Endovaginal Imaging: Vaginal Mesh and Implants

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Learning Objectives

1. To familiarize the reader with the ultrasound appearance of vaginal mesh
2. To enhance the ultrasound machine operator's ability to visualize the mesh
3. To familiarize the reader to common vaginal mesh kit patterns

Introduction

Polypropylene mesh is highly echogenic [1] and cannot be directly visualized with radiography, computed tomography, or magnetic resonance imaging [2]. Therefore, ultrasound imaging is the method of choice for evaluating polypropylene mesh used for pelvic organ prolapse (POP) repair. Different techniques and approaches of ultrasound imaging are shown to benefit in assessing transvaginal mesh (TVM) presences, locations, and complications [3–8]. Ultrasound is helpful to surgeons in gaining information regarding position; intrapelvic route; the relationship of mesh to pain; and the location of mesh in relation to structures such as sacrospinous ligament, pudendal nerve, and extent of the mesh postoperatively. Such information can be correlated with clinical complications and the success and failure of surgical procedures [9–11]. Moreover, the ultrasound findings may aid in surgical planning for correction in patients affected by mesh complications or reoperations. It can help explain the etiology of pelvic pain and dyspareunia associated with mesh. It is also useful in patients with a history of mesh surgery in whom the exact nature of the surgery or the site of mesh placement is unknown [3]. This chapter will focus on the history and type of mesh used in POP surgery and on the ultrasound imaging of mesh complications obtained from different imaging approaches.

History and Type of Vaginal Mesh

Increasing life expectancy has resulted in a growing number of older women seeking gynecological care; POP is the most frequent gynecological pathology leading to hysterectomy in women

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older than 55 years of age [12]. Pelvic organ prolapse is recognized as having a significant adverse effect on women's health and quality of life. The lifetime risk for surgery for POP has been estimated to be around 11.1% [13], and 30% of these women will undergo at least one reoperation for recurrent prolapse [14]. Studies on etiology and genetic influence that are aimed at elucidating this problem are still ongoing. The need for POP surgery increases with age [15], and it has been conservatively estimated that the surgical workload related to POP will increase by 46% over the next four decades as our population ages [16]. According to the 2010 Census population report, the female population in the United States reached more than 157 million (50.8%); as many as 9,420,000 of these women might be at risk for POP surgery [17].

Pelvic reconstructive surgery for genital prolapse, with or without mesh, is accompanied by a significant improvement in quality of life and prolapse-related symptoms [18]. Sacrocolpopexy has become the standard abdominal procedure to correct POP; in the past century, the Amreich-Richter sacrospinous fixation has been used widely as a vaginal surgical approach. However, the ease of use of vaginal mesh kits combined with the aggressive marketing of these products led to rapid adoption of these techniques in clinical practice without proper long-term trials.

In the past decade, different heterologous meshes for the treatment of prolapse have been introduced in an effort to improve long-term results with vaginal POP surgery. The use of artificial meshes has a long tradition in abdominal wall surgery. Since the 1950s, surgical mesh has been used to repair abdominal hernias. The abdominal hernia repair has had known complications of pain, mesh shrinkage, and recurrence associated with it. In the 1970s, gynecologists began using surgical mesh products indicated for hernia repair for abdominal repair of POP, and in the 1990s urogynecologists began using surgical mesh for surgical treatment of stress urinary incontinence (SUI) and vaginal repair of POP. To do so, a few highly trained surgeons would cut the mesh to the desired shape for SUI repair or POP repair and then place the mesh through a corresponding incision. Over time, manufacturers responded to this clinical observation by developing mesh products specifically designed for SUI and POP repair, marketed to a wider audience of gynecologists and urologists [19]. In 1996, the surgical fabrics (ProteGen Sling) device (Boston Scientific, Marlborough, Massachusetts, USA) became the first pre-configured surgical mesh product cleared for surgical treatment of SUI. The ProteGen was withdrawn from the market due to complications, but to this date patients still present with its complications. In 2002, Gynemesh® PS (Ethicon/Gynecare, Somerville, New Jersey, USA) became the first pre-configured surgical mesh product cleared for POP repair.

Over the next few years, surgical mesh products evolved into "kits" that included tools to aid in the delivery/insertion of the vaginal mesh. The reasoning behind this was that sacrocolpopexies were performed by highly trained individuals, and the industry was looking for a disruptive technology to popularize POP repair. Because of the mesh use in abdominal hernia repair and trocar use in sling procedures, the industry made the leap of putting the mesh and trocars together and produce them into the market via FDA 510 K process. A 510(k) is a premarket submission made to FDA to demonstrate that the device to be marketed is at least as safe and effective, that is, substantially equivalent, to a legally marketed device, 21 Code of Federal Regulations (CFR) 807.92(a)(3), that is not subject to premarket approval. The first kits for POP repair, the AMS Apogee™ System and the AMS Perigee™ System (American Medical Systems, Minnetonka, Minnesota, USA), were cleared in 2004. Surgical mesh kits continued to differ in regard to introducer instrumentation, tissue fixation anchors, surgical technique, and incorporation of absorbable materials into the mesh, features intended to differentiate one company's kit from another's as the companies rushed to enter POP market [19]. The US Food and Drug Administration (FDA) also approved the Prolift (Ethicon/Gynecare) among many other kits. The Prolift required inserting trocars into the pudendal nerve space between the sacrospinous and sacrotuberous ligaments. This is a sacred space to pelvic surgeons, as the pudendal nerve is responsible for the clitoral, urethral, vaginal,

perineal, and anal selection. Injury to the main branch of the pudendal nerve results in pain in all branches, and selective injury to single branches can result in anything from pain to spasm or voiding and defecatory dysfunction. Pudendal neuralgia in the presence of mesh and scarring is a new area of diagnostic and therapeutic challenge. Based on the update released by the FDA in 2010, "at least 100,000 POP repairs that used surgical mesh" were performed and "about 75,000 of these were transvaginal procedures" [19]. This statement suggested that at least 225,000 TVM (TVM) procedures were done in a 3-year period (2008–2010) [20].

During the past decade, gynecologists have seen widespread use of graft material placed in the vagina as an alternative or augmentation to traditional surgical repairs in order to correct POP. This can be largely credited to the suggestion that the use of mesh improved the outcome of the surgical correction while reducing the recurrence rate of POP. This suggestion has not held true for the posterior compartment. As a result, several "mesh kits" were introduced onto the surgical market, promoting a minimally invasive alternative to the conventional armada of surgical techniques to repair vaginal and uterine prolapse. The placement of surgical mesh was intended to increase the longevity of POP repairs. In general, mesh products for POP repair were configured to match the anatomical defect they are designed to correct. The majority of the meshes are used for anterior prolapse repair, followed by posterior and apical vaginal repair. The main purpose of using grafts in reconstructive surgery was to reconstruct the distorted anatomy with a material that was reportedly safe and provided an anatomically appropriate result. The ideal graft desired was deemed to be inert, non-carcinogenic, with high tensile strength and flexibility, non-allergenic, non-inflammatory, able to be sterilized, non-modifiable by body tissue, convenient, and affordable [19]. To this date, except for the patient's own tissues, there is no existing graft that has all of these characteristics.

Synthetic meshes are classified into four types based on filament number and pore size. Type 1 meshes are polypropylene, monofilament, and microporous (75 m) (e.g., Marlex; Atrium™ [American Medical Systems, Minnetonka, Minnesota, USA], Gynecare Gynemesh™ [Ethicon, Somerville, New Jersey, USA], Pelvitex™ [C. R. Bard, Murray Hill, New Jersey, USA]). Type 2 meshes are microporous (10 m) and multifilamentous (e.g., Gore-tex™ [W. L. Gore Associates, Newark, Delaware, USA]). Type 3 meshes are multifilamentous, although having both microporous and microporous components (e.g., Teflon™ [DuPont de Nemours, Wilmington, Delaware, USA], Mersilene [Ethicon], IVS™ [Tyco Healthcare/US Surgical, Norwalk, Connecticut, USA]). Type 4 meshes, also known as polypropylene sheets, have a pore size of 1 micrometer (e.g., Silastic™ [C. R. Bard], Celgard™ [Celgard, Charlotte, North Carolina, USA]) [21].

The FDA first formally warned the public about the complications of the use of TVM for treatment of POP in 2008. In spite of this warning, the interest in mesh kits continued between 2008–2010 [20]. Complications reported to the MAUDE (Manufacturer and User Facility Device Experience) database following the initial warning ultimately led the FDA to issue an updated Public Health Notification in 2011 that included a significantly stronger warning for transvaginal POP meshes [20]. In 2014, the FDA proposed to reclassify surgical mesh for transvaginal POP repair from class II devices to class III, thus requiring increased safety and efficacy data for mesh kits prior to FDA approval [22]. This reclassification was based on the tentative determination that the previously used mechanisms of approval were not sufficient to provide reasonable assurance of safety and effectiveness for this device. In addition, the FDA proposed to reclassify urogynecologic surgical mesh instrumentation (e.g., manual gastroenterology-urology surgical instrument and accessories or manual surgical instrument for general use) from class I to class II. On its own initiative based on new information [20] the FDA is reclassifying both the surgical mesh for transvaginal repair and the urogynecologic surgical mesh instrumentation. A five-fold increase in the number of adverse medical device reports associated with mesh for POP in the years after the initial warning also prompted the FDA to release a safety

communication in 2011 [23]. The updated FDA warning stated that TVM was not routinely found to be more effective than native tissue repair and may expose patients to greater risk [19]. Although the FDA communication was written to promote understanding of the risks associated with TVM and to encourage informed decision-making by patients and healthcare providers, it resulted in a great deal of confusion, controversy, and concern regarding the role of TVM [23]. In this period a group of urogynecologists had been trained mostly with vaginal mesh kits and lacked the benefit of training to perform traditional pelvic reconstructive surgery.

Against this historical background we review mesh complications, with specific emphasis on vaginally placed mesh and ultrasound findings.

Ultrasonographic Findings of Mesh

The aim of POP repair using mesh implants is to restore the normal anatomy and to reinforce the defective fascia of the pelvic floor. The mesh insertion technique should be proper to avoid tension or overcorrection on one compartment, which may lead to pain or increased tension on another compartment. However, the exact nature of proper placement remains unknown. The instructions are to place the mesh with sufficient spread without folding. Malplacement that is ill-defined would result in a lower degree of vaginal support and potentially lead to prolapse recurrence [9]. The dissection plane should be between the vaginal fascia, the bladder anteriorly and the rectum posteriorly. The underlying vaginal mucosa should remain well vascularized to avoid vaginal erosion and then mesh exposure [24]. Two-dimensional (2D), 3D, 4D perineal and 3D endovaginal ultrasound have played a major role in the evaluation of mesh placement postoperatively because it is cheap, non-invasive, more easily available, also providing useful information in real time [8]. The detection of potential normal or abnormal location and extent is useful in providing information for clinical correlation and preoperative planning for mesh complication.

Perineal/Introital Approach

Tunn et al. reported polypropylene mesh identification postoperatively using the introital approach. A 5-MHz vaginal sector probe was used to identify the implants in midsagittal view to measure the distal-to-proximal length and thickness [4]. The hyperechoic polypropylene mesh is demonstrated under the bladder neck and bladder base within the vesicovaginal space after anterior compartment repair (Fig. 9.1). For posterior compartment repair with TVM, the hyperechoic mesh is seen under the vagina (Fig. 9.2). These images demonstrate that much can be accomplished with a simple 2D perineal ultrasound probe. If a physician lacks fancy 3D ultrasound equipment, 2D imaging may provide sufficient information provided that the urogynecologist is trained in pelvic floor ultrasound imaging.

Velemir et al. examined mesh appearance postoperatively using introital 2D ultrasonography in patients who had undergone anterior and/or posterior vaginal wall prolapse surgery with the Prolift system. They concluded that severe mesh retraction leads to a lack of covering of the distal part of the vaginal walls, which is associated with posterior prolapse recurrence [6]. In addition, in a previous study aimed to explore the correlation between mesh appearance and success after 6

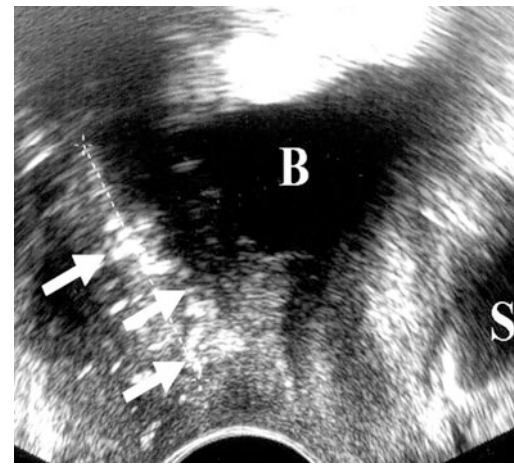

Fig. 9.1 Introital ultrasound image in midsagittal view showing the anterior mesh for anterior compartment repair. Bladder (B), symphysis (S) (from Tunn et al. [4], with permission)

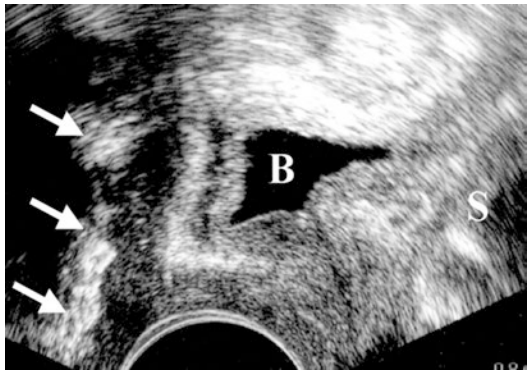

Fig. 9.2 Introital ultrasound image in midsagittal view showing the posterior mesh for posterior compartment repair. Bladder (B), symphysis (S) (from Tunn et al. [4], with permission)

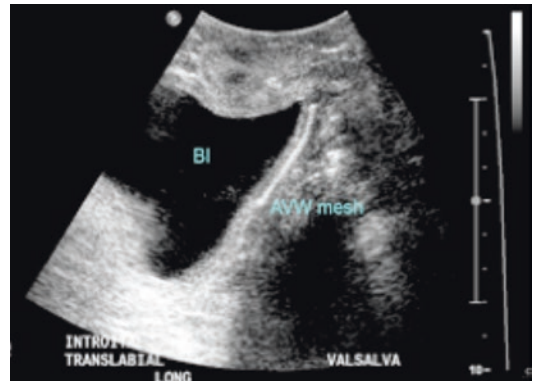

Fig. 9.3 2D translabial ultrasound image in sagittal plane showing the anterior vaginal wall (AVW) mesh. Bladder (Bl) (from Staack et al. [26], with permission)

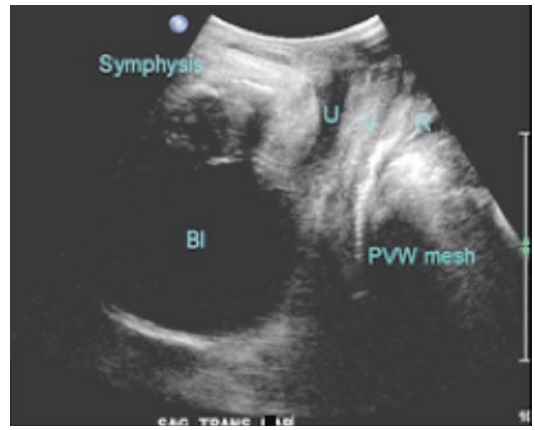

Fig. 9.4 2D translabial ultrasound image in sagittal plane showing the posterior vaginal wall (PVW) mesh. Bladder (Bl), urethra (U), vagina (V), rectum (R) (from Staack et al. [26], with permission)

months of anterior vaginal mesh repair, the introital ultrasound approach was used and demonstrated that mesh retraction was significantly greater in patients who reported de novo overactive bladder and vaginal pain [25].

In the literature 2D, 3D, 4D perineal/introital techniques are widely reported to identify anatomic and dynamic aspects of vaginal polypropylene mesh implants [7, 26, 27]. The midsagittal plane provides views of the pubic bone, urethra, bladder, vagina, and rectoanal angle. The anterior and posterior vaginal wall meshes are identified in Figs. 9.3 and 9.4, respectively [26]. However, 2D perineal sonography depiction of the location of vaginal mesh kits may be difficult because of the distance to the mesh arms. Therefore, for these groups of patients, 3D or 4D perineal ultrasound may be helpful [28], and the endovaginal approach provides the greatest amount of information.

Endovaginal Approach

A recent study demonstrates that 3D endovaginal ultrasound (3D-EVUS) imaging May be the best tool to evaluate the presence, location, and extent of polypropylene mesh, especially in patients with a complicated treatment history [3]. 3D-EVUS has proven to have a high sensitivity for the detection of vaginal mesh or slings. As a result, it can explain the reason for complications or failure and aid to plan for further surgical intervention. Polypropylene mesh can be clearly identified with 3D-EVUS sonography, as it produces a distinct echogenic signal on sonography [5]. Polypropylene mesh appears as a thin echogenic wavy structure adjacent to the vaginal wall with minimal acoustic shadowing. The anterior mesh is demonstrated under the bladder neck and proximal urethra (Fig. 9.5) and the posterior mesh is demonstrated under vagina and transvaginal ultrasound probe (Fig. 9.6a, b). The advantage of multicompartment 3D ultrasound is the fact that the 3D data volume can be manipulated using a combination of straight and oblique planes to determine the intrapelvic course of mesh implants.

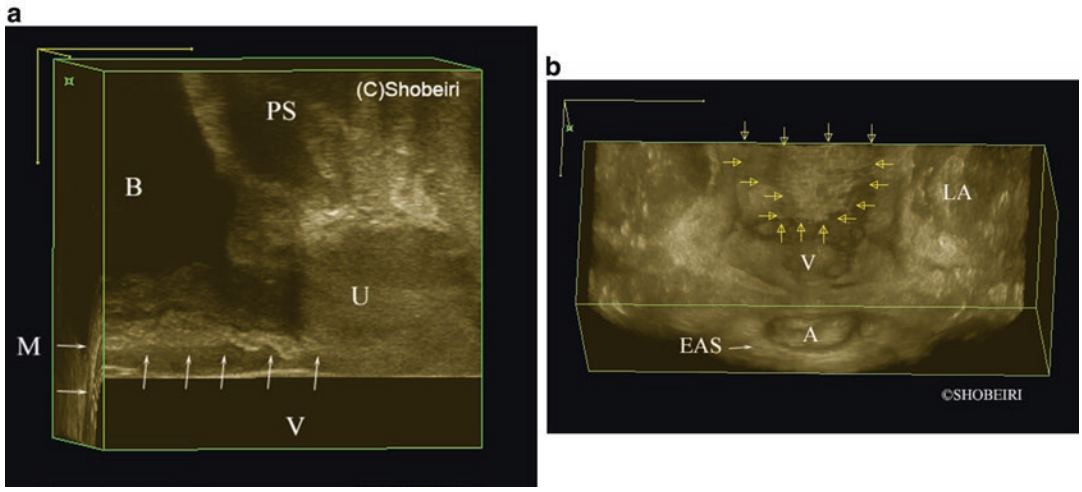

Fig. 9.5 (**a**) 3D endovaginal ultrasound image (anterior compartment) in sagittal plane showing the anterior vaginal wall mesh (M). Bladder (B), urethra (U), vagina (V), pubic symphysis (PS). (**b**) 3D Coronal tilted view of the posterior compartment obtained using an endovaginal probe. *Arrows* point to the edges of the posterior mesh. External anal sphincter (EAS), vagina (V), levator ani (LA), Anus (A)

Endoanal Approach

Endoanal ultrasonography (EAUS) and endorectal ultrasonography (ERUS) are also useful in determining the location and extent of mesh implants. Endoanal ultrasound is especially useful in evaluating vaginal mesh kits when the upper vagina has collapsed. By using the endoanal approach, one can get past the short vagina and image the sacrospinous-sacrospinous mesh bridge created by the mesh (Fig. 9.6c). When a tight bridge exists, the operator has to be careful while advancing the probe should there be any resistance. Additionally, sometimes the endoanal approach may be better tolerated in patients with levator ani muscle spasm or myalgia. The folded anterior vaginal mesh is demonstrated in Fig. 9.7. Figure 9.8 shows posterior vaginal mesh located at perineum. A useful modality for visualization of mesh is the rendered view of the mesh (see Fig. 9.8b, c).

Mesh Complications and Ultrasonographic Findings

Transvaginal mesh has been used for POP repair for many years, and complications related to mesh have been widely reported. A Cochrane review reported an erosion rate of 10.3% after anterior vaginal wall repair with polypropylene mesh [29]. A systematic review from 2014 concluded that the mean total complication rate in anterior, posterior, and combined mesh repair are 8–27%, 3.5–20% and 13–40%, respectively [30]. Complications related to mesh in female pelvic floor surgery are classified according to the International Urogynecological Association (IUGA)/International Continence Society (ICS) into (1) local complications, (2) complications to surrounding organs, and (3) systemic complications [31]. A recent retrospective multicenter chart review stated that the affected site of mesh complications could occur at the area or away from the suture line in 250 patients with TVM complications after POP surgery [32]. Ultrasound findings related to complications of TVM will be discussed according to the IUGA/ICS classification.

Mesh Contraction (Shrinkage)

One of the more disappointing aspects of vaginal mesh was the fact that it sometimes failed, especially in the anterior compartment. The anterior mesh kits such as the AMS Perigee did not have secure anterior anchoring points and bunched up (Fig. 9.9). Mesh contraction can be associated

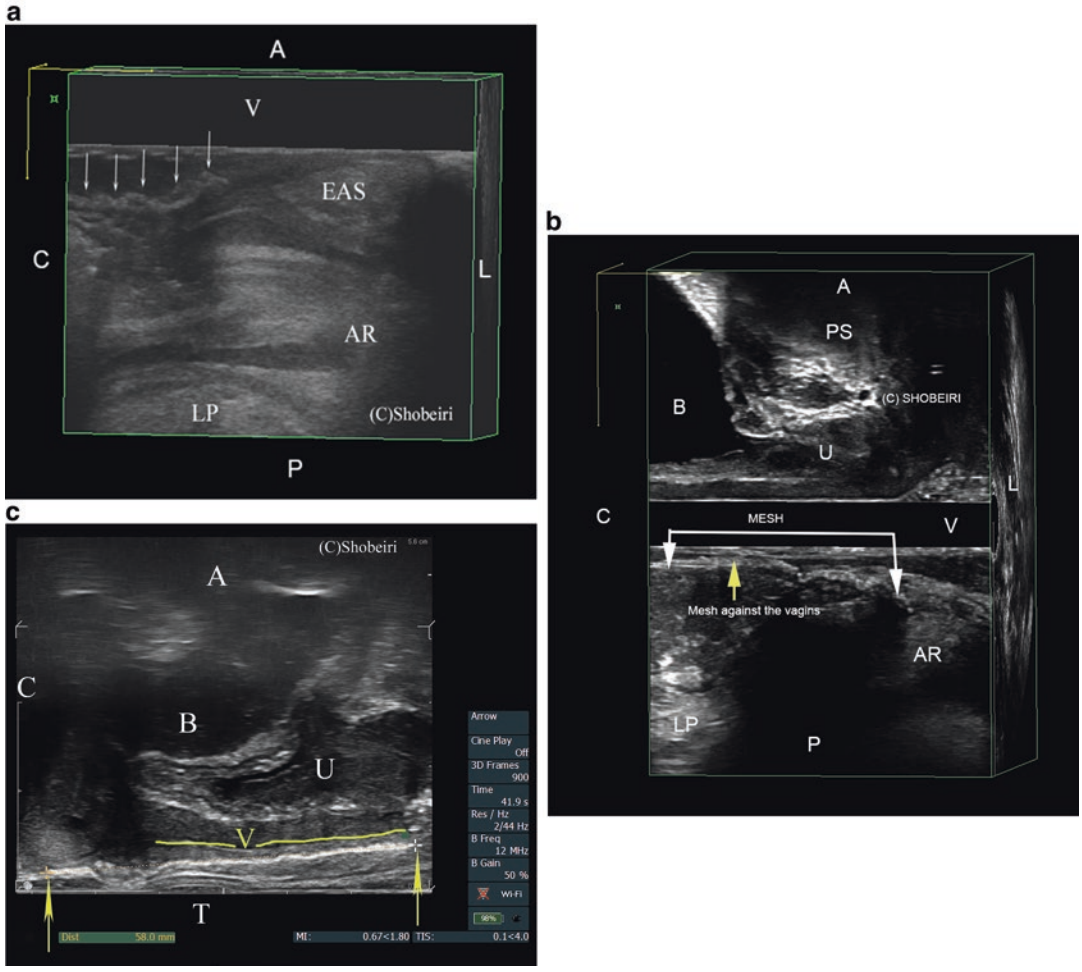

Fig. 9.6 (**a**) 3D endovaginal ultrasound image (posterior compartment) in sagittal plane showing the posterior vaginal wall mesh (*white arrows*). Vagina (V), anorectum (AR), external anal sphincter (EAS), levator plate (LP); anterior (A), posterior (P), cephalad (C), left (L). (**b**) 3D endovaginal ultrasound image in midsagittal plane showing the posterior vaginal wall mesh prominence (*white arrows*). Vagina (V), anorectum (AR), levator plate (LP), anterior (A), posterior (P), cephalad (C), left (L), urethra (U). (**c**) 3D endoanal ultrasound image in midsagittal plane showing the posterior vaginal wall mesh in full length (*yellow arrows* point to the 58 mm cursors) past the apex of the vagina (V) (*yellow line*). Transducer (T) in anorectum, anterior (A), bladder (B), cephalad (C), urethra (U)

with the development of focally painful segments of hardened mesh. This phenomenon likely underlies the development of primary vaginal pain syndromes and dyspareunia following vaginal mesh use. Pain can usually be reproduced by palpation of the contracted mesh segment, typically along the apical mesh arms. Collagen deposition and contraction within the mesh pores may be responsible for mesh hardening and nerve fiber entrapment; another cause of this finding is over tensioning of the mesh arms during implantation. The main clinical features include severe vaginal pain with movement, dyspareunia, and focal tenderness over contracted portions of the mesh on vaginal examination. Exact etiology of shrinkage of synthetic mesh after implantation is most likely inflammation and tissue ingrowth, but different theories have been suggested. Graft shrinkage could be due to physical consequence of the inflammatory response to the mesh or result of inadequate tissue ingrowth into the mesh. There is growing evidence to suggest that

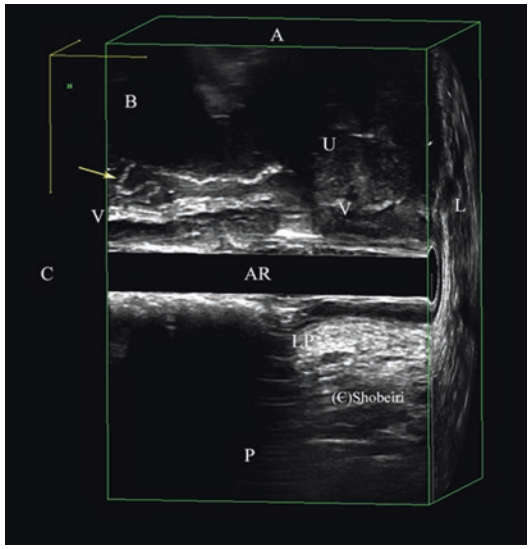

Fig. 9.7 360° 3D endoanal ultrasound image in sagittal plane showing the folding anterior vaginal wall mesh (*yellow arrow*). Bladder (V), urethra (U), vagina (V), anorectum (AR), levator plate (LP), anterior (A), posterior (P), cephalad (C), left (L)

synthetic mesh shrinks significantly once incorporated in the biological tissues.

There has been controversy as to whether or not mesh shrinkage and folding are continuous processes or are limited to the immediate post-operative period [4, 6, 33, 34]. The current consensus is that mesh folding and shrinkage are associated with complications and pain [9]. Based on this assumption, it has been proposed that together with investing in the development of new materials, the focus should also be on improving surgical technique and quality control in order to allow the mesh to be implanted flat and well spread out, anchored to underlying tissues, thus preventing immediate post-operative folding [9] but making the mesh flat requires tensioning it which in turn does not allow room for shrinkage of mesh. Ultrasound imaging is used to evaluate the appearance of polypropylene meshes on the significance of mesh shrinkage and folding. Moreover, 3D-EVUS can also be helpful in mapping meshes placed in multiple compartments when physical examination cannot exactly locate the existence of contraction. 3D-EVUS also nicely demonstrates the mesh arms to the sacrospinous ligaments. An arm under tension may be harder to see as it ropes (see Fig. 9.8d, e).

Mesh Extrusion

One of the more recognized complications related to vaginally placed mesh is mesh extrusion. Mesh extrusion is considered to be mesh visualized through the vaginal epithelium. Although standardized terminology now exists to describe complications such as mesh erosion or extrusion [35], the variability of the use of the term in the literature makes it difficult to identify exact exposure rates.

Mesh extrusion rates vary from 0 to 25% in different studies [36, 37]. A Cochrane review by Maher et al. [18] suggested that use of vaginal mesh was associated with an 11.4% rate of mesh extrusion and a 6.8% rate of surgical re-intervention. A non-significant increase in rates of vaginal mesh exposure and reoperation for vaginal mesh exposure after vaginal mesh surgery in comparison to laparoscopic sacrocolpopexy has also been recognized (13 vs 2%, $P = 0.07$ and 9 vs 2%, $P = 0.11$, respectively) [38]. Symptoms associated with mesh extrusion are not insignificant; they include pelvic pain, infection, de novo dyspareunia (painful sex for patient or partner), de novo vaginal bleeding, atypical vaginal discharge, and the need for additional corrective surgeries [22].

A number of risk factors for mesh extrusion have been identified. Patient factors such as smoking status and vaginal atrophy can affect both the tissue integrity and surgical site healing, making exposure in these individuals more likely [39, 40]. Some studies have recognized older age as a risk factor for exposure, but it is unclear if this association is due strictly to age or to the more advanced vaginal atrophy often seen in older women, especially since a number of studies have not found a difference in extrusion rates between younger and older women [41].

It was recognized early on in the adoption of vaginal meshes that factors related to the mesh itself were capable of increasing the risk of mesh exposure. The majority of studies evaluate the effect of mesh type on extrusion; however, it is reasonable to extrapolate from the effects to their use in prolapse mesh kits. These factors are primarily related to pore size and mesh materials. Polypropylene meshes with large pore size (type 4

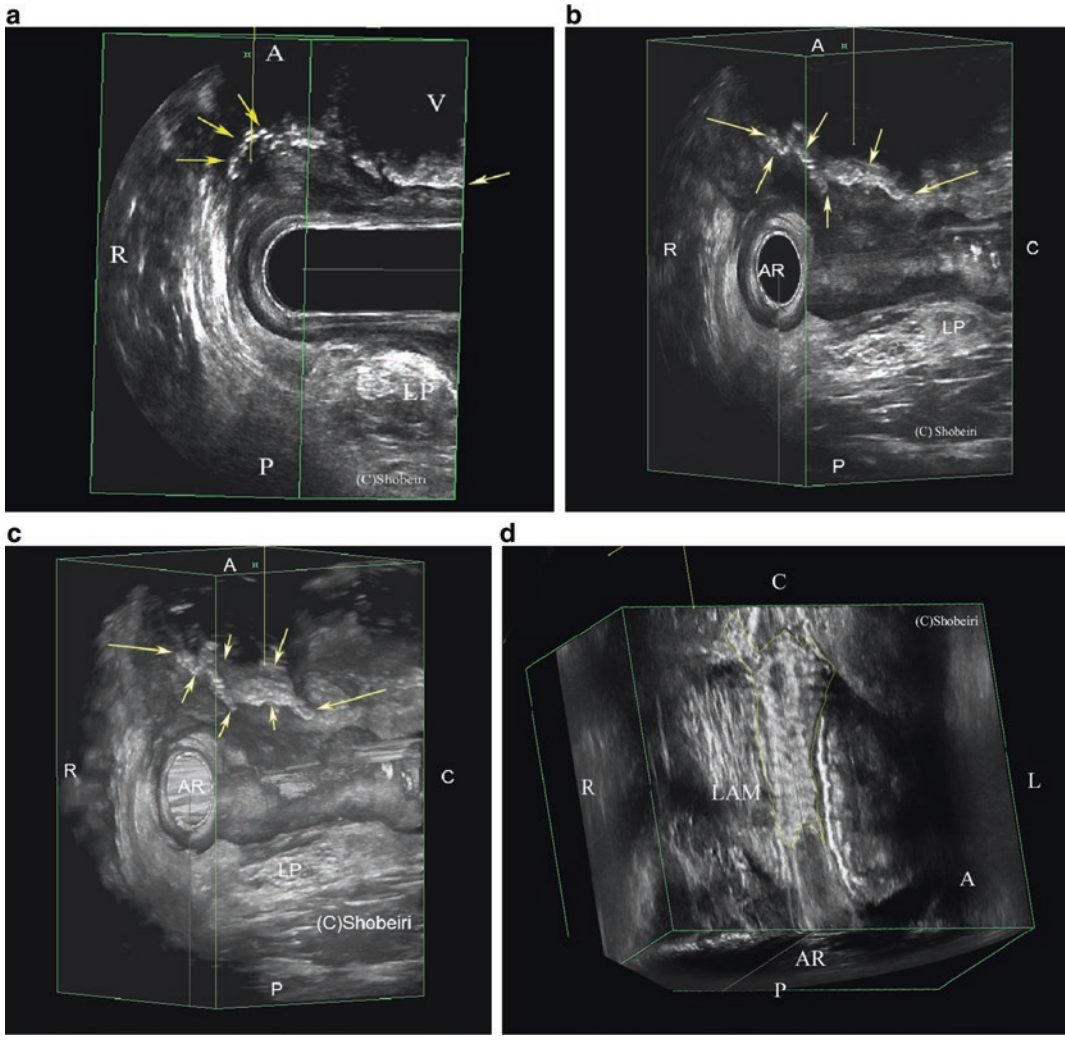

Fig. 9.8 (**a**) 360° 3D endoanal ultrasound image in midsagittal plane showing the posterior vaginal wall mesh (*yellow arrows*) at perineum. Vagina (V), levator plate (LP), anterior (A), posterior (P), right (R). (**b**) 360° 3D endoanal ultrasound image in left parasagittal plane showing the posterior vaginal wall mesh (*yellow arrows*) with anterior extrusion. Levator plate (LP), anterior (A), posterior (P), right (R), cephalad (C), anterior (A). (**c**) 360° 3D endoanal ultrasound rendered image in left parasagittal plane showing the posterior vaginal wall mesh (*yellow arrows*) with anterior extrusion. The mesh is enhanced in the rendered post-processing. Levator plate (LP), anterior (A), posterior (P), right (R), cephalad (C). (**d**) Unprocessed view of a 3D endovaginal ultrasound volume cut in coronal plane showing the posterior vaginal wall mesh (*outlined* is the pathognomonic mesh lattice). In this view the vagina cannot be seen, as the image is looking posteriorly from inside the vagina. Anorectum (AR), levator ani muscle (levator M), anterior (A), cephalad (C), left (L), posterior (P), right (R). (**e**) Post-processed rendered view of a 3D endovaginal ultrasound volume cut in coronal plane showing the posterior vaginal wall mesh (*outlined* is the pathognomonic mesh lattice), the arrows point to the left mesh arm. In this view the vagina cannot be seen, as the image is looking posteriorly from inside the vagina. Note that the posterior mesh generally pulls away from the anal sphincter complex. Here a *line* is drawn to denote where the detached mesh is shrunken and coiled compared to the more superior aspect of the mesh. Anorectum (A), puborectalis (PR), iliococcygeus (IC), ischiorectal fat (IRF), cephalad (C), left (L), posterior (P), right (R). (**f**) 360° 3D endovaginal ultrasound volume midsagittal plane showing the left side of pelvis with anterior and posterior vaginal wall mesh. In this view the mesh in the anterior vagina is 1 mm and the posterior mesh is 2 mm (*large arrows*) from the vaginal epithelium. Vagina (V), anorectum (AR), anterior (A), cephalad (C), left (L), posterior (P), urethra (U), bladder (B). (**g**) 360° 3D endovaginal ultrasound volume midsagittal plane showing the left side of pelvis with posterior sacrocolpoperineopexy mesh (SCP) and a sling (S). In this view the SCP mesh is deeper than what is typically seen with vaginal mesh. Note that both the SCP and the sling mesh create acoustic shadowing the obscures underlying structures. Transducer (T), sling (S), bladder (B), anorectum (AR), anterior (A), cephalad (C), left (L), posterior (P). (**h**) 360° 3D endovaginal ultrasound volume midsagittal plane showing the bladder with an implanted mesh (*arrows*) and a growth at the trigone (*denoted with* Ca). The growth proved to be a neoplasm. Transducer (T), bladder (B), anterior (A), cephalad (C), bladder (B), urethra (U)

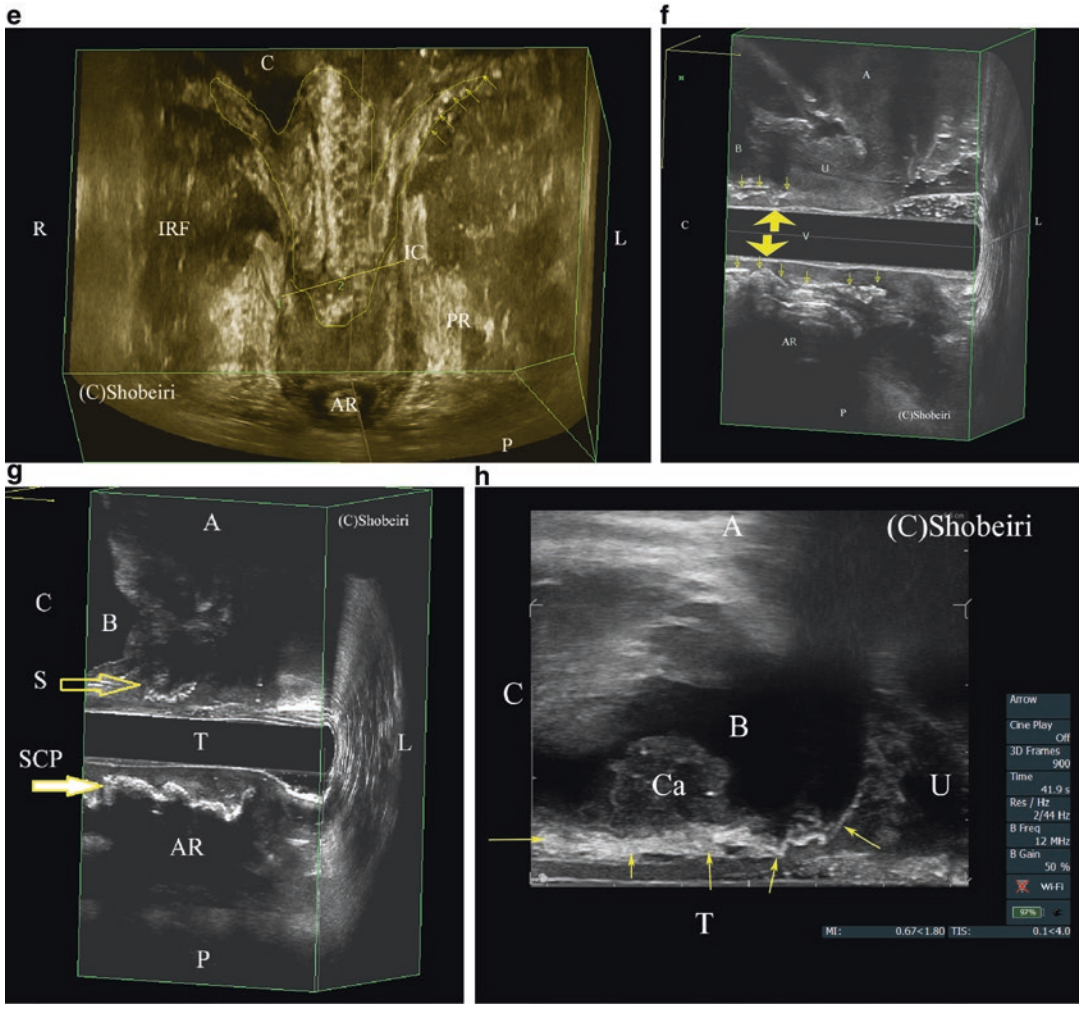

Fig. 9.8 (continued)

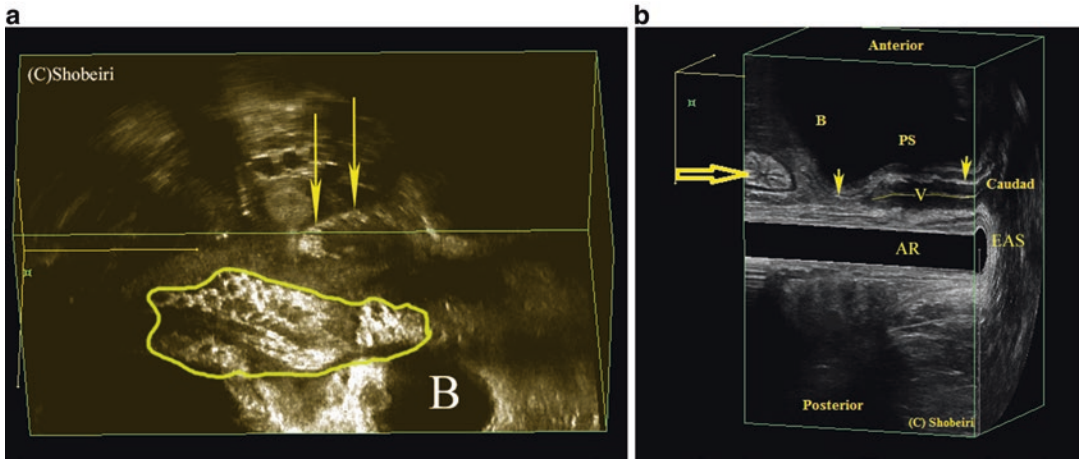

Fig. 9.9 (**a**) 360° 3D endovaginal ultrasound rendered image showing the apical shrunken mesh and one arm of the mesh. Bladder (B). (**b**) 360° 3D endoanal ultrasound midsagittal image showing an anterior mesh that is flat (*two yellow arrows*). The patient has an apical symptomatic enterocele (*hollow arrow*). The physical exam is not significant. An apical sacrocolpopexy relieved patient of her symptoms. Bladder (B), transducer in anorectum (AR), pubic symphysis (PS), vagina (V), external anal sphincter (EAS)

meshes) are associated with a lower exposure rate than many of their predecessors, which were designed to be tightly woven or nonporous. Another risk factor for mesh exposure that is now recognized is the depth of the vaginal dissection prior to mesh placement. As evidenced by the recognized risk factors for mesh exposure, prevention of exposure is the optimal "management" strategy for these (and other) complications. Preventative measures include avoiding the above-mentioned risk factors wherever possible, such as the use of lighter-weight polypropylene materials with larger pore sizes, use of transverse vaginal incisions for vaginal dissection (rather than vertical or t-shaped vaginal incisions), avoidance of folding the mesh, appropriate thickness of dissection, and deferring mesh placement to a time remote from hysterectomy. That said, there are no long-term studies showing how long mesh extrusion can be prevented given the fact that it is implanted in the vesicovaginal or rectovaginal tissue that has an average thickness of 5 mm. Endovaginal ultrasound imaging has the added benefit of placing the probe adjacent to the area of interest. Ultrasound is the only imaging modality that can visualize mesh easily. It has higher sensitivity for detection of mesh presence when physical examination fails to visualize or palpate the mesh in the vaginal canal. The mesh implanted via sacrocolpoperineopexy looks different, as it is deep and anterior to the rectum (Fig. 9.8f, g).

Urinary Tract or Lower Gastrointestinal Tract Compromise or Perforation

Urinary tract and gastrointestinal tract complications after vaginal mesh surgery are less common than after surgery for the anti-incontinence sling [42]. The violation of the genitourinary system or the gastrointestinal tract by mesh is called erosion. Mesh complications involving the bladder and rectum represent the minority of cases reported [43–46]. Recently, there was increased interest regarding the association between the polypropylene mesh/slings and bladder cancer. Ostergard and Azadi suggested that since oncogenesis is related to the presence of a foreign body that causes the chronic inflammatory reaction, implantation of the polypropylene mesh may cause carcinogenesis many years later [47]. The possibility of such association has been raised and needs further surveillance. However, based on current evidence, the risk of carcinogenesis related to polypropylene mesh is low [48–50]. Regardless, if a foci of cancer that needs to be resected or removed is close to the underlying mesh, the intervention may be complicated. 3D-EVUS can easily demonstrate uroepithelial masses on the trigonal area (see Fig. 9.8h).

In patients with a history of TVM for POP repair or slings for SUI, vaginal, urinary or bowel problems should be carefully investigated [51]. A detailed clinical history-taking and thorough physical examination are essential. Symptoms of abnormal vaginal discharge or bleeding, dyspareunia, pelvic or groin pain, urinary tract infections, voiding dysfunction, urinary incontinence, as well as vaginal bulge and bowel complaints should be documented. Information regarding previous pelvic surgeries, type of mesh used, complications, and treatments is crucial. A careful and gentle pelvic examination is necessary to assess mesh exposure in the relevant compartments, taking account of scar tissue, prolapse, vaginal discharge/bleeding, and areas of tenderness or discomfort. Valsalva maneuver should be performed to investigate prolapse recurrence and SUI. Ultrasound imaging is useful to identify the location of mesh or sling in patients with complications. 3D EVUS of the anterior pelvic compartment shows polypropylene mesh eroding into the bladder in Fig. 9.10.

Musculoskeletal: Pain, Lump, Decreased Elasticity, and Sinus Formation

Pelvic pain, including dyspareunia, is a widely acknowledged complication of mesh exposure. The incidence of mesh-related pelvic pain is as high as 30%. Pelvic pain may be groin pain related to the passage of the mesh arms through muscle tissue, ligament, or nerve entrapment. In some

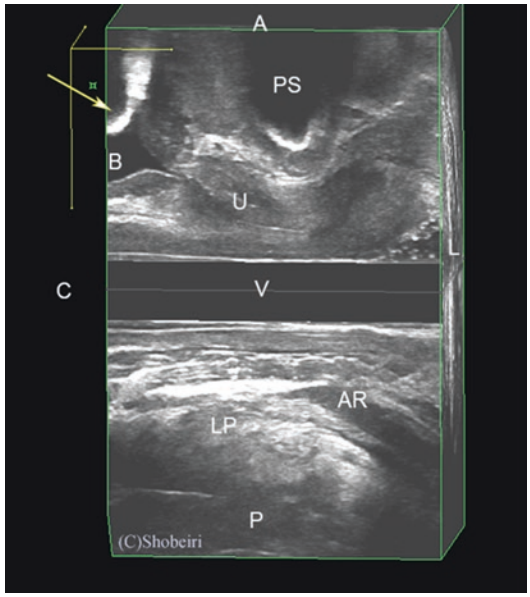

Fig. 9.10 360° 3D endovaginal ultrasound image in sagittal plane showing the sling mesh (*yellow arrow*) in the bladder (B). Vagina (V), pubic symphysis (P), external anal sphincter (EAS), anorectum (AR), levator plate (LP), anterior (A), posterior (P), cephalad (C), left (L)

cases mesh designed to be anchored in the sacrospinous ligament can lead to pudendal and sciatic neuropathies, while mesh passing through the obturator space can cause obturator neuropathies. In our practice, we have seen many patients with pain originating after a mesh procedure develop pelvic floor myalgias, which in turn cause pelvic pain and dyspareunia. A focally painful segment of hardened mesh due to shrinkage of the vaginal mesh implant may lead to primary vaginal pain syndromes and dyspareunia following vaginal mesh use. A recent case series reported high incidence of pain along contracted mesh sites. Severe vaginal pain and focal tenderness are reported, which can be confirmed by palpation of the mesh segment [52]. To do so, a long cotton swab is introduced in front of the ultrasound probe and the area is probed under ultrasound visualization. It is best to touch the area away from the area of pain in a random fashion and subsequently touch the mesh (Fig. 9.11). In a patient with pudendal neuralgia, all the nerve branch territory is painful. Pressing on the ischial spine may reproduce pain, and because of nerve entrapment and scarring the patient may have constant rather than positional pain. Removal of the mesh arms needs to be done via a transgluteal approach, which requires expertise and specialized training. The sacrotuberous ligament is divided or cut to access the pudendal nerve, and then the nerve itself is freed up by removing the underlying sacrospinous ligament. In the presence of mesh and scar tissue it is almost impossible to remove the mesh arms; even if mesh removal is achieved, the pudendal pain will persist (Fig. 9.12).

The main clinical features of mesh pain can include groin pain, suprapubic pain, dyspareunia, vaginal tightness, severe vaginal pain with movement, and vaginal shortening on vaginal examination. Over-tensioning of the mesh arms during implantation and collagen deposition and contraction within the mesh pores may lead to further mesh hardening and nerve fiber entrapment. It is always necessary to characterize pain symptoms related to mesh complications vs. chronic pain syndromes or myalgias. The worst cases are patients with chronic pain whose pain is exacerbated due to new mesh pain. Pelvic sonography has the fundamental role in the evaluation of pelvic pain. Transvaginal sonography (TVS) and endovaginal sonography (EVS) with higher resolution of anatomic detail are always the first option in patients with history of mesh placement who can tolerate vaginal insertion, especially in the cases that involve patients that have had polypropylene mesh inserted into their vaginal wall to treat SUI or POP.

In an abstract presented at 2016 American Urogynecologic Society meeting [53] comparing mesh length between posterior and anterior compartments, the posterior meshes were significantly longer than anterior (42.1 mm ± 11.9 vs. 25.8 mm ± 9, $p < 0.0001$) and more often associated with pain. In the posterior compartment, the mean mesh length seen on ultrasound was significantly longer in women with pain than women without pain (46.5 ± 9 mm vs. 31.8 ± 12.1 mm, $P = 0.0001$). There was also a higher proportion of a "flat" mesh pattern 14/25 (58.3%) in the posterior compartment associated with the presence of pain ($P = 0.013$). In the posterior compartment, a smaller distance between the distal edge of the mesh and the anal sphincter was significantly associated with the presence of pain (8 mm (0, 37) vs. 21 mm (8, 35)), ($P = 0.024$).

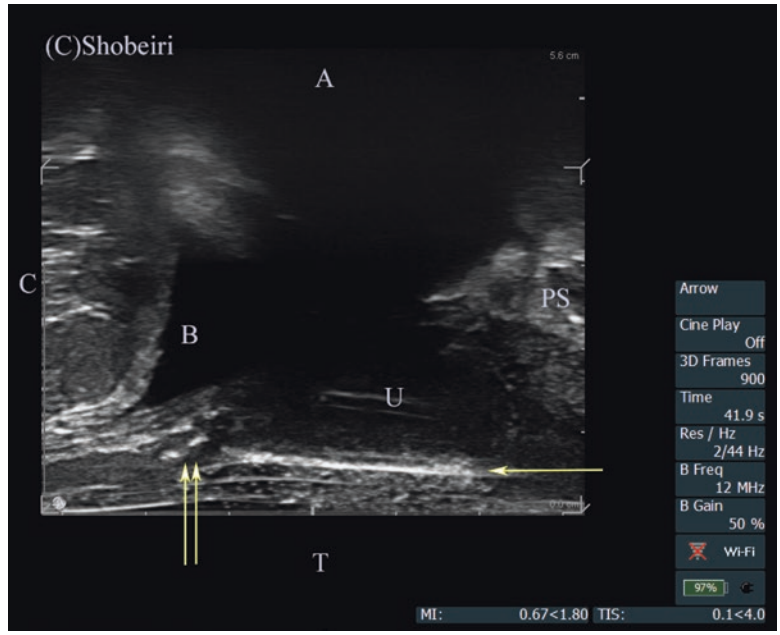

Fig. 9.11 360° 3D endovaginal ultrasound image in sagittal plane showing the sling mesh remnant (*double yellow arrow*) under the bladder (B) being touched with a long cotton swab (*single arrow*) for sensitivity testing with ultrasound guidance. Transducer (T) in vagina, pubic symphysis (PS), anterior (A), cephalad (C), urethra (U)

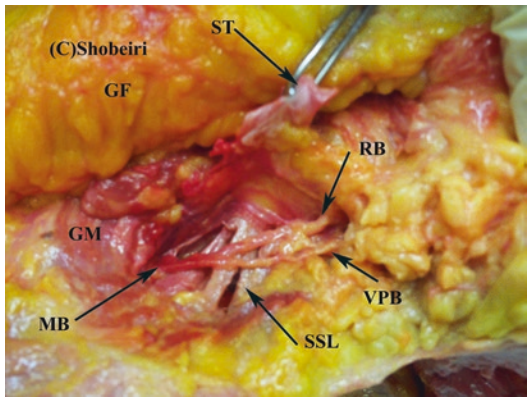

Fig. 9.12 Cadaveric dissection demonstrating the course of the pudendal nerve in relation to the sacrospinous ligament. The pudendal nerve through a space in between the sacrospinous (SSL) and sacrotuberous (ST) ligaments. Here the ST is cut and lifted with an Allis clamp. To get to this space via a posterior approach the skin is cut, the gluteal fat (GF) is traversed, the glutinous maximus (GM) fascia and fibers are divided, and the ST is located, divided, or cut. The main body of the pudendal nerve (MB) divides and forms the rectal branch (RB) and the vaginoperineal branch (VPB). The RB-VPB division is variable even from one side to the other side of the same patient. Depending on the placement of trocar and mesh, the patient's presentation can be variable

In the anterior compartment, there was no significant association between ultrasound appearance of the mesh and the presence of pain. However, there was a higher number of mesh erosions (6/26) in the anterior compartment, most of which had an abnormal pattern on ultrasound (three had a folding pattern and one was convoluted). In both compartments the ultrasound had a 100% sensitivity for detection of mesh erosions. In this population of patients presenting with mesh complications, the posterior meshes were more often visualized as a "flat" pattern with a higher frequency of pain. Mesh complications of the anterior compartment had a higher frequency of folding and shrinkage (Table 9.1).

Table 9.1 Pain in a population of patients presenting with mesh complications—posterior vs. anterior compartments (from Shobeiri et al. [53], with permission)

	Patients with pain *n* (%)	Patients without pain *n* (%)	*P* value
Posterior	(*n* = 25)	(*n* = 10)	
Folding	6 (24)	8 (80)	0.002
Prominence	4 (16.6)	0	0.23
Flat	14 (58.3)	1 (10)	0.013
Convoluted	0	1 (10)	0.42
Anterior	(*n* = 17)	(*n* = 9)	
Folding	7 (41.1)	6 (66.6)	0.45
Prominence	2 (11.7)	0	0.23
Flat	7 (41.1)	2 (22)	0.34
Convoluted	1 (5.6)	1 (11)	0.72

Conclusion

Ultrasound imaging techniques are ideal for the depiction of polypropylene mesh used for POP repair. Ultrasound imaging is necessary to determine the location and function of vaginal mesh in patients with postoperative problems, which may help assess the likelihood of success for surgery. Moreover, mesh complications related to adjacent tissue or organs can be identified using imaging; thus, the proper plan for effective interventions can be designed.

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