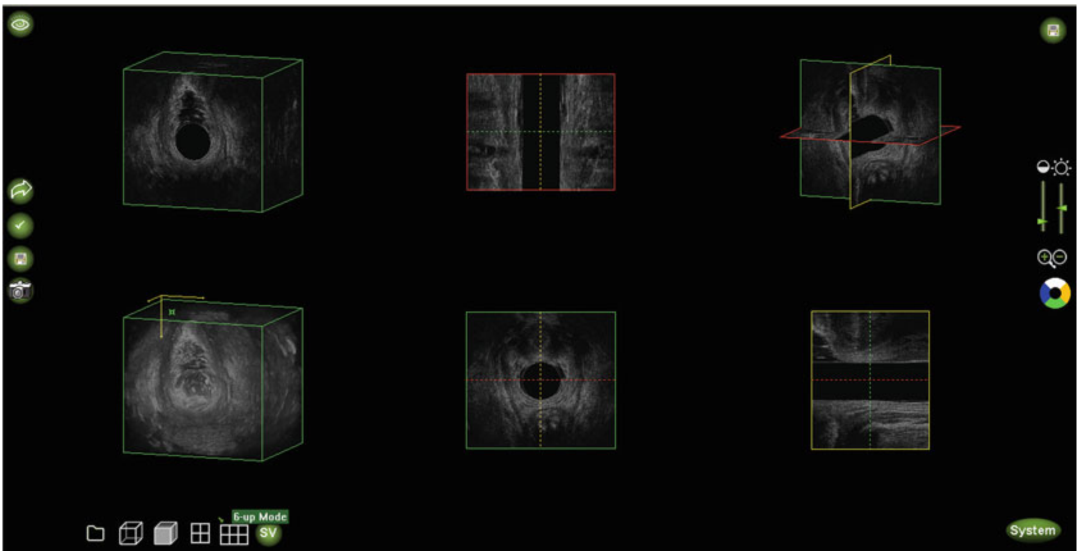

Fig. 2.23 The screen view of BK 3D software. The 6 shot view or the 6-up mode is a very useful tool as many functions can be carried out simultaneously © SHOBEIRI 2013

The typical ray-/beam-tracing algorithm sends a ray/beam from each point (pixel) of the viewing screen through the 3D space rendered. The beam passing through the volume data reaches the different elements (voxels) in the data set. Depending on the various render mode settings, the data from each voxel may be stored as a referral for the next voxel and further used in a filtering calculation, may be discarded, or may modify the existing value of the beam. The final displayed pixel color is computed from the color, transparency, and reflectivity of all the volumes and surfaces encountered by the beam. The weighted summation of these images produces the volume-rendered view. The render mode is useful for visualization of tapes and meshes that may seem isoechoic due to dense tissue ingrowth. The dark colors appear darker and the light colors appear lighter in rendered mode and anything in between has lesser intensity.

There are two icons that can give four or six concurrent views on the screen (Fig. 2.23). This is an interactive screen, and as the *x*, *y*, and *z* planes are moved on the upper right, all the other views adjust automatically to let the viewer know exactly what they are viewing. One important feature of BK 3D software is that analysis is not restricted to axial, coronal, and sagittal planes. The planes can be tilted (Fig. 2.24) to follow the structures to their insertion points. This corrects for any operator error that may have occurred during acquisition. Multiple planes can be manipulated at once (Fig. 2.25).

2.3 Multicompartmental Ultrasonographic Techniques

2.3.1 Patient Positioning

During examination, the patient may be placed in the dorsal lithotomy, in the left lateral or in the prone position. The patient's positioning depends on cultural factors, local acceptable practices, physician's specialty, and equipment availability. In the United States urogynecologists perform pelvic examination in dorsal lithotomy position. At our institution, the pelvic floor ultrasound including endoanal examinations are performed in dorsal lithotomy position. This position allows symmetrical acquisition of ultrasound volumes regardless of being done endovaginally or endoanally [3, 4].

Imaging of the pelvic floor can be done in one or combination of the following five steps depending on the patient's presenting symptoms (Fig. 2.26).

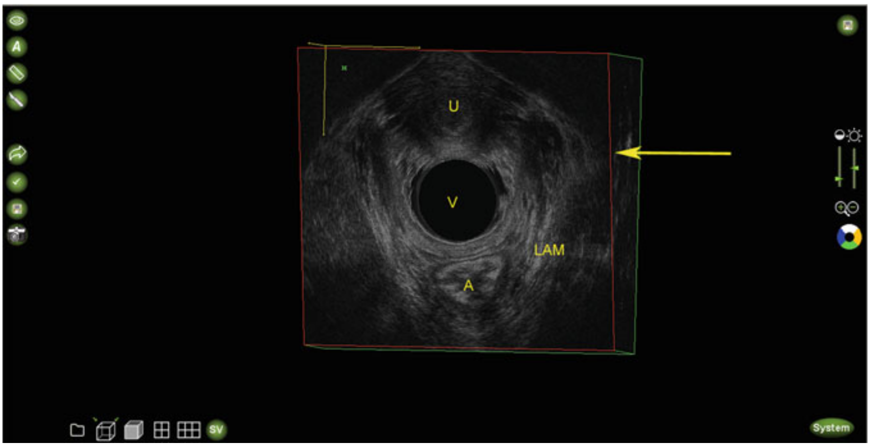

Fig. 2.24 One unique function of the BK software is the capability to twist the planes to follow the structure in axial, sagittal, or coronal planes. While twisting the planes the wire frame turns red to denote the action. The urethra (U), vagina (V), and the anus (A) are marked. The *yellow arrow* points to the tilting of the frame in axial view © SHOBEIRI 2013

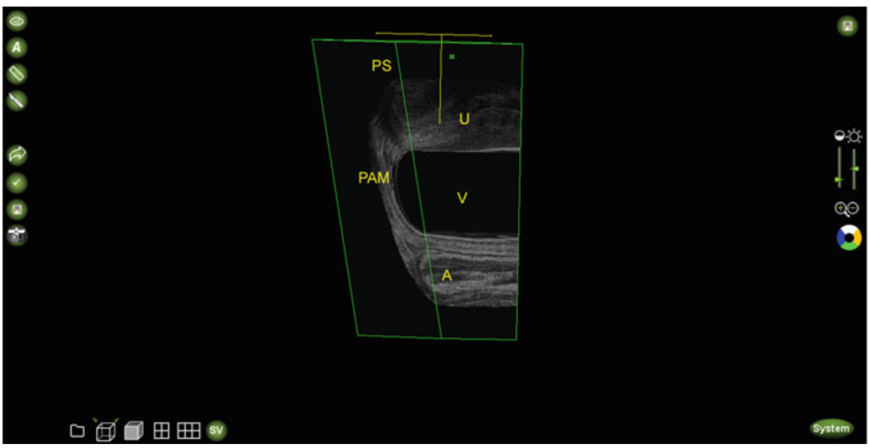

Fig. 2.25 Multiple functions can be performed at once. Here the data volume that has been sculpted to cut out the puborectalis muscle and isolate the puboanalis muscle (PAM) is rotated in right midsagittal view to show the length of the urethra (U), vagina (V), and anus (A). PS is the pubic symphysis © SHOBEIRI 2013

2.3.2 2D Transperineal Functional Imaging

Indications: Enterocele, Rectocele, Cystocele, Mesh, Slings.

The probe surface is covered with gel and a nonpowdered glove or cover before it can be placed on the perineum between the labia. The symphysis pubis is seen anteriorly. Sequentially, the urethra, vagina, and the anal canal and the levator plate are seen anteriorly to posteriorly. A good-quality image contains both the symphysis pubis and the levator plate. The scanning is performed in the lithotomy position with a comfortable volume in the bladder. Generally if the patient is asked to empty her bladder, by the time scanning is started, sufficient volume is in the bladder to differentiate the structures. High bladder volume may prevent prolapse from manifesting itself. If needed, the patient can be asked to stand up for scanning.

Bladder neck descent (BND) can be measured in rest and maximum Valsalva; however, no definition of normal exists. Although funneling may be

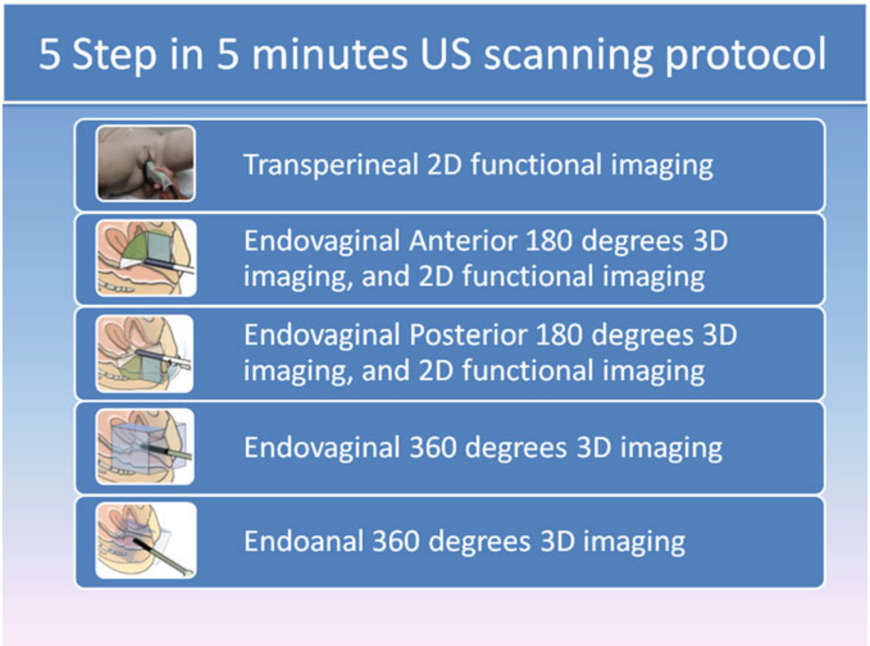

Fig. 2.26 Five steps for performing pelvic floor ultrasound © SHOBEIRI 2013

seen during ultrasonography, no clear ultrasound definition is available.

Transperineal ultrasound is most useful for indirect assessment of pelvic floor function. Measuring the distance from the symphysis pubis to the levator plate gives the anterior posterior (AP) measurement of the minimal levator hiatus which can be measured at rest and in Valsalva.

Different forms of cystocele can be identified, but the cervix is difficult to appreciate due to its hypoechoic nature. The imaging is very useful posteriorly as a high rectocele can be differentiated from a sigmoidocele and a low rectocele from a perineocele.

The patient is asked to empty the bladder. By the time you start imaging, she will have enough urine in the bladder to make the bladder hypoechoic. You can use a glove or an unlubricated ultrasound gel-filled condom/probe cover. Place ample water-soluble gel on the probe and place on the perineum or between the labia while paying attention to the screen (Fig. 2.27). The probe is placed on the perineum and between the labia (Fig. 2.28) such that the image on the screen appears as if the patient is standing up facing the right side of the screen (Fig. 2.29). General guidelines for the settings are shown in Table 2.7. You can obtain measurements with resting, Valsalva and squeeze for the distance from the edge of the pubic symphysis to the edge of the levator plate that

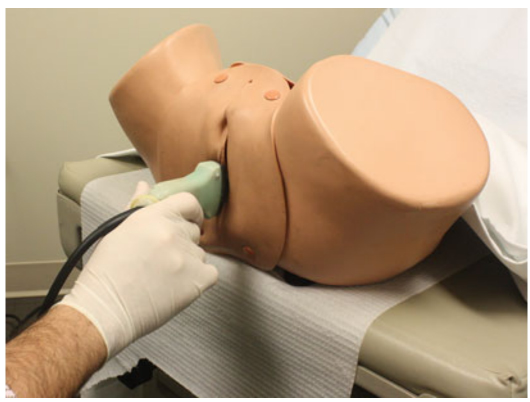

Fig. 2.27 The patient position and the 8802 probe position during transperineal scanning © SHOBEIRI 2013

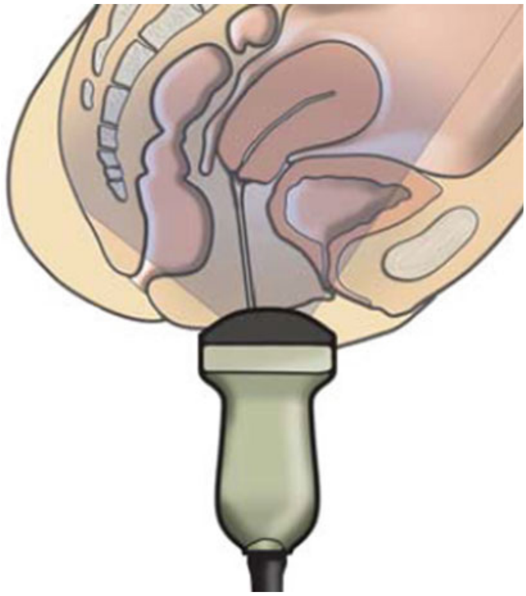

Fig. 2.28 This view demonstrates Incorrect positioning as the starting 2D field of view should include pubic symphysis anteriorly and the anorectal angle posteriorly. The field of view as demonstrated does not contain the pubic symphysis, and as such the distance from the edge of the pubic symphysis to the edge of the levator plate that creates the anorectal angle cannot be obtained. Depending on the patient's body habitus and pelvic floor laxity, the field of view may need to be made larger

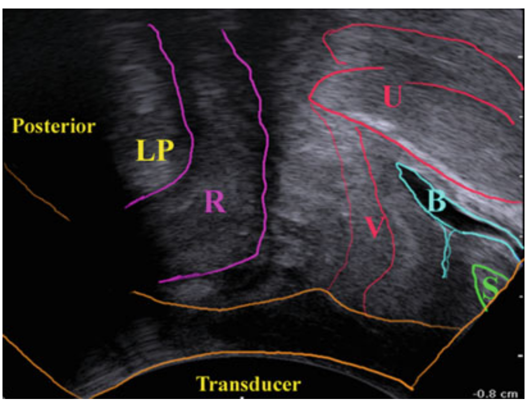

Fig. 2.29 This view demonstrates CORRECT positioning as the starting 2D field of view includes the pubic symphysis (S) anteriorly and the levator plate (LP) posteriorly. Also noted are the bladder (B), uterus (U), vagina (V), and anorectum (R) © SHOBEIRI 2013

Table 2.7 Describes the sample steps for performing transperineal 2D imaging using any abdominal probe

8802 transperineal imaging
Identify the 8802 transducer
Identify the probe orientation
Press the button on the side of the probe to activate the probe
Set the depth at 6.7 cm
Set the resolution at 1/32 Hz
Place the transducer on the perineal area and obtain sagittal view of the bladder, vagina, and the rectum (including the midsagittal view of pubic symphysis)
Adjust the gain
Ask the subject to cough or bear down to visualize the movement of anterior, apical, and posterior compartments
If you want the video clip of the action, press the DISK button which records the action for the past 10 s
Ask the subject to "squeeze vaginal muscles or perform Kegels" to visualize the movement of the levator plate
If you want the video clip of the action, press the DISK button which records the action for the past 10 s

In this example an 8802 probe is used

creates the anorectal angle. This has been shown to correlate well with levator function.

2.3.3 2D/3D Endovaginal Anterior Compartment Imaging

Indications: Voiding dysfunction, Enterocele, Cystocele, Location of mesh and slings, Anterior vaginal masses and cysts, Fistulas.

There are two BK probes available for this purpose, the 8848 (Fig. 2.30) and 8838 (Fig. 2.31). You can use an unlubricated ultrasound gel-filled condom/probe cover. Place ample water-soluble gel on the probe and place in the vagina (Fig. 2.32). 2D dynamic view of the urethra and bladder comes to view (Fig. 2.33). The measurement protocol for 8848 probe is in Table 2.8. Measurements of the urethral structures or any visible mesh or sling can be obtained (Fig. 2.34). Although bladder funneling can be visualized, this may be impeded by the presence of probe in the vagina [2, 5, 6].

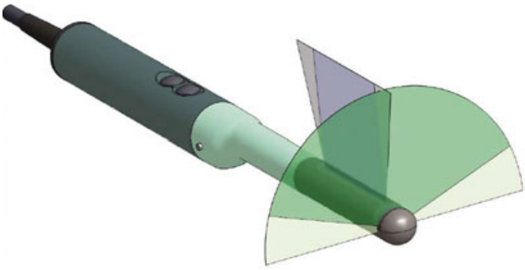

Fig. 2.30 8848 probe. Demonstrating 180° axial and sagittal planes

Fig. 2.31 8838 probe. Demonstrating the 360° rotation. The probe can be programmed to obtain 180° anterior or posterior 3D volume acquisition if this is desired

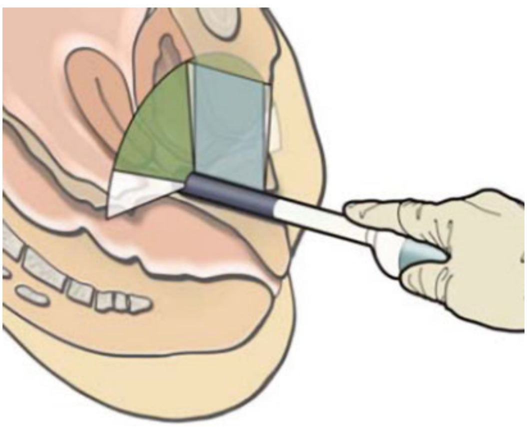

Fig. 2.32 8848 probe vaginal placement. The probe is generally advanced cephalad to the vesicourethral junction for image acquisition. Slight posterior pressure is desired when patient is prompted to cough or Valsalva

2.3.4 2D/3D Endovaginal Posterior Compartment Imaging

Indications: Defecatory dysfunction, Constipation, Intussusception, Sigmoidocele, Enterocele, Rectocele, Perineocele, Mesh, Posterior vaginal masses and cysts, Fistulas.

The same two BK probes, the 8848 and 8838, used for anterior imaging can be used for posterior imaging as well. You can use an unlubricated ultrasound gel-filled condom/probe cover. Place ample water-soluble gel on the probe and place in the vagina (Fig. 2.35). 2D dynamic view of the anal canal and the levator plate comes to view (Fig. 2.36). The measurement protocol for 8848 probe is in Table 2.9. Measurements of the external anal sphincter, internal anal sphincter, and any visible mesh can be obtained (Fig. 2.37). If EAS and IAS are abnormal by endovaginal ultrasound, follow-up study by endoanal ultrasound should be performed if the patient has anal incontinence. Ask the patient to squeeze and Valsalva to visualize any high rectocele, enterocele, sigmoidocele, or intussusception. Visualization of a low rectocele may be impeded by the presence of probe in the vagina.

2.3.5 3D 360 Endovaginal Imaging

Indications: Mesh, Vaginal masses and cysts, Levator ani muscle subdivisions and defects.

3D endovaginal US may be performed with 2052 or 8838 probe or a radial electronic probe (type AR 54 AW, frequency: 5–10 MHz, Hitachi Medical Systems, Japan) to be discussed in chapter on emerging technologies. Since the Hitachi probe is withdrawn by hand, the measurements are not reliable (more about the Hitachi probe in emerging technology chapter).

Before the probe is inserted into the vagina, a gel-containing condom is placed over the probe. Any air bubbles are removed by squeezing the gel-filled condom downward (Fig. 2.38). Water-soluble lubricant is placed on the exterior of the cover, and the probe is advanced to the vesicourethral junction (Fig. 2.39). The probe should be inserted easily and gently (Fig. 2.40). If any pain is experienced, the procedure should be stopped.

Using 2052 probe, the pubic symphysis and the urethra are anterior, the levator ani lateral, and the anus posterior (Fig. 2.39). Generally starting the scanning from the vesicourethral junction will continue 6 cm caudad to include the perineal body (Fig. 2.41). The protocol for scanning with 2052 probe is in Table 2.10. In

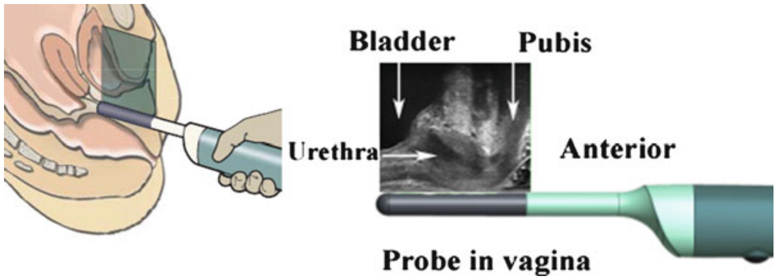

Fig. 2.33 Composite of anterior compartment imaging with 8838 probe. To the *right* the image as seen on the screen is demonstrated. The probe is advanced to the vesicourethral junction to visualize the full length of the urethra © SHOBEIRI 2013

Table 2.8 Describes the sample steps for performing endovaginal 2D/3D imaging using an 8848 probe

8848 endovaginal anterior imaging
Identify 8848 probe and attach the mechanical mover
Press the button on the probe to activate it
Confirm setting at 12 MHz
Insert the probe with the grooves on the transducer pointing anteriorly
Identify the depth on the upper right-hand side of the screen as 5.6 cm
Identify bladder, urethra, and the pubic symphysis
You can freeze the view and visualize periurethral structures and obtain urethral measurements
Press the probe posteriorly and ask the patient to Valsalva to visualize bladder neck funneling
Press the 3D button
Position the selection box on the screen to the desired area for 3D acquisition
Identify the resolution as 1/34 Hz
Identify the extent at 179°
Set spacing at every 0.3°
Acknowledge the time needed for scanning
Push the 3D button on the machine to activate probe rotation
This concludes 3D imaging of the anterior compartment

patients with perineal descensus, two overlapping 3D ultrasound volumes may need to be obtained. The 2052 probe generally obtains adequate images of the anterior and posterior compartment, but since the 2D images are in axial plane, dynamic imaging of the anterior and posterior compartments cannot be performed. Also, the sagittal images are less clear than the ones obtained by 8838.

Using 8838 probe, the bladder and the urethra are visualized in sagittal orientation on the screen. Advance the probe until vesicourethral junction is visualized and follow the protocol on Table 2.11. The probe rotates internally 360° (Fig. 2.42). Not only the 8838 probe obtains excellent views of anterior and posterior compartment, it has internalized rotational mechanism and is capable of dynamic imaging of anterior and posterior compartments. The levator ani appears different from that of 2052, and the views in axial view are pixelated. We run a protocol of imaging 360° every 0.55° in 30.8 s to obtain 655 frames. Again it is important to keep the hand and the elbow holding the probe steadied on a support such as own knees or a cushion while the other hand runs the controls on the console (Fig. 2.43). During endocavitary imaging the patients may be tempted to talk to alleviate their anxiety. It is important to calm the patients, let them know what is happening, and share with them that during scanning their talking and body movements may distort the desired image acquisition [4, 7].

2.3.6 3D 360 Endoanal Imaging

Indications: Perianal masses and cysts, Perianal fistulas, Anal sphincter injury.

3D endoanal US may be performed with 2052 or 8838 probes or a radial electronic probe (type AR 54 AW, frequency: 5–10 MHz, Hitachi Medical Systems, Japan) to be discussed in chapter on emerging technologies. Since the Hitachi probe is hand drawn, repeatable measurements may not be obtained.

Before the probe is inserted into the anus, a gel-containing condom is placed over the probe.

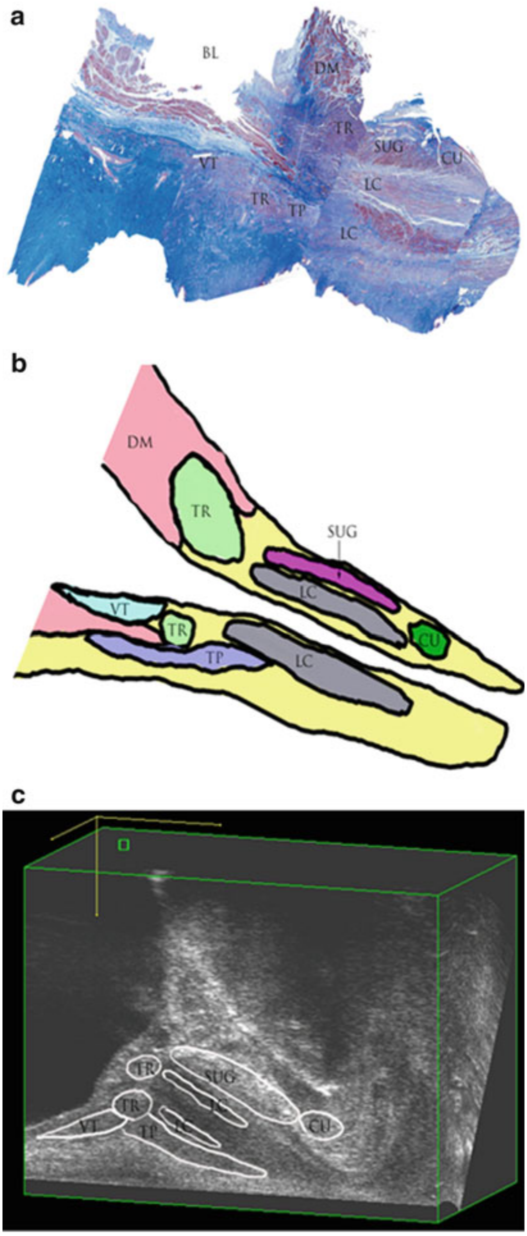

Fig. 2.34 The view of the *left side* of the anterior compartment: (**a**) histologic section, (**b**) drawing of the anterior compartment structures, and (**c**) the left sagittal view of the 3D EVUS cube with the structures marked. *BL* bladder, *CU* compressor urethra, *LCM* longitudinal and circular layer, *P* pubic bone, *PCF* pubocervical fascia, *SUG* striated urogenital sphincter, *TP* trigonal plate, *TR* trigonal ring, *U* urethra, *UT* uterus, *V* vagina, *VT* vesical trigone. From © Shobeiri, IUGJ

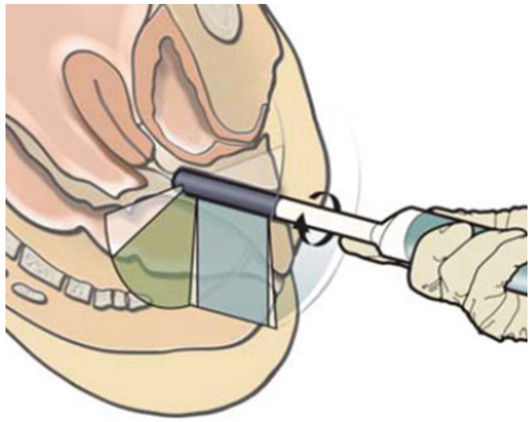

Fig. 2.35 8848 probe vaginal placement. The probe is generally advanced until the perineal body is to the *right* of the screen prior to image acquisition. Slight anterior pressure is desired when patient is prompted to cough or Valsalva

Any air bubbles are removed by squeezing the gel-filled condom downward. Water-soluble lubricant is placed on the exterior of the condom. The probe should be inserted easily and gently. If any pain is experienced, the procedure should be stopped (Fig. 2.44). The probe is pushed to the cephalad edge of the levator plate and the 3D button is pushed on the console.

Using 2052 probe, the anterior aspect of the anal canal is superior (12 o'clock) on the screen, right lateral is left (9 o'clock), left lateral is right (3 o'clock), and posterior is inferior (6 o'clock). The length of recorded data should extend from the upper aspect of the "U"-shaped sling of the levator plate to the anal verge [8, 9].

Using 8838 probe, the probe is inserted until the perineal body is anterior and to the right of the screen. You will visualize the midsagittal view of the rectovaginal septum as you advance the probe (Fig. 2.40) and follow the protocol on Table 2.11. The 8838 probe obtains excellent views of the anal sphincter complex. However, since there are no axial reference points and also because the images appear rendered, it has a

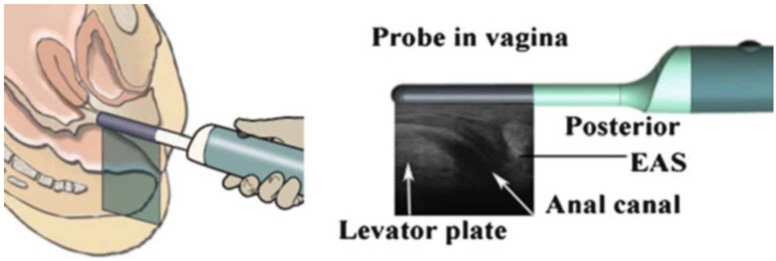

Fig. 2.36 Composite of posterior compartment imaging with 8838 probe. To the *right* the image as seen on the screen is demonstrated. The probe is advanced until the perineal body/EAS complex is visualized to the *right* of the screen © SHOBEIRI 2013

Table 2.9 Describes the sample steps for performing posterior compartment endovaginal 2D/3D imaging using an 8848 probe

8848 endovaginal posterior imaging
Identify 8848 probe and attach the mechanical mover
Press the button on the probe to activate it
Confirm setting at 12 MHz
Insert the probe with the grooves on the transducer pointing posteriorly
Identify the depth on the upper right-hand side of the screen as 4.9 cm
Identify external anal sphincter, internal anal sphincter, and the levator plate
Ask the patient to perform a Kegel to view levator plate movement
Ask patient to first perform Valsalva to view intussusception, rectocele, or inability to relax the levator plate
Press the 3D button
Position the selection box on the screen to the desired area for 3D acquisition
Identify the resolution as 1/34 Hz
Identify the extent at 179°
Set spacing at every 0.3°
Acknowledge the time needed for scanning
Push the 3D button on the machine to activate probe rotation
This concludes 3D imaging of the anterior compartment

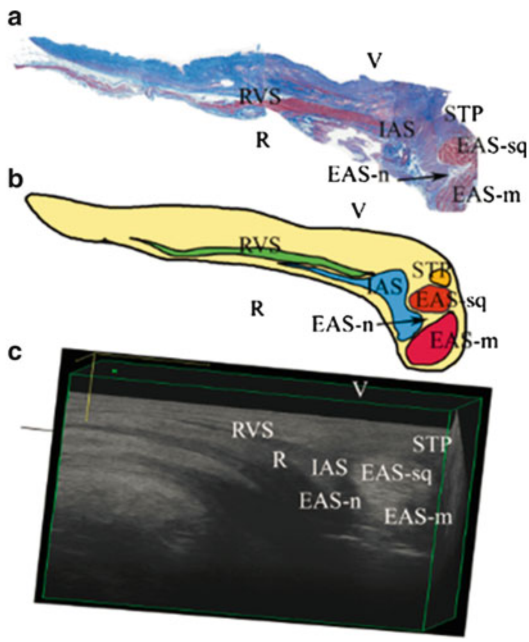

Fig. 2.37 The view of the *left side* of the posterior compartment: (**a**) histologic section, (**b**) drawing of the posterior compartment structures, and (**c**) the left sagittal view of the 3D EVUS volume with the structures marked. *EAS-m* external anal sphincter main section, *EAS-n* external anal sphincter notch, *EAS-sq* external anal sphincter subcutaneous section, *IAS* internal anal sphincter, *IAS-L* internal anal sphincter length, *IAS-T* internal anal sphincter thickness, *R* rectum, *RS* rectovaginal septum, *STP* superficial transverse perinei, *V* vagina. From © Shobeiri, IUGJ

Fig. 2.38 Application of probe cover to a 2052 probe. Adequate removal of air bubbles is mandatory. Ample gel is applied to the outside of the cover © SHOBEIRI 2013

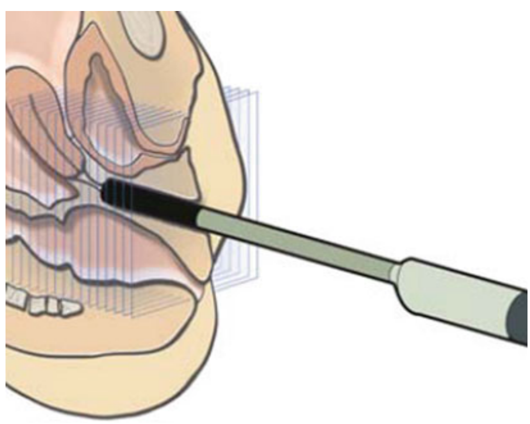

Fig. 2.39 2052 probe vaginal placement. The probe is generally advanced until the vesicourethral junction is viewed. Pressing the 3D button will obtain a serious of axial images which will be packaged as a 3D volume

Fig. 2.40 Correct placement of an endovaginal probe. The hand is kept steady and the arm is placed on the knee or an elbow rest while the 3D volumes are being obtained © SHOBEIRI 2013

moderate learning curve. While with 2052 the axial images are displayed on the screen and the operator has an idea about the integrity of the anal complex, with 8838 the data volume has to be manipulated after data acquisition to obtain useful information. 8838s internalized rotational mechanism and good tissue penetration may visualize the entire levator ani muscle as long as there is no air in the rectum and if some gel is placed in the vagina (Fig. 2.45). However, if avulsion of the levator ani is the point of interest, an anal probe will place the operator further from the site of defect which is the site of the levator ani attachment to the pubic bone. The levator ani also may appear different from that of 2052 and the views in axial view are pixelated. With either 2052 or 8838 probe used endoanally, the images appear similar (Fig. 2.46) (in publication).

2.4 Summary

Ultrasound visualization of pelvic floor structures requires a multicompartmental approach. Knowledge of anatomy, functionality of different probes, and capabilities of ultrasound machine used is essential for acquisition of meaningful images.

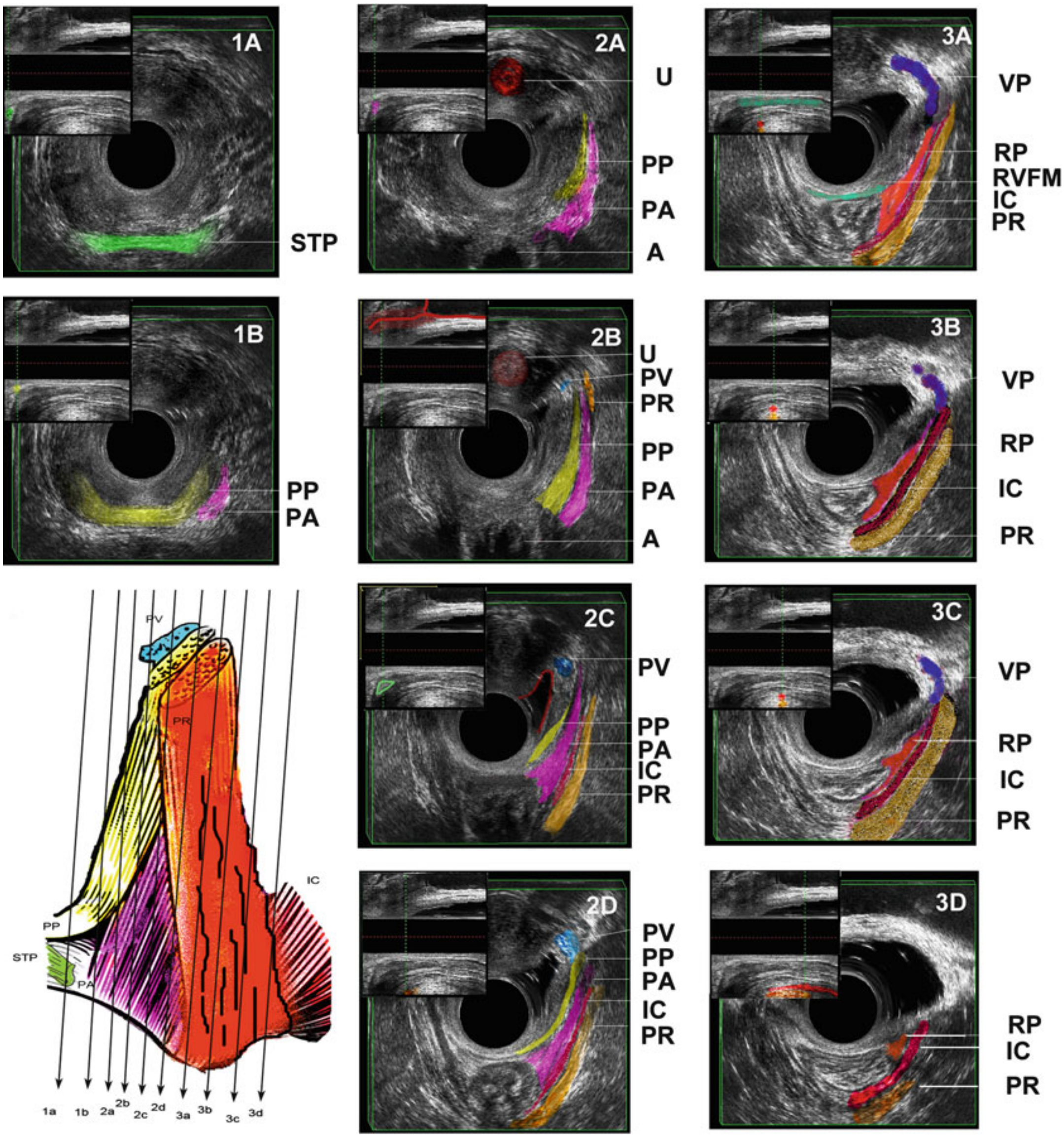

Fig. 2.41 Levator ani subdivisions seen at different levels. Midline structures are identified in lateral views with corresponding colors in the picture inserts at the *upper left* corner of the ultrasound images at each level. The relative position of levator ani subdivisions during ultrasound imaging: levels 1A–3D are identified in the figure insert. The *green vertical line* in the insert corresponds to the relative position in the vagina where the image is obtained. (**a**) Level 1A: at 0 cm, the first muscle seen is superficial transverse perinei (STP) (*green*) with mixed echogenicity. (**b**) Level 1B: immediately cephalad to superficial transverse perinei is puboperinealis (PP) (*yellow*) that can be traced to pubic bone (PB) with manipulation of 3D volume. It comes in at a 45° angle as a mixed echoic band to join the perineal body. Lateral to it, the puboanalis (PA) is seen as a hypoechoic triangle (*pink*). (**c**) Level 2A: this level marks the attachment of the muscles to the pubic arch. The external urethral meatus (U) is visible (*dark red*). Puboperinealis and puboanalis insertions are highlighted. The anus (A) is marked. (**d**) Level 2B: (PV) pubovaginalis (*blue*) and (PR) puborectalis (*mustard*) insertion come to view. The urethra and the bladder are outlined (*red*) in the lateral view. (**e**) Level 2C: the heart-shape vaginal sulcus (outlined in *red*) marks the pubovaginalis insertion. (IC) Iliococcygeus fibers (*red*) come into view. Perineal body is outlined in the lateral view. (**f**) Level 2D: puboanalis is starting to thin out. Puborectalis is seen in the lateral view. (**g**) Level 3A: puboperinealis and puboanalis become obscure. Anatomically, puboanalis becomes a thick fibromuscularis layer forming a tendineus sheet, rectal pillar (RP). Perivesical venous plexus (VP) are prominent (*purple*). Rectovaginal fibromuscularis (RVFM) is shown (*green*) in sagittal view as a continuous mixed echogenic structure approaching the perineal body

Table 2.10 Describes the sample steps for performing endovaginal 3D imaging of the pelvic floor using a 2052 probe

2052 endovaginal 360° imaging
Identify the 2052 transducer
Set the depth at 3.9 cm
Press the button on the probe to activate the transducer
Press the 3D button
Insert the probe to the 5–6 cm mark at the hymenal level
Visualize the vesicourethral junction
Identify the extent as 60 mm and the spacing at 0.2 mm
Confirm the time required for scanning
Press the 3D button
Maximize the box to be scanned to the desired position
Press the 3D button
Keep your hand steady and level while performing the ultrasound imaging

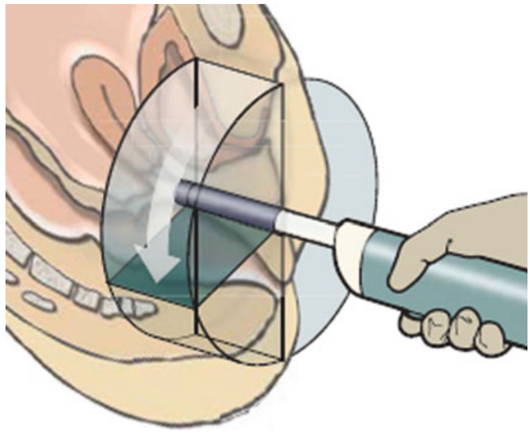

Fig. 2.42 8838 probe vaginal placement. The probe is generally advanced until the vesicourethral junction is viewed. Pressing the 3D button will obtain radial images of the pelvic floor which will be packaged as a 3D volume

Table 2.11 Describes the sample steps for performing endovaginal anterior, posterior, and lateral 3D imaging of the pelvic floor using an 8838 probe

8838 endovaginal anterior, posterior, lateral imaging
Identify 8838 probe
Press the button on the probe to activate it
Identify the depth on the upper right-hand side of the screen as 5.6 cm
Identify bladder, urethra, and the pubic symphysis and withdraw the probe until vesicourethral junction is visible to the left side of the screen
Set imaging for every 0.55°
Set the rotation at 360°
Press the 3D button
Position the selection box on the screen to the desired area for 3D acquisition
Acknowledge the time needed for scanning
Push the 3D button on the machine to activate probe rotation
Keep the hand steady and level while performing the ultrasound imaging
If the patient has perineal descensus, the perineal body may not be included in your 3D volume. Withdraw the probe slightly and redo the steps
This concludes 3D imaging of the anterior, posterior, and lateral compartments

Fig. 2.41 (continued) and laterally attaching to RP. (h) Level 3B: rectal pillar (orange) is easily seen. The iliococcygeus becomes prominent and widens. (i) Level 3C: the iliococcygeus widens further and inserts into arcus tendineus fascia pelvis (ATFP). (j) Level 3D: puborectalis and fade out of view. Puborectalis (mustard) and iliococcygeus (red) are outlined in the lateral view showing their entire course. Adapted from © Shobeiri, Obstet and Gynecol 2009

Fig. 2.43 Correct two handed operation of the probe and the machine © SHOBEIRI 2013

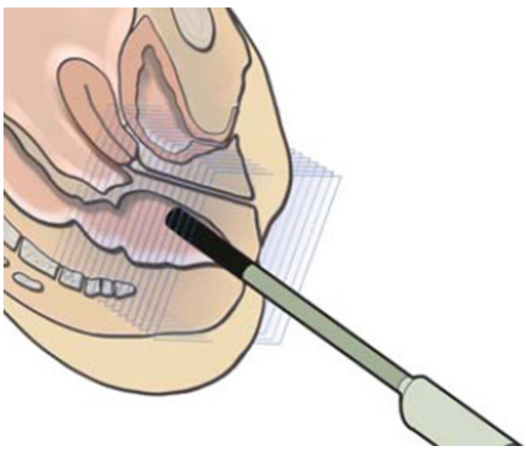

Fig. 2.44 Advancement of an endoanal probe requires initial acute angle entry. Subsequently the hand to be readjusted such that the ultrasound rays are perpendicular to the external anal sphincter fibers

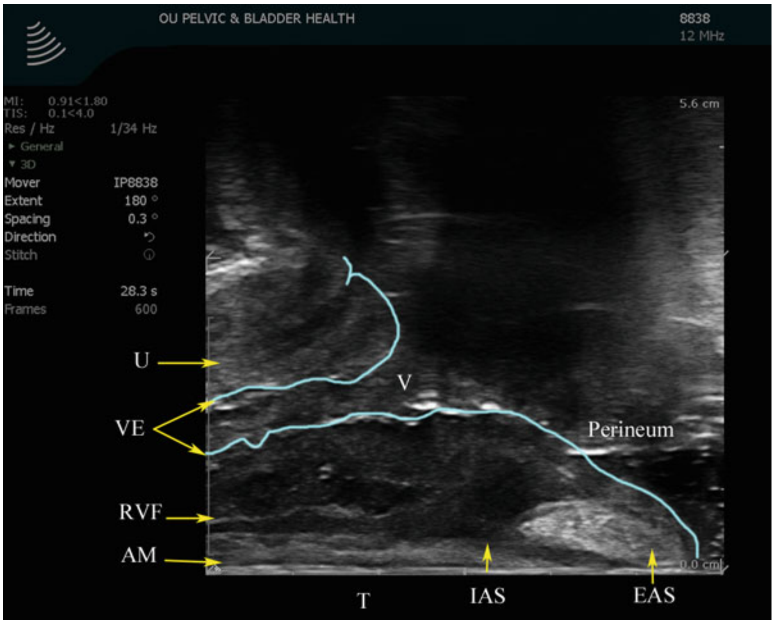

Fig. 2.45 8838 view of the perineal area upon anal entry. The external anal sphincter (EAS), internal anal sphincter (IAS), probe in the anorectum (T), anal mucosa (AM), rectovaginal fascia (RVF), vaginal epithelium (VE), urethra (U), and the vagina are marked (V) © SHOBEIRI 2013

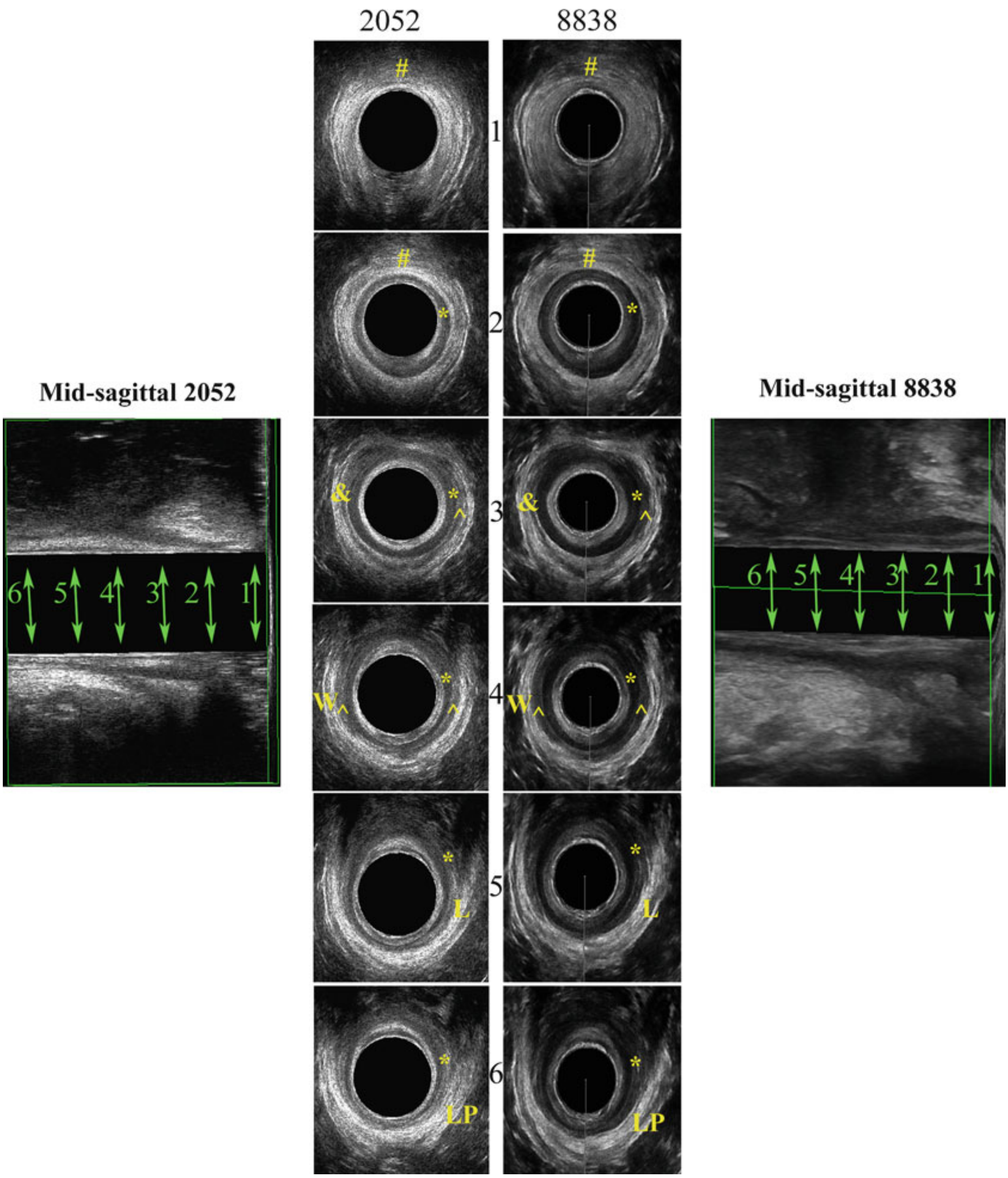

Fig. 2.46 Endoanal views of the levator plate and anal complex at different levels. The images to the *right* are from 8838 and the ones to the *left* from 2052. The axial images are placed side by side at levels 1–6 for comparison. 1. The subcutaneous part of the EAS is visualized with # mark. 2. The first hyperechoic layer, from inner to outer, corresponds to the interface of the probe with the anal mucosal surface; the second hyperechoic layer adjacent to the probe is the subepithelial tissue. Immediately adjacent to it is the internal anal sphincter (IAS) marked with *. The IAS merges with the circular muscle of the rectum, extending from the anorectal junction to approximately 1 cm below the dentate line. 3. The fourth main part of EAS is marked with &. 4. The winged portion of the EAS is marked with W. The longitudinal muscle (LM) has mixed echogenicity and is marked with ^. 5. The puborectalis fibers are seen winging out marked with L. 6. The levator plate fibers are seen winging out marked with LP © SHOBEIRI 2013

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