

Imaging of slings and meshes

Abstract

The popularity of imaging in pelvic floor medicine continues to increase. Among the various modalities, ultrasound is superior as it is cheap, safe, easily accessible and simple, resulting in high patient compliance. It is the only technique that allows imaging of modern wide-weave polypropylene sling or mesh implants, and imaging of such implants is commonly required due to the popularity of surgical techniques that involve the placement of slings and meshes. This review article will discuss the role of translabial ultrasound in the evaluation of synthetic implants used in the treatment of urinary incontinence and pelvic organ prolapse.

Keywords: mesh, prolapse, suburethral sling, urinary incontinence, ultrasound.

Introduction

Approximately one third of prolapse procedures are performed for recurrence¹ after pelvic reconstructive surgery. Hence, there is a continuing search for improved surgical techniques. Among the different forms of pelvic organ prolapse, prolapse of the anterior compartment is particularly challenging to surgeons, with a reported failure rate after traditional anterior colporrhaphy of up to 63%.²⁻⁵ While vaginal mesh implants have been used for decades to augment prolapse repairs in an attempt to reduce recurrence rates, they became popular due to the introduction of commercial mesh kits that allowed for effective anchoring of implants, improving their load-bearing capabilities. Following the worldwide success of midurethral slings introduced in the early 1990s,⁶ wide-weave polypropylene slings have become the gold standard in the surgical treatment of stress urinary incontinence. The introduction of transobturator midurethral slings triggered the development of anterior vaginal wall meshes anchored via the transobturator route (Anterior Prolift™ Ethicon, Somerville, NJ, USA and Perigee™ American Medical Systems, Minnetonka, MN, USA) in 2003–2004. At the same time, posterior meshes anchored through the ischioanal fossa were introduced (Posterior Prolift™ Ethicon, Somerville, NJ, USA and Apogee™ American Medical Systems, Minnetonka, MN, USA). These innovations were rapidly adopted by pelvic surgeons, resulting in a surge in vaginal mesh procedures from 8.1% in 2005 to 22.8% in 2010, constituting 75% of prolapse procedures using mesh in USA.⁷ While current data do not support the use of vaginal mesh in the posterior compartment, anterior mesh repair has been shown to be associated with improved anatomical outcomes as compared to native tissue repair.^{4,8-12}

Following the marked rise in the use of suburethral slings and vaginal mesh procedures,

surgeons have been witnessing a dramatic increase in mesh/sling related complications.^{13,14} Some of these are challenging to manage and serious.¹⁵⁻¹⁸ This is particularly an issue with transvaginal mesh, leading to a heated debate in regards to mesh use. Recurrent symptoms after mesh/sling implant surgery pose another set of novel problems that may baffle clinicians and cause substantial management problems.

In this review the authors will focus on those applications of pelvic floor ultrasound that are useful for surgeons dealing with patients after modern mesh/sling placement and for those contemplating the use of these synthetic implants. Posterior compartment meshes and biological meshes will not be considered in this review as there is currently no evidence supporting their use.

Methods

Among the various imaging techniques, pelvic floor assessment is best performed by transperineal or translabial ultrasound. The technique is cheap, safe with no irradiation, easy to perform with high patient compliance, and the necessary equipment is commonly available. Ultrasound also allows dynamic imaging of the pelvic floor providing information in real time at 30Hz or higher¹⁹ which is particularly useful in assessing the functional anatomy of the pelvic floor. Even with four-dimensional (4D) imaging systems originally developed for foetal assessment, temporal resolution is higher than single-plane dynamic MRI. The superiority of ultrasound is particularly obvious when it comes to imaging modern synthetic implants as modern wide-weave polypropylene mesh and sling implants are highly echogenic in the anterior vaginal wall on ultrasound but not visible on x-ray, CT or MRI. As a result vaginal and translabial ultrasound have been used to assess slings and meshes for over a decade.

Basic requirements for pelvic floor assessment

Ka Lai Shek¹
PhD

Hans Peter Dietz²
MD PhD

¹Liverpool Hospital
University of Western
Sydney
Liverpool
New South Wales
Australia

²Nepean Clinical School
University of Sydney
Sydney
New South Wales
Australia

Correspondence to email
shekkaikai@yahoo.com.hk

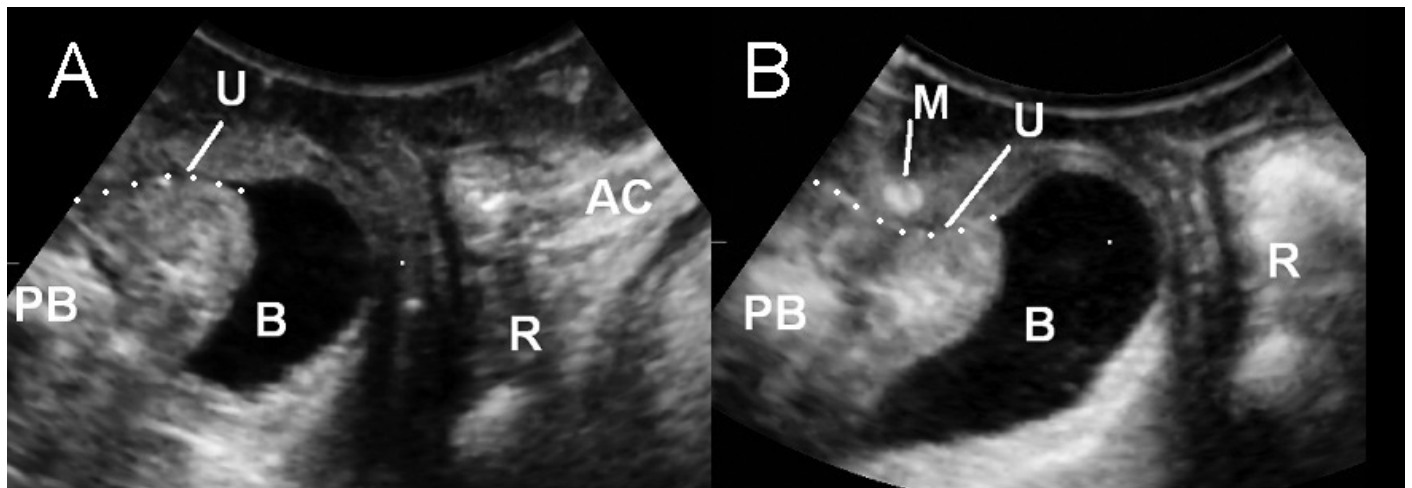


Figure 1: Ultrasound in midsagittal plane before (A) and after (B) a Monarc sling placement in a patient cured of stress urinary incontinence. PB, pubic bone. B, bladder. U, urethra. R, rectum. AC, anal canal. M, Monarc sling.

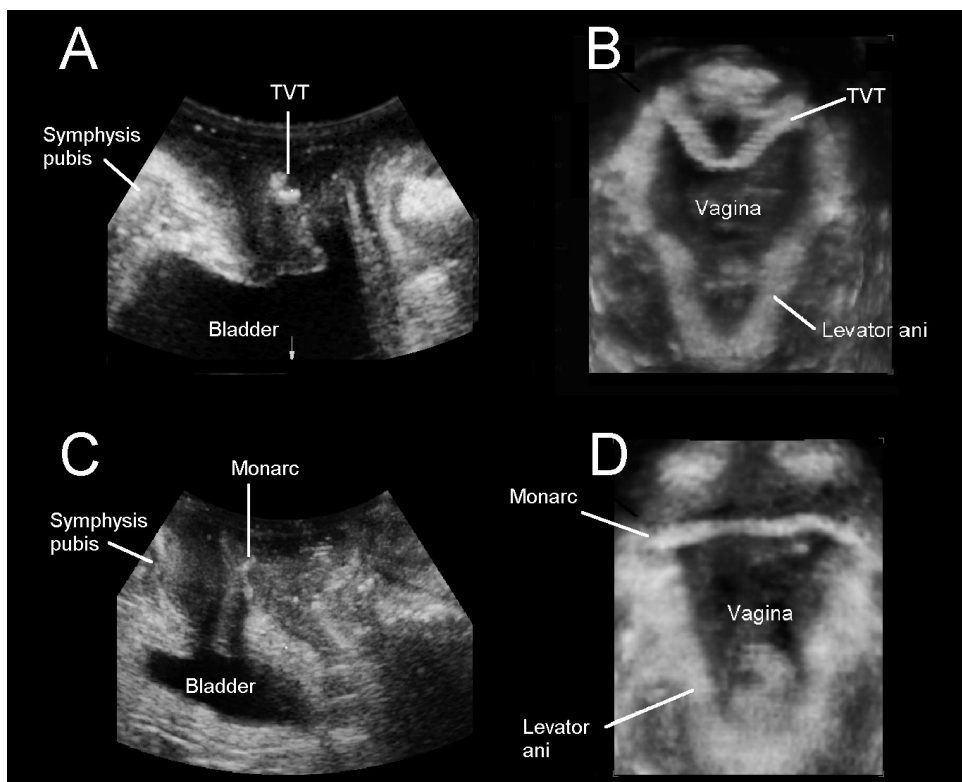


Figure 2: Axial plane showing a retropubic sling curving ventrally toward pubic symphysis (B) and a transobturator sling tracking laterally towards the insertion of the puborectalis muscle and obturator foramen (D). Reproduced with permission from reference 19.

include a B mode capable 2D ultrasound system with cine loop function, a 3.5–6 MHz curved array transducer and a video-printer. A 4D system also allows imaging in the axial plane which is useful for assessing the integrity of the puborectalis muscle as well as the levator hiatal area. This capability is particularly useful when considering the use of synthetic mesh as it allows the identification of patients at high risk of prolapse recurrence after surgery. Modern 4D ultrasound systems designed for prenatal diagnosis are well suited for pelvic floor assessment. A 70–90° aperture with an acquisition angle of at least 70° allows visualisation of the entire levator hiatus in real time with little transducer manipulation. The method of imaging has been described in details in a review article of this bulletin and updated in two recent review articles.^{19–21} For mesh or sling implants, imaging is best performed on Valsalva manoeuvre when they are best seen to rotate around the fulcrum

of the pubic bone at the anterior vaginal wall.

Imaging of suburethral slings

Translabial or perineal ultrasound has contributed significantly to the evaluation and investigation of suburethral slings. On ultrasound the modern wide-weave polypropylene slings appear as an echogenic structure dorsal to the urethra. Depending on the degree of tension it may appear as a straight line, curved line or it may be c-shaped in appearance. Its therapeutic effect -dynamic urethral compression against the posterior surface of the symphysis pubis at times of increased intra-abdominal pressure- is easily observed on real time ultrasound²² (Figure 1). Studies on urethral mobility using ultrasound have suggested that its mechanism of action, i.e. compression on the midurethra, is more physiological than Burch colposuspension, the previous gold standard anti-

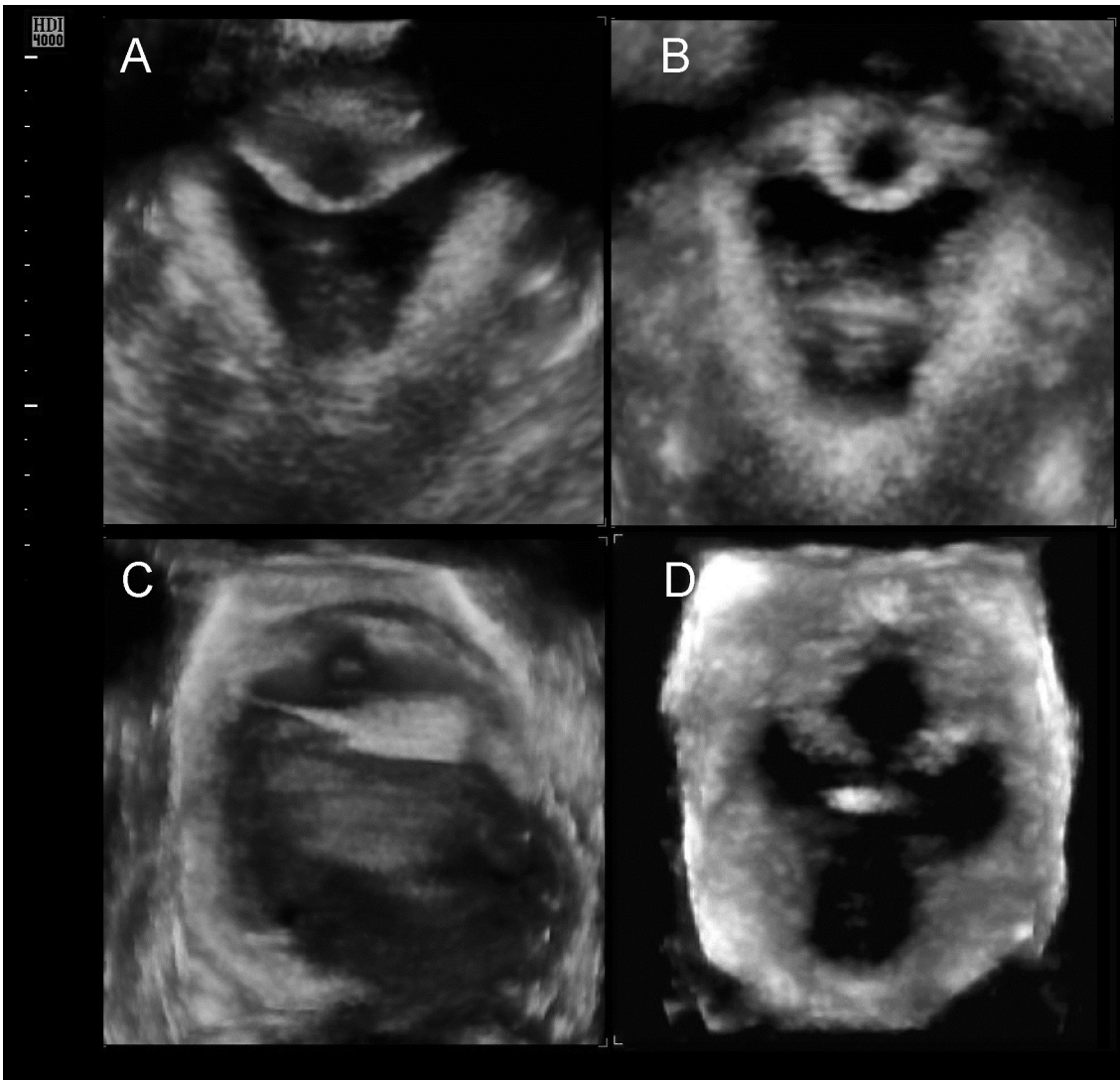


Figure 3: Variations in suburethral sling placement in the axial plane. (A) Usual appearance for a retropubic sling. (B) Appearance of a very tight retropubic sling. (C) A twisted sling and (D) appearances after sling division. Reproduced with permission from reference 26.

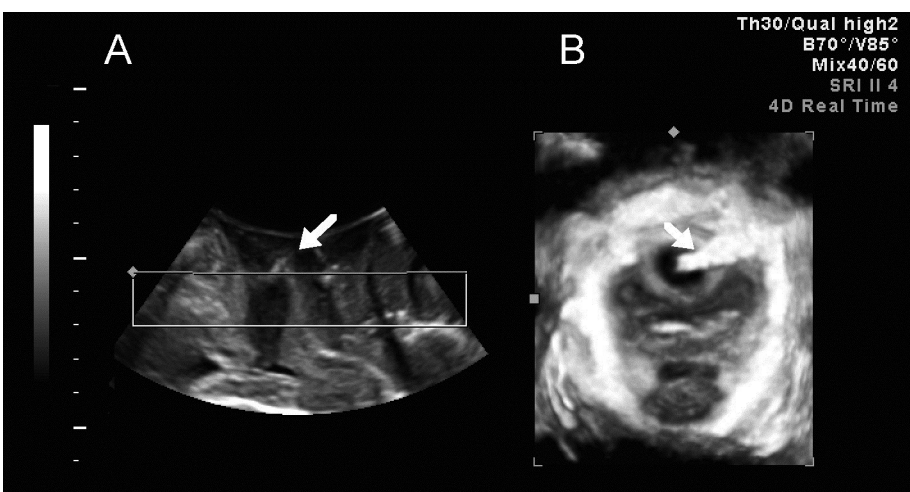


Figure 4: Urethral perforation of tension-free vaginal tape as imaged in the midsagittal plane with the implant (A) in an axial rendered volume (B) with the implant indicated by the arrow. Part of the sling had been removed elsewhere prior to this assessment in an attempt to alleviate voiding dysfunction. Reproduced with permission from reference 30.

incontinence procedure, which immobilises the bladder neck, creating a highly unphysiological appearance.^{23,24}

Ultrasound can confirm the presence of a suburethral sling or detect one in women who are unaware of the type of previous surgery; it may allow an educated guess of the type of sling²⁵ and can distinguish between transobturator and transretzius slings (Figure 2). Variations in placement such as asymmetry, position

along the longitudinal axis of the urethra, partial or complete perforation of the urethral rhabdosphincter and/ or longitudinal smooth muscle of the urethra ('tethering'), varying width, tape twisting and the effect of tape division can be visualised (Figure 3). Ultrasound has helped allay concern about sling contraction and shortening over time as those implants seem to remain inert over long periods of time.²⁷

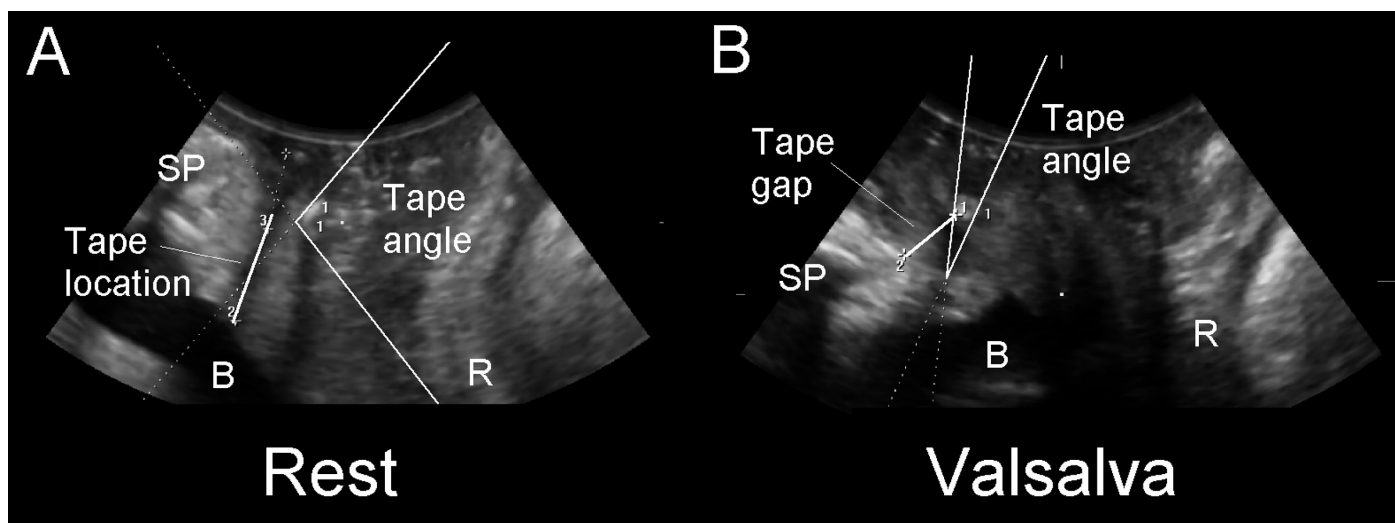


Figure 5: Ultrasound parameters of tape ‘tightness’. The sling pubis gap i.e. the shortest distance between the sling and posterior symphyseal margin on Valsalva seems to be the most useful. Reproduced with permission from reference 30.

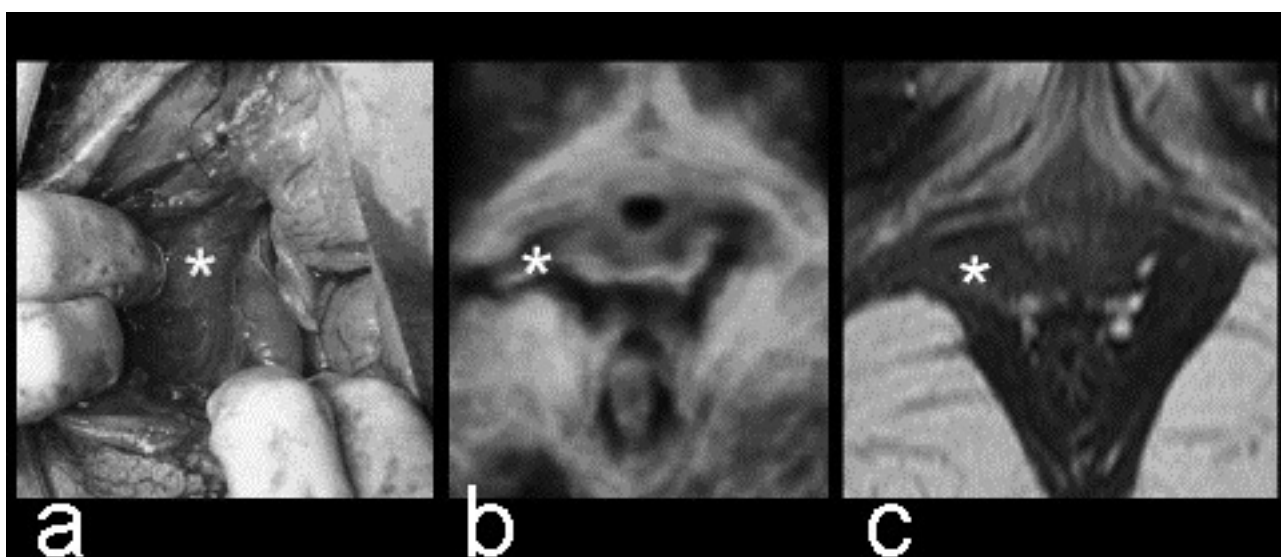


Figure 6: Right-sided levator avulsion (marked by *) as seen on exploration of large vaginal tear after normal vaginal delivery at term (a), as imaged on rendered ultrasound volume (b), and on magnetic resonance imaging (c). Reproduced with permission from reference 19.

While sling placement beneath the middle third of the urethra is considered important for efficacy,²⁸ ultrasound has shown remarkable variation in sling location along the urethra which does not seem to affect clinical success²⁹ unless slings are located under the bladder neck rather than adjacent the urethra. This seems to occur if incisions for sling placement are unusually large, or if a sling is inserted concomitantly with an anterior repair, utilising a single incision. In such instances the implant will tend to move too far cranially and may cause appearances reminiscent of the bladder neck deformation encountered after Burch colposuspension. However, with standard insertion technique one would expect the sling to be located between the 20th and 80th centile of urethral length. If this is the case, location relative to the rhabdosphincter may matter more, especially in the long run. Urethral perforation/erosion or near perforation/erosion are readily apparent on ultrasound (Figure 4), although the definitive diagnosis of full urethral perforation/erosion requires cysto-urethroscopy.

Ultrasound can assess the functional effect of a suburethral

sling on Valsalva manoeuvre. Assessment of sling ‘tightness’ can be quantified with the ‘tape angle’ i.e. the angle between the cranial and caudal aspects of the sling, or the ‘sling-pubis gap’ i.e. the shortest distance between sling and posterior surface of the pubis on Valsalva³¹ (Figure 5). The latter appears to be a more valid parameter of sling ‘tightness’. In a patient with worsened symptoms of bladder irritability or clinically significant voiding dysfunction after sling surgery, a tape that assumes a tight c-shaped appearance at rest and is close to the urethra with a sling-pubis gap of less than 7 mm makes functional obstruction highly likely and suggests that sling division may well be beneficial. On the other hand, in a patient with recurrent stress urinary incontinence after sling placement, a sling that remains straight in appearance on Valsalva and shows a wide sling pubis gap of 15 mm or more suggests inadequate tension or anchoring failure, implying that a repeat sling, preferably placed tighter than the first, could be an option. It should be acknowledged however that it is difficult to judge outcome by ultrasound appearances alone as other factors, e.g. urethral closure pressure may confound relationships between

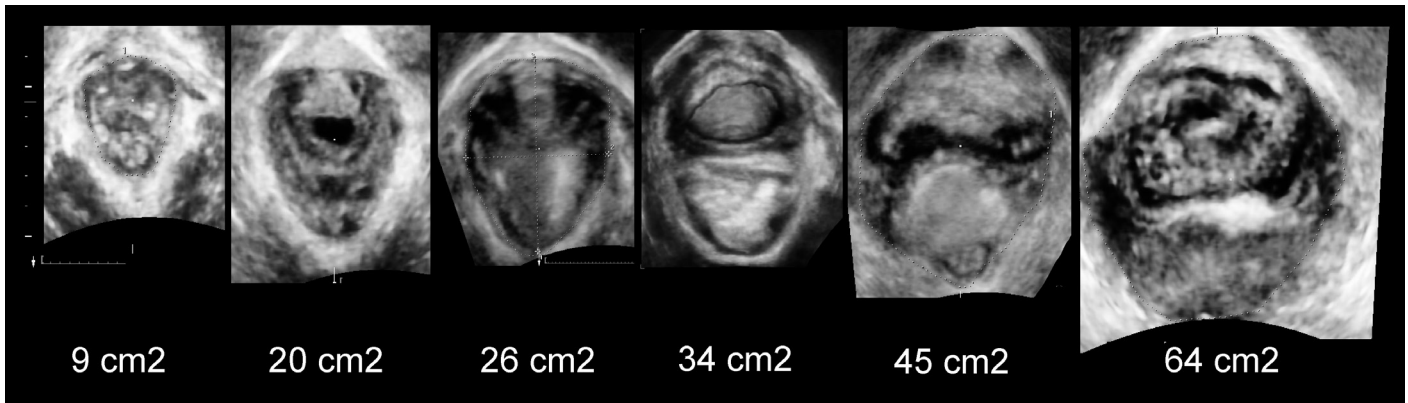


Figure 7: Ultrasound images in the axial plane showing different degrees of hiatal distensibility on maximum Valsalva maneuver. The limit of normality (mean plus 2 standard deviation⁵⁷ or as a predictor of symptoms of prolapse⁵⁸) is 25 cm². Reproduced with permission from reference 59.

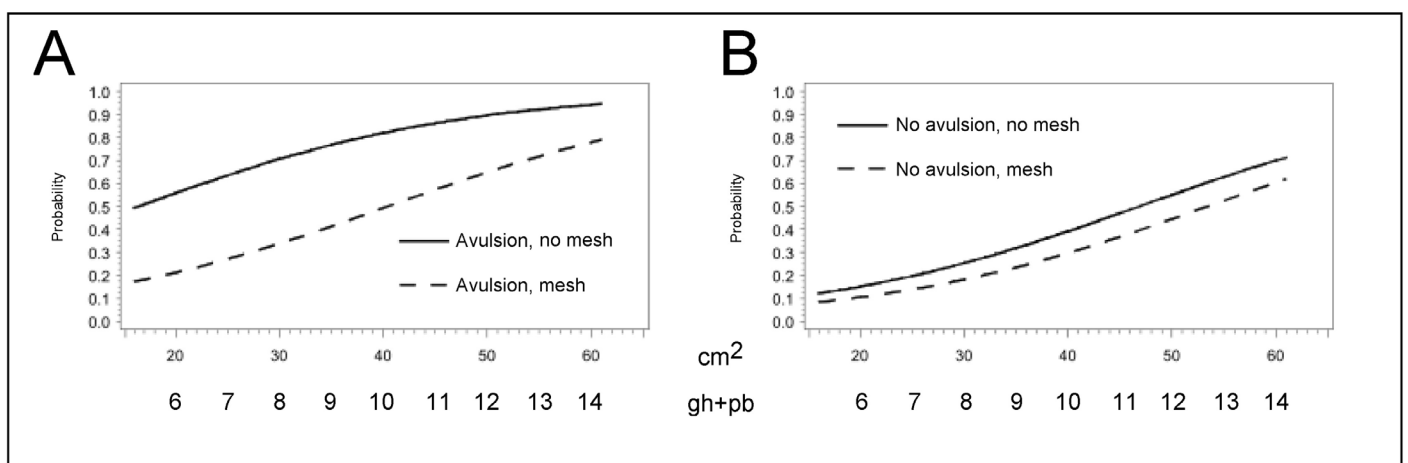


Figure 8: Probability of cystocele recurrence 2.5 years after anterior colporrhaphy in women with (A) and without (B) levator avulsion, relative to hiatal area and use of anterior transvaginal mesh (n=334). _____, no mesh; ---, with mesh. Reproduced with permission from reference 43.

ultrasound parameters and functional outcome.^{32,33} Furthermore a loosely placed sling may still be functional due to urethral kinking around the sling as a result of significant cystocele.

Despite the complexity of the issue, preoperative ultrasound is likely to help in predicting the likelihood of operative success. Urethral mobility has been shown to be associated with cure of stress urinary incontinence after suburethral slings³⁴⁻³⁶. In the authors' opinion women with a mild degree of urethral hypermobility, i.e. between 2.5 and 3.5 cm of bladder neck descent, are likely to do better than those with an immobile urethra. In the latter cases it is more difficult to get the tension of the suburethral sling right, providing dynamic compression while avoiding excessive obstruction leading to voiding difficulties or irritative bladder symptoms.

Imaging of anterior compartment mesh

While suburethral slings have been established as the gold standard in the surgical treatment for urodynamic stress incontinence, the use of transvaginal mesh in prolapse repairs is controversial. Since 2004 the growing popularity of vaginal mesh procedures has led to concerns about mesh safety and efficacy. In 2008 the Food and Drug Administration (FDA) issued a first warning concerning mesh use and in 2011, a second notification alerting clinicians to the potential complications associated with transvaginal mesh.^{14,37} There is an ongoing heated debate over mesh use.³⁸⁻⁴⁰ In the midst

of controversies pelvic reconstructive surgeons and patients are left to make clinical decisions. The main motivation for mesh use is the high probability of prolapse recurrence which is clearly reduced after mesh use, but recurrence still occurs in women after implant surgery. In a surgical audit of anterior compartment mesh surgery, 38% of patients were found to have recurrence, signifying that anchoring structures are not load resistant enough to provide pelvic organ support in some women. It is apparent that there is room to improve the design of mesh anchoring. On the other hand, the substantial minority of patients with prolapse recurrence after mesh use also provide new challenges to clinicians. Surgeons are confronted with novel anatomical situations and surgical problems.⁴¹

Better patient selection

There is no doubt that significant mesh complications do occur and can be a major problem for patients and caregivers alike, but transvaginal mesh repair has clearly been shown to be effective in reducing prolapse recurrence.^{4,8-10,12,42} The probability of recurrence after cystocele repair has been shown to vary markedly from 10 to 90% between individuals.⁴³ Hence, the balance between risks and benefits of transvaginal mesh repairs versus traditional surgery will differ from patient to patient. In some patients this balance will favour the use of mesh regardless of potential mesh related complications. This is most likely in women at high risk of prolapse recurrence after conventional

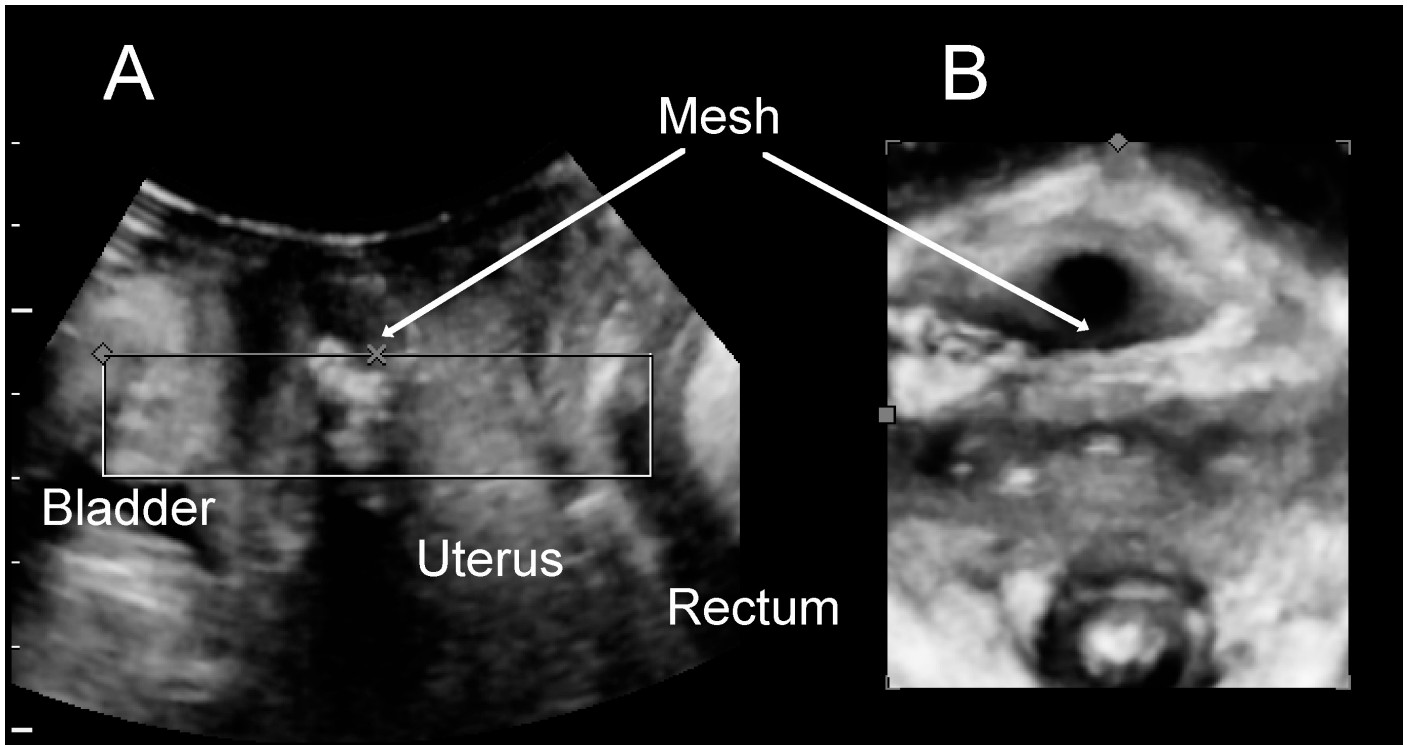


Figure 9: Appearance of a folded anterior transvaginal mesh in the midsagittal (left) and axial (right) plane. Reproduced with permission from reference 69.

surgery. It seems prudent therefore to assess individual recurrence risk whenever mesh implantation is contemplated.

A number of risk factors for prolapse recurrence after pelvic reconstructive surgery have been documented in the literature, including younger age,^{44,45} a family history of prolapse,⁴⁶ preoperative prolapse grading,^{44–47} poor pelvic floor muscle contractility,⁴⁸ previous hysterectomy, body mass index,⁴⁵ previous prolapse surgery, a larger genital hiatus⁴⁸ and sacrospinous fixation.⁴⁶ More recently levator avulsion^{3,12,46,49,50} and hiatal ballooning,⁴³ i.e. excessive distensibility of the levator hiatus, have been shown to be important risk factors for prolapse recurrence. Levator avulsion, a form of maternal birth injury where the most ventromedial aspect of the levator ani muscle is detached from the inferior ramus of the os pubis, has been reported in 10–35% of women after a first vaginal birth.^{51–53} It is associated with hiatal ballooning, reduced pelvic floor muscle contractility and increased muscle distensibility⁵⁴ and has been shown to be a predictor for anterior compartment recurrence with an odds ratio of around 2.5 to 3.0^{3,46} after anterior colporrhaphy. The impact of major levator defects has been confirmed on MRI. In a series of 83 women Morgan, *et al.* reported poorer anterior vaginal support in patients with major levator defects 6 weeks after primary surgery for prolapse.⁵⁵ The predictive effect of avulsion in prolapse recurrence applies even in women after placement of anterior compartment mesh. In a study on 209 patients at a mean of 2.2 years after Perigee or Anterior Prolift, 35% of women with avulsion were shown to have recurrent cystocele on ultrasound as compared to 19% of those in whom the levator was intact (odds ratio 2.24).⁵⁶ In a study on prolapse recurrence,⁴³ which included 334 patients at a mean follow-up of 2.5 years after cystocele repair, levator avulsion was associated with an odds ratio of 2.95 for recurrence, and hiatal area on Valsalva conveyed an additional 7% per cm² for risk of recurrence (Figure 6 and 7). This implies that the likelihood of recurrence may vary from 10 to 90% in a patient

with a given degree of cystocele, depending on the integrity of the levator ani muscle and hiatal area on Valsalva⁴⁴ (Figure 8). Both factors in combination may effectively identify patients in whom conventional surgery is likely to fail, and this effect seems to explain most other described predictors of recurrence such as younger age, enlarged genital hiatus and poor levator contractility. It is evident that imaging studies, especially modern 4D pelvic floor ultrasound, can facilitate patient counselling and decisions on technique prior to prolapse surgery.

Avulsion is best diagnosed by tomographic translabial imaging, a method that is now well standardised,⁶⁰ commonly available on standard ultrasound systems and at least equivalent to diagnosis by magnetic resonance imaging.⁶¹ The assessment of hiatal dimensions is similarly well standardised and validated, with both single plane measurements⁵⁷ and area determination in rendered volumes⁶² similarly useful.

In view of the increasing medicolegal relevance of mesh complications and the acrimonious discussion regarding the use of mesh, it seems prudent to restrict the use of transvaginal mesh to the anterior compartment and to women at high risk of recurrence. This does not only affect clinical practice but also research. It seems plainly unethical to use mesh for prolapse repair in patients at low risk of recurrence and expose them to the potential mesh related complications. Limiting surgical trials of novel techniques to patients at high risk of recurrence greatly increases the power of a study to demonstrate differences between groups, requiring a smaller number of tested subjects and less resources.⁶³ In an excellent example of successful study planning, a randomised controlled study on only 72 women diagnosed with levator avulsion by Svabik, *et al.* showed a huge difference in prolapse recurrence, both clinically (3% vs 65%) and on ultrasound (2.8% vs 61.7%) 12 months after Total Prolift versus sacrospinous fixation, favouring mesh repair⁵⁰.

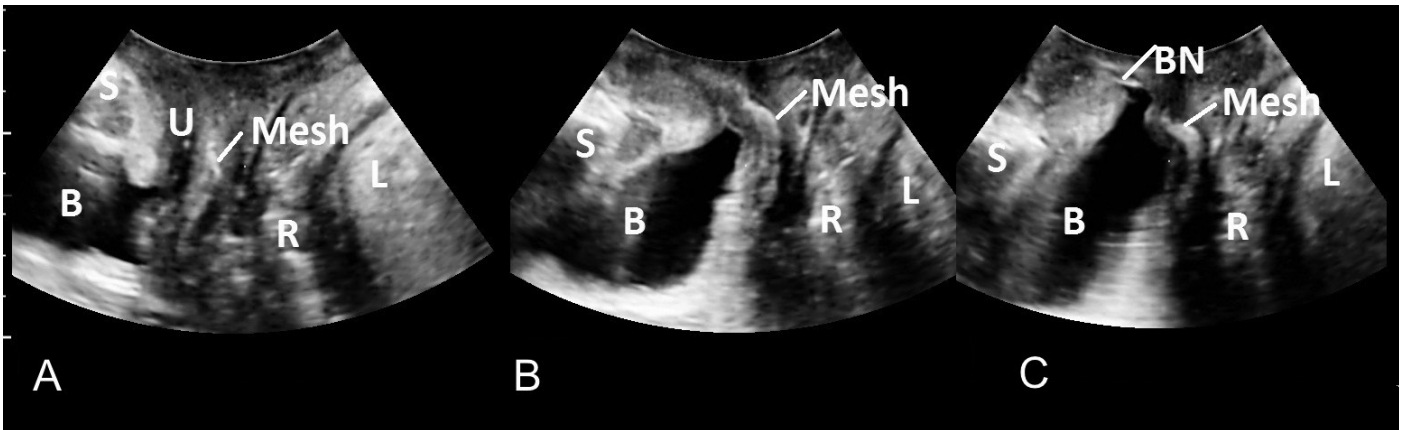


Figure 10: Midsagittal view showing anterior mesh failure: (A) at rest; (B) on submaximal Valsalva maneuver; (C) on maximum Valsalva. Cystocele recurred ventral and caudal to a well-supported mesh suggests that the caudal aspect of the implant was insufficiently secured to the bladder neck, leading to dislodgement of the mesh from the bladder base. B, bladder; BN, bladder neck; L, levator ani muscle; R, rectum; S, pubic symphysis; U, urethra. Reproduced with permission from reference 41.



Figure 11: Midsagittal view showing apical mesh failure: (A) at rest; (B) on submaximal Valsalva maneuver; (C) on maximum Valsalva. Cystocele recurred dorsal to the mesh with high mobility of the apical aspect of the implant suggesting dislodgement of apical attachment. B, bladder; S, pubic symphysis; U, urethra. Reproduced with permission from reference 75.

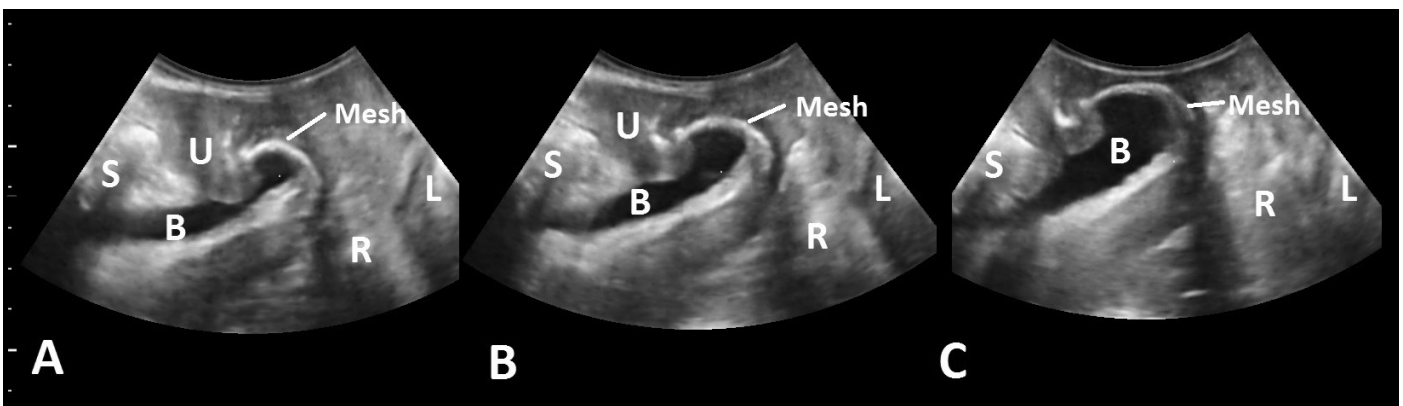


Figure 12: Midsagittal view showing global mesh failure (A) at rest; (B) on submaximal Valsalva maneuver; (C) on maximum Valsalva. Cystocele recurred behind the mesh associated with high mobility of the entire implant on Valsalva suggesting dislodgement of both lateral and apical attachments. B, bladder; L, levator ani muscle; R, rectum; S, pubic symphysis; U, urethra. Reproduced with permission from reference 41.

Dealing with complications: 'shrinkage' and erosion

Vaginal mesh erosion, chronic pelvic pain and dyspareunia are the most consistent and common mesh-related complications.^{64,65} In a recent systematic review, graft erosion rates were reported to be around 10%, with dyspareunia in approximately 9% of patients. It is believed that concomitant hysterectomy, surgeon's experience, the use of inverted 'T' vaginal incisions, smoking

and diabetes mellitus are risk factors for vaginal erosion.⁶⁶ Imaging seems to be largely irrelevant in the management of vaginal erosion as the condition can be easily diagnosed on clinical examination.

On the other hand, however, pelvic pain/dyspareunia is a substantial potential management problem. Mesh retraction, contraction or shrinkage is believed by some to be the cause of

pelvic pain^{64,67} and recurrence.⁶⁸ Ultrasound could be useful in diagnosing mesh 'contraction', where the mesh appears folded and thickened instead of flat and smooth (Figure 9). Mesh retraction/contraction is thought to be the consequence of patient's immune response to the mesh implant,⁷⁰ although this is an unproven concept. From an anatomical point of view, it is difficult to expect an 8 cm long mesh to remain flat and smooth once implanted into the anterior vaginal wall between bladder neck and apex, even if the mesh is well fixated with sutures. It is likely to fold on implantation simply because there is too much material for the space available. To date, claims of mesh shrinkage, retraction or contraction have been based on studies employing single time points i.e. not on longitudinal observation.^{67,71,72} In a study by Tunn, *et al.* using introital ultrasound the authors reported a 60% reduction in mesh length on comparing preimplantation measurements with ultrasound findings at 6 weeks,⁷¹ however, no further postoperative data was available.

Retraction/contraction after mesh implantation in prolapse repair may well exist, however, it is likely to be limited during the period of physiological wound healing. In a study comparing intraoperative mesh length with ultrasound measurements obtained four days and 3–5 months after Anterior Prolift, the authors reported a marked reduction from preimplantation mesh length of 90.3 mm to 57.1 mm on early ultrasound and a further reduction in mesh length by around 15% on comparing the early and late ultrasound measurements (57.1 mm vs 48.3mm). The authors commented that most of the so called 'mesh contraction/retraction' is due to intraoperative folding as a result of implantation of excessive mesh material.⁷³ In a study on forty women who were seen at least twice between 3 months to 4.6 years after Perigee implantation, amounting to 60 woman-years, we did not find any reduction in mesh dimension between the two time points, arguing against the existence of mesh contraction/retraction⁷⁴ beyond the period of physiological wound healing.

From the currently available data, the appearances of mesh contraction, retraction or shrinkage are likely to be caused by folding due to implantation of excessive mesh material, or secondary to surgical technique where the mesh has not been sufficiently fixed to the underlying tissues. This implies that we should be able to avoid such appearances by adjusting mesh design and surgical technique. Implantation of excessive mesh material should be avoided and implants should be anchored securely, both to underlying tissues and to the pelvic sidewall.

Assessing anchoring mechanisms: towards better mesh engineering

While transvaginal mesh is associated with better anatomical outcomes, in a substantial minority of patients prolapse recurs due to mesh failure. It is important for pelvic reconstructive surgeons and engineers involved in the design of mesh implants to understand why meshes fail to allow improvement of implant design and alter the risk-benefit balance for individual patients. Ultrasound imaging can be of great utility in this regard. Anterior vaginal wall mesh is apparent on ultrasound as a highly echogenic linear structure situated dorsal to the bladder neck, caudal and dorsal to the trigone and the posterior bladder wall. It is more clearly visible on Valsalva maneuver. Based on the assumption that a mesh

moving several cm on Valsalva is unlikely to be securely anchored, we have observed mesh anchoring failure in 38% of patients after anterior compartment mesh.⁴¹ In this series of 296 women at a mean follow-up of 1.8 years after either Anterior Prolift™ (Ethicon, Somerville, NJ, USA), Perigee™ (American Medical Systems, Minnetonka, MN, USA) or Anterior Elevate™ (American Medical Systems, Minnetonka, MN, USA), three patterns of mesh failures associated with distinctive forms of mesh mobility on Valsalva were identified. They are 1) Anterior failure (3%): cystocele recurs anterior and ventral to well supported mesh (Figure 10); 2) Apical failure (8%): cystocele or uterine prolapse recurs associated with high mobility of the cranial end of mesh (Figure 11) and 3) Global failure (27%): recurrent cystocele associated with high mobility of the entire mesh (Figure 12). All three types of mesh failures have been observed in each of the three anterior transvaginal meshes studied. Apical failure very likely occurs as a result of dislodgement of the cranial anchors and/ or superior transobturator arms, giving rise to the appearance of a 'high' cystocele, similar to what is seen after Burch colposuspension. In global failure the entire mesh has become excessively mobile, implying a complete absence of effective anchoring and dislodgement of both cranial and caudal anchors/arms. Global failure is particularly common in non-anchored meshes and second-generation meshes without transobturator arms. It appears that plastic sidewall anchors are less load resistant and more likely to dislodge compared to meshes with transobturator arms.⁴¹

Both apical and global failures were shown to be associated with hiatal area on Valsalva.⁴¹ Such an association is not difficult to understand if one imagines how the mesh traverses the anterior part of the levator hiatus. The larger the hiatus, the greater the load that will be placed on mesh anchors, and the higher is the likelihood of dislodgement. Anterior mesh failure is, on the other hand, a result of dislodgement of the caudal mesh aspect from the bladder base, secondary to inadequate surgical fixation.

It is important to realise that mesh anchoring is a crucial factor for mesh success or failure. A mesh overlay without effective anchoring is unlikely to provide adequate support but will likely increase complication rates compared to traditional native tissue repair. It has become clear that current implant designs are suboptimal as regards anchoring and that there is substantial room for improvement. This could be achieved by optimising current technology, for instance, by widening anchoring arms, or by providing greater 'grip' through the use of Velcro-like mesh surfaces. Further research in this area with the use of mathematical modeling may also help to better understand the mechanical behaviour of implants. It has been experimentally determined that the force required to dislodge one transobturator arm⁷⁶ is about 5–6 N. Higher forces are likely to be required in vivo, given that forces are exerted at an angle to the mesh arms/anchors and that anterior anchored meshes are suspended by four arms. Since mesh arm dislodgement is strongly associated with hiatal area on Valsalva, this parameter is likely to be a crucial input variable for pelvic floor modelling.

Dealing with recurrence after mesh: using the implant as an asset

Ultrasound imaging is particularly useful in the management of prolapse recurrence after mesh implantation. Depending on the

type of recurrence and associated findings on imaging, one may use the 'failed' mesh for repair, converting it into an asset. In the case of anterior failure the mesh is well anchored to the sidewall but has dislodged from the bladder neck, leading to a recurrent cystocele anterior and caudal to the implant. This type of failure can be easily treated by dissecting the recurrent cystocele and the caudal mesh margin, and reattaching the mesh to the bladder neck. With dislodgement of cranial supports as in apical failure, clearly the implant needs to be re-suspended cranially. This can be achieved by bilaterally extending the mesh to the sacrospinous ligaments as is routine in some 2nd generation anchored meshes. It may require a mesh extension and one needs to take care to leave sufficient space between mesh arms and sacrum to avoid bowel obstruction. Alternatively one may approach the implant abdominally to suspend the unsupported mesh margin cranially in the form of a sacrocolpopexy.

Global failure is the most common form of mesh failure and the most difficult to manage. Reattaching the mesh as for apical failure may provide effective apical support but may not result in sufficient Level II support owing to a lack of lateral attachment. In the current climate placement of a second mesh after removing part or all of the 'failed' mesh needs to be approached with great caution.

Investigating pathophysiology: towards treatment of causes, not effects

Considering that one third of prolapse surgeries are performed for recurrence,¹ there is an urgent need for clinicians to understand the pathophysiology of POP better. While aetiology is likely complex and multifactorial, childbirth has been consistently shown to be a strong risk factor for POP in epidemiological studies.^{77,78} Recent imaging studies have suggested that levator trauma is plausibly the missing link between childbirth and POP. Levator avulsion or 'levator macrotrauma' and irreversible overdistension of the hiatus or 'levator microtrauma' have been shown to be strong risk factors for POP development and recurrence after surgery.^{3,43,46,49,56,79-81} From a pathophysiological point of view POP can be considered a form of hernia. It is herniation of pelvic organs, be it the bladder, uterus, small or large bowel, through the levator hiatus, the hernial portal, into the vagina. This hernial portal is defined by the pubic bone anteriorly and the levator ani muscle laterally and posteriorly. Loss of integrity of the levator ani muscle is associated with enlargement of the levator hiatus and impaired pelvic organ support. It is likely, however, that other mechanisms, for instance fascial damage associated with levator avulsion, also contributes to the pathophysiological mechanism,⁸⁰ and for posterior compartment prolapse this is already well established.

Conclusion

The capability to demonstrate modern urogynaecological implants such as suburethral slings and prolapse meshes on ultrasound has enhanced the utility of diagnostic ultrasound in pelvic floor medicine. Ultrasound has helped us understand how these implants succeed or fail. Imaging allows us to identify patients at risk of failure or recurrence and is useful in patient counseling and selection. It also facilitates the recognition and

management of certain complications and of recurrence.

The current debate surrounding the use of mesh in pelvic reconstructive surgery is highly emotional and often rather poorly informed. Much of the confusion at present is secondary to a lack of diagnostic effort, both before and after mesh surgery. The best surgical endeavours are likely to fail if they are based on an inaccurate diagnosis. Any further attempts at optimising prolapse surgery should be preceded by a conscious effort to first improve patient assessment, and ultrasound imaging has a major role to play in this regard.

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