

Association between 3D endovaginal and 2D perineal pelvic floor ultrasound findings and symptoms in women presenting with mid-urethral sling complications

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KEYWORDS: complications; endovaginal ultrasound; mesh; mid-urethral sling; perineal ultrasound; tension-free vaginal tape; three-dimensional pelvic floor ultrasound

CONTRIBUTION

What are the novel findings of this work?

The association between two-dimensional perineal and three-dimensional endovaginal ultrasound findings and patient symptoms in a cohort of women with mid-urethral sling (MUS) complications has not been shown before. MUS position within the rhabdosphincter and C-shaped MUS both at rest and on Valsalva maneuver were associated with voiding dysfunction. MUS position in the distal third of the urethra was associated with a higher incidence of recurrent urinary tract infection.

What are the clinical implications of this work?

This study adds to the limited body of evidence for best practice in the assessment of complications after MUS placement. As recurrent urinary tract infection and voiding dysfunction appear to be related to tape location, care needs to be taken during MUS insertion to ensure correct placement.

ABSTRACT

Objectives To present the characteristics of women attending a tertiary urogynaecology pelvic floor scan clinic with mid-urethral sling (MUS) complications and examine the association between patient symptoms and findings on two-dimensional (2D) perineal and three-dimensional (3D) endovaginal ultrasound.

Methods This was a cross-sectional study of all women with MUS complications referred to a specialist pelvic floor ultrasound clinic between October 2016 and

October 2018. Detailed history was obtained regarding their symptoms and time of onset. All patients underwent 2D perineal and 3D endovaginal ultrasound assessment. The association between patient symptoms and ultrasound findings was evaluated using logistic regression analysis. Only symptomatic women with a single MUS, without other pelvic floor mesh, prior mesh excision or bulking agents, were included in the regression analysis.

Results A total of 311 women with a history of MUS surgery were seen during the study period. Vaginal and/or non-vaginal pain was reported by 80% of patients and this was the primary presenting complaint in 59% of the patients. One-third of the patients reported symptoms starting within 4 weeks after surgery. The data of 172 patients were included in the regression analysis. MUS position within the rhabdosphincter was significantly associated with voiding dysfunction (odds ratio (OR), 10.6 (95% CI, 2.2–50.9); $P = 0.003$). Voiding dysfunction was highest in those with C-shaped MUS both at rest and on Valsalva maneuver (OR, 3.2 (95% CI, 1.3–7.6); $P < 0.001$). MUS position in the distal third of the urethra was significantly associated with a higher rate of recurrent urinary tract infection (OR, 2.9 (95% CI, 1.3–6.3); $P = 0.01$).

Conclusions Pelvic floor ultrasound can provide insight into the position and shape of the MUS, which could explain some patient symptoms and guide management or surgical planning. © 2020 The Authors. Ultrasound in Obstetrics & Gynecology published by John Wiley & Sons Ltd on behalf of International Society of Ultrasound in Obstetrics and Gynecology.

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INTRODUCTION

The controversy surrounding the use of mesh for the treatment of pelvic floor dysfunction continues, with a growing number of patients presenting with complications attributed to mesh¹. Associated symptoms include mesh extrusion, infection, chronic pain and sexual dysfunction^{2,3}, as well as ongoing disability following removal⁴. As pelvic floor ultrasound is increasingly being utilized within urogynecology⁵, its usefulness in investigating mesh complications is gradually being recognized⁶. However, there are still large gaps in our understanding of its full clinical applicability. Although clinical examination has been shown to be superior to ultrasound in diagnosing vaginal mesh extrusion⁷, assessment of other features of the mesh implant, such as its precise location and its position in relation to neighboring structures, may provide valuable information for surgical planning or investigating complex symptoms. Ultrasound is the only imaging modality that can clearly visualize the mesh in the pelvic floor, owing to its echogenicity⁶. Research to date has mostly utilized three- and four-dimensional (3D/4D) transperineal or translabial modalities^{8–11}. Perineal pelvic floor ultrasound (pPFUS) allows dynamic assessment of mid-urethral slings (MUS) and is performed using curvilinear probes, which are widely available in most gynecology departments. Although 3D endovaginal ultrasound (EVUS) requires specialist equipment, it offers reliable, high-resolution imaging of the whole pelvic floor¹². It is useful in the diagnosis of posterior compartment disorders and pelvic organ prolapse^{13,14}, evaluation of the location and distribution of urethral bulking agents^{15,16}, assessment of the presence and location of mesh for prolapse and associated complications¹⁷ and diagnosis of urethrovaginal fistulas and vaginal cysts^{18,19}. The benefits of the technique are its simplicity and ability to provide high-resolution images owing to the close proximity to the pelvic structures, and it is associated with excellent interobserver agreement²⁰. Analysis of the 3D volume allows assessment of mesh morphology and the adjacent pelvic anatomy, providing patients and clinicians with the opportunity to visualize the entire course of the pelvic floor mesh²¹.

We hypothesize that MUS location can contribute to patient symptoms and therefore that ultrasound is a useful adjunctive investigation when assessing women presenting with complications following mesh incontinence surgery.

The objective of this study was to present the characteristics of women with a history of MUS surgery attending a tertiary urogynecology pelvic floor ultrasound clinic and to examine the association between their symptoms and two-dimensional (2D) pPFUS and 3D EVUS findings.

METHODS

This was a cross-sectional study of all women presenting to a tertiary urogynecology pelvic floor ultrasound clinic for MUS complications from October 2016 to October 2018. For all patients, a detailed history was taken regarding their symptoms and time of onset, including subjective presence of pain, urinary, bowel and prolapse symptoms and details of previous surgical history. Non-vaginal pain was considered any pain reported in the back, groin, abdomen or legs. Exclusion criteria from the analysis of the association between ultrasound findings and patient symptoms were the presence of more than one MUS, other pelvic mesh or urethral bulking agent, prior partial or complete MUS excision or being asymptomatic.

2D pPFUS and 3D EVUS, both validated imaging techniques, were performed according to standardized methods using a Flex Focus 500 ultrasound system (BK Medical, Herlev, Denmark)^{5,7}. All scans were performed and analyzed by, or directly supervised by, the senior author (R.T.). The methodology for performing the scans has been reported previously²¹. The mesh was identified by its characteristic honeycomb-like appearance (Figure 1).

For 2D pPFUS, a convex transducer (4.3–6 MHz, Type 8802; BK Medical) was placed over the labia of the patient. A mid-sagittal image was obtained with the transducer in a vertical position, to evaluate the distance between the mesh implant and the symphysis pubis, as well as the mesh shape at rest and on maximum Valsalva maneuver. The mid-point of the MUS was taken as the reference point for measurements. The transducer was rotated 90° to a horizontal position to assess for curling

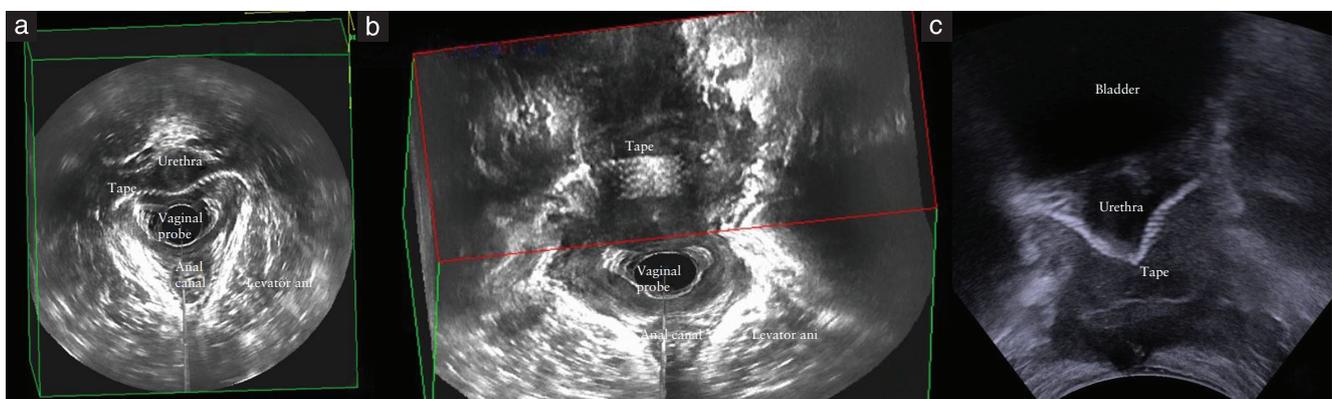


Figure 1 Honeycomb appearance of mesh (labeled 'Tape') on three-dimensional endovaginal ultrasound (a,b) and two-dimensional transperineal pelvic floor ultrasound (c).

or folding. This was diagnosed subjectively as an obvious non-flat or non-linear appearance of the mesh implant. The distance from the MUS to the symphysis pubis was measured (in mm) from the center of the MUS to the tip of the symphysis pubis seen on mid-sagittal view (Figure 2). The shape of the MUS was assessed in the mid-sagittal view, at rest and on maximum Valsalva maneuver. MUS shapes were categorized as Type 1 (flat shape both at rest and on Valsalva maneuver), Type 2 (flat at rest and C-shaped on Valsalva) or Type 3 (C-shaped both at rest and on Valsalva), as previously reported (Figure 2)²².

3D EVUS was performed at rest using a Type 8838, 6–12 MHz, 360° rotational probe (BK Medical). The

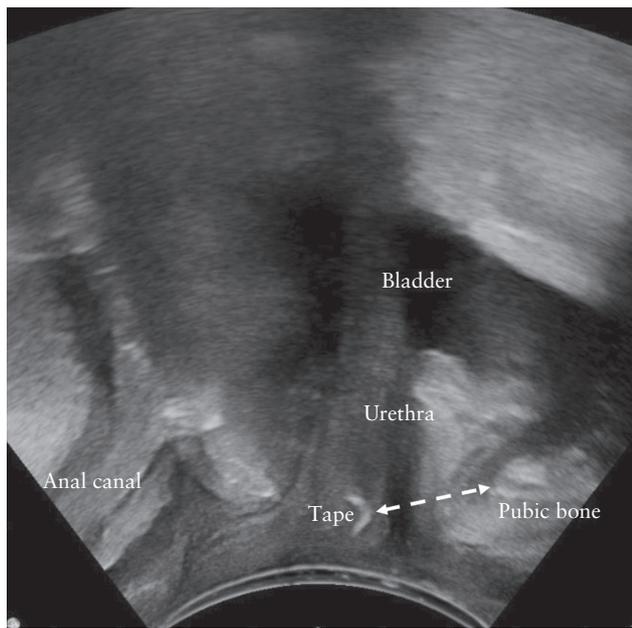


Figure 2 Mid-sagittal two-dimensional transperineal pelvic floor ultrasound image obtained at rest, showing C-shaped mid-urethral sling (MUS) (labeled ‘Tape’). Distance from center of MUS to pubic symphysis (dashed double-headed arrow) was measured. When MUS maintains its C-shaped appearance on Valsalva maneuver, it is considered to have C-to-C (Type 3) shape.

3D volume allowed assessment of the type and position of the MUS in the sagittal, coronal and axial planes. The following measurements were obtained in the mid-sagittal view: urethral length (in mm) from the bladder neck to the urethral meatus (Figure 3) and distance from the MUS to the bladder neck (in mm), measured from the midpoint of the MUS to the level of the bladder neck, parallel to the urethral lumen (Figure 3). The position of the MUS along the urethra was then calculated as a percentage of the urethral length and reported according to its location in the proximal third, middle third or distal third of the urethra. The distance from the MUS to the urethral lumen was then measured from the middle of the MUS to the center of the urethral lumen (in mm) (Figure 3).

In addition, the following were evaluated: (1) folding of the mesh implant was assessed by reviewing the 3D volume in the coronal, sagittal and axial planes (Figure 4); (2) mesh proximity to the urethral rhabdosphincter or bladder wall was assessed by manipulation of the 3D

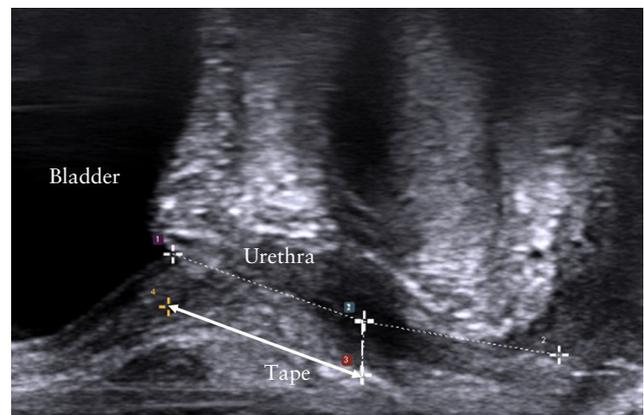


Figure 3 Mid-sagittal endovaginal ultrasound image showing measurement of: urethral length from beaked bladder neck to urethral meatus (dotted line); distance from mid-urethral sling (labeled ‘Tape’) to bladder neck (solid white line); distance from midpoint of mid-urethral sling to urethral lumen (dashed white line).

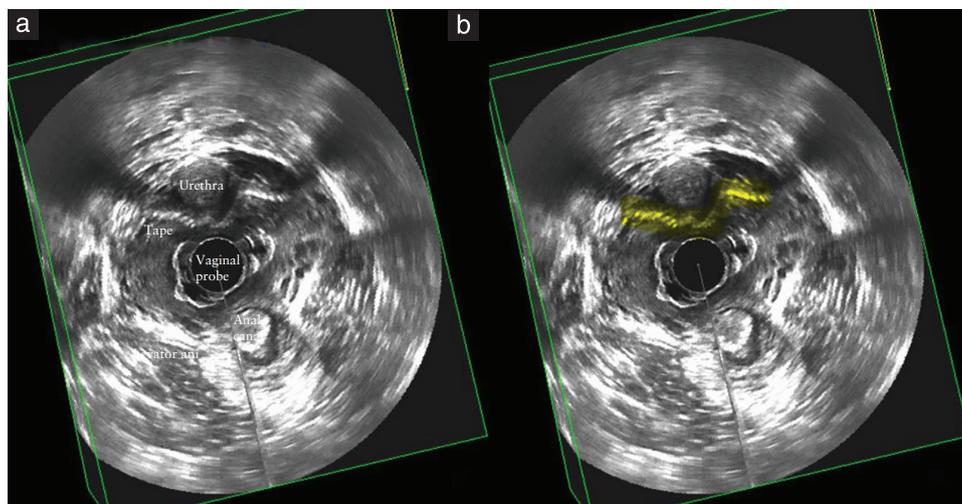


Figure 4 Three-dimensional endovaginal ultrasound images (axial plane) showing folding/curling of mid-urethral sling (labeled ‘Tape’ in (a)) beneath urethra. Tape is highlighted (yellow) in (b).

volume in the coronal, sagittal and axial planes; and (3) the type of MUS was determined by observing the direction of the MUS arms: a transobturator tape was diagnosed if the arms were traced laterally into the obturator foramen, and a retropubic mid-urethral sling if the arms traversed upwards towards the pubic bone⁶.

Institutional research and development approval was obtained for this study (YLC/MC/PFU2) and ethical approval was not deemed necessary.

Statistical analysis

Only symptomatic patients with a single intact MUS were included in the analysis of the association between ultrasound findings and symptoms. Patients' symptoms were considered as binary variables, either present or absent. Logistic regression analysis was performed both unadjusted and then re-examining the relationships adjusting for predetermined patient and treatment factors (age, previous prolapse repair, history of MUS extrusion, time since MUS insertion, presence of pelvic organ prolapse and type of MUS inserted). The size effects of each variable with the outcome were summarized as odds ratios (ORs). For categorical variables, ORs give the odds of the symptom relative to the odds in a baseline category. For continuous variables, ORs represent the relative change in the odds of the symptoms for a one-unit increase in each variable (other-sized increases shown when one-unit increase was too small). Each ultrasound factor was examined in separate analyses and $P < 0.05$ was considered to indicate statistical significance.

RESULTS

Over the 2-year study period, 311 women with a reported history of MUS insertion were seen in our pelvic floor ultrasound clinic. The indications for pelvic floor ultrasound were localization of MUS in 243 women (78%) and localization of MUS remnant in 68 (22%). Twenty (6%) patients had had two MUSs inserted. Further concomitant procedures are listed in Table 1. Reported complications at the time of surgery or within 24 h occurred in 32/311 (10%) patients and included: acute retention in 22 (7%), bladder injury in five (2%), sepsis in two (1%), hemorrhage in one (0.3%), hematoma formation in one (0.3%) and bowel injury in one (0.3%). Presenting symptoms starting within 4 weeks after MUS insertion were reported by 98/311 (32%) patients. The primary presenting symptom was chronic, non-localized pain in 182/311 (59%) women. Details of all other presenting and concomitant symptoms are shown in Table 1. In total, 249/311 (80%) reported any pain (vaginal and/or non-vaginal) either as a primary or concomitant complaint.

The primary scan outcomes were: the shape/type/position of a MUS was depicted in 225 (72%) patients, the absence or presence and location of MUS remnants was diagnosed in 68 (22%), unexpected presence or absence of MUS or bulking agent or other pelvic floor

Table 1 Presenting symptoms and surgical history of 311 women attending pelvic floor ultrasound clinic with reported history of mid-urethral sling (MUS) insertion

| Patient history | Value |
|--|----------|
| Main presenting complaint | |
| Non-localized pain | 182 (59) |
| Persistent SUI | 38 (12) |
| Recurrent urinary tract infection | 22 (7) |
| Voiding dysfunction | 20 (6) |
| Mesh extrusion | 17 (5) |
| Asymptomatic but seeking reassurance | 12 (4) |
| Dyspareunia | 8 (3) |
| Vaginal lump | 5 (2) |
| Recurrent SUI | 5 (2) |
| Vaginal bleeding | 2 (1) |
| Concurrent symptoms | |
| Pain in back, groin, abdomen or legs | 216 (69) |
| Vaginal pain | 148 (48) |
| Urinary urgency | 134 (43) |
| SUI | 97 (31) |
| Voiding difficulty | 92 (30) |
| Recurrent urinary tract infection | 84 (27) |
| Bowel symptoms | 57 (18) |
| Dyspareunia | 20 (6) |
| Vaginal discharge | 10 (3) |
| Surgical history* | |
| MUS excision or division (partial or full) | 108 (35) |
| Hysterectomy | 93 (30) |
| Over-sewing or trimming for extrusions | 80 (26) |
| Native-tissue prolapse repair | 27 (9) |
| Two MUSs | 20 (6) |
| Urethral bulking procedure | 15 (5) |
| Anterior repair with mesh | 9 (3) |
| Posterior repair with mesh | 9 (3) |
| Sacrohysteropexy | 7 (2) |
| Mesh rectopexy | 3 (1) |

Data are given as n (%). *Some patients had more than one surgical procedure. SUI, stress urinary incontinence.

mesh was identified in nine (3%), a previously unknown vaginal mesh exposure was diagnosed in seven (2%) and previously unknown organ extrusion was diagnosed in two (1%).

A total of 172 symptomatic women with a single MUS were included in the analysis of the association between ultrasound findings and patient symptoms (Figure 5). Their mean age was 54.1 ± 9.9 years and the median time since MUS insertion was 8 years (interquartile range, 4–10 years).

Table 2 shows the association between patient symptoms and ultrasound findings. Adjusting for confounding variables did not affect the results, so only the unadjusted ORs have been presented.

MUS position within the rhabdosphincter was significantly associated with voiding dysfunction (OR, 10.6 (95% CI, 2.2–50.9); $P = 0.003$). The odds of voiding dysfunction were over 10 times higher if the MUS was within the rhabdosphincter. Unadjusted analysis suggested that the incidence of stress urinary incontinence would be lower if the MUS was positioned within the rhabdosphincter.

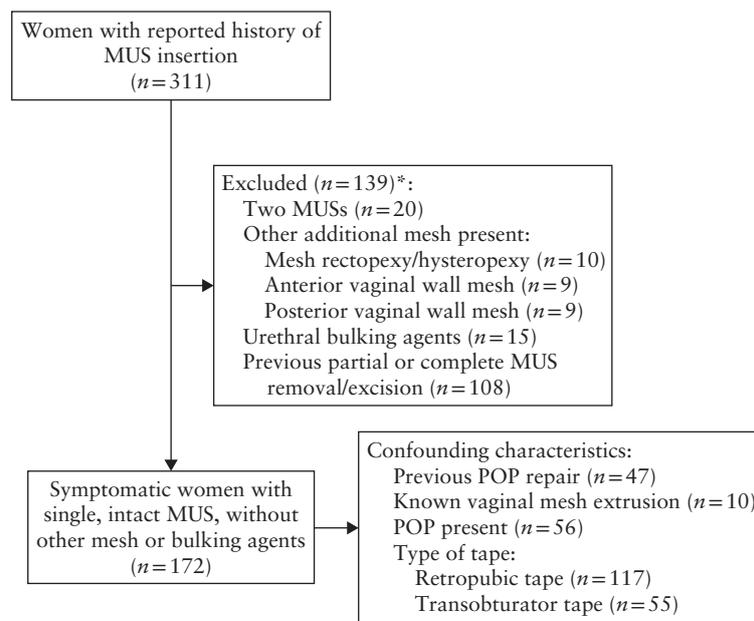


Figure 5 Flowchart showing inclusion of symptomatic patients with single mid-urethral sling (MUS) in final analysis evaluating association between sonographic findings and symptoms. *Some patients had more than one exclusion criteria. POP, pelvic organ prolapse.

The incidence of voiding dysfunction was highest in women with MUS shape Type 3 (C-shaped at rest and on Valsalva), occurring in 64% of these patients. In contrast, only 36% of patients with MUS shape Type 1 (flat at rest and on Valsalva) had voiding dysfunction. The unadjusted analysis suggested that the likelihood of voiding dysfunction was 3.2 times higher in patients with Type-3 than in those with Type-1 MUS shape.

Patients with MUS located in the proximal third and those with MUS located in the middle third of the urethra were analyzed together because of the small number of patients with a proximally located MUS. Distal MUS position in relation to urethral length was significantly associated with a higher incidence of recurrent urinary tract infection (OR, 2.9 (95% CI, 1.3–6.3); $P=0.01$) compared with proximal or mid-urethral MUS position. The odds of recurrent urinary tract infection were over twice as high in the group with a distal MUS position, compared with the group with a proximal or mid-urethral position, for both the unadjusted and adjusted analyses.

No ultrasound features or measurements were associated with urinary urgency, vaginal or back/groin/abdominal/leg pain or dyspareunia either before or after adjusting for patient and treatment factors.

DISCUSSION

The objective of this study was to present the characteristics of women with a history of MUS surgery attending a specialist pelvic floor scan clinic and examine the association between ultrasound findings and their symptoms. The most common presenting complaint was non-localized, chronic pain, which in one-third of the patients started within 4 weeks after surgery. MUS position within the rhabdosphincter and MUS shape

Type 3 were associated with voiding dysfunction. Distal position of the MUS in relation to the urethral length was associated with a higher rate of recurrent urinary tract infection.

Pain has been reported to be the most common mesh-related complaint, along with dyspareunia^{7,23}. It is therefore unsurprising that 80% of our cohort reported vaginal and/or non-vaginal pain. Owing to its multifactorial etiology and the frequent coexistence of comorbidities, it is difficult to ascertain the prevalence of pain attributed directly to mesh. In contrast to previous reports²⁴, we found no association between pain (vaginal or non-vaginal) and MUS folding or proximity to the urethral rhabdosphincter. This may be explained by a lack of specification of the type or location of pain.

Many of the patients in our cohort had complex surgical histories with multiple urogynecological procedures, highlighting the value of pelvic floor ultrasound. Although clinical examination has been shown to be superior to ultrasound for identifying mesh extrusion, ultrasound is best for diagnosing visceral involvement⁷ and identifying organ extrusion or exposure (3% of our patients), and it contributes to the holistic management. Ultrasound findings influence the counseling process and subsequent surgical planning; in 6% of the women in our cohort, the MUS was positioned within the rhabdosphincter, which could increase the risk of urethroplasty during revision surgery. The finding that one-third of women developed symptoms in the short postoperative period suggests that close follow-up, specifically within the first 4 weeks, may be beneficial. The nationally proposed surgical databases in the UK could aid in such monitoring and tracking¹.

Few of our findings complement those reported previously using 3D/4D ultrasound. Kociszewski *et al.*⁹ utilized a translabial approach to describe optimal MUS

Table 2 Association between patient symptoms and findings on two-dimensional perineal pelvic floor ultrasound and three-dimensional endovaginal ultrasound in 172 women with single mid-urethral sling (MUS)

| Symptom/ ultrasound finding | Presence of symptom (n/N (%)) | Unadjusted odds ratio (95% CI)* | P |
|--|-------------------------------------|---------------------------------------|---------|
| <i>Stress urinary incontinence</i> | | | |
| Distance to urethral lumen | — | 1.1 (1.0–1.4) | 0.2 |
| Distance to symphysis pubis† | — | 1.2 (0.8–1.7) | 0.4 |
| Position along urethra | | | |
| Proximal or middle | 44/140 (31) | 1.0 | 0.3 |
| Distal | 7/32 (22) | 0.6 (0.3–1.5) | |
| Placement in rhabdosphincter | | | |
| No | 51/161 (32) | ‡ | 0.04 |
| Yes | 0/11 (0) | | |
| Curling/folding | | | |
| No | 40/137 (29) | 1.0 | 0.8 |
| Yes | 11/35 (31) | 1.1 (0.5–2.5) | |
| MUS shape§ | | | |
| Type 1 | 19/56 (34) | 1.0 | 0.7 |
| Type 2 | 22/80 (28) | 0.7 (0.4–1.6) | |
| Type 3 | 10/36 (28) | 0.8 (0.3–1.9) | |
| <i>Urinary urgency</i> | | | |
| Distance to urethral lumen | — | 1.1 (1.0–1.3) | 0.2 |
| Distance to symphysis pubis† | — | 0.9 (0.7–1.3) | 0.7 |
| Position along urethra | | | |
| Proximal or middle | 67/140 (48) | 1.0 | 0.2 |
| Distal | 11/32 (34) | 0.6 (0.3–1.3) | |
| Placement in rhabdosphincter | | | |
| No | 74/161 (46) | 1.0 | 0.5 |
| Yes | 4/11 (36) | 0.7 (0.2–2.4) | |
| Curling/folding | | | |
| No | 64/137 (47) | 1.0 | 0.5 |
| Yes | 14/35 (40) | 0.8 (0.4–1.6) | |
| MUS shape§ | | | |
| Type 1 | 26/56 (46) | 1.0 | 0.3 |
| Type 2 | 32/80 (40) | 0.8 (0.4–1.5) | |
| Type 3 | 25/36 (69) | 1.4 (0.6–3.4) | |
| <i>Voiding dysfunction</i> | | | |
| Distance to urethral lumen | — | 0.8 (0.7–1.0) | 0.07 |
| Distance to symphysis pubis† | — | 0.9 (0.6–1.4) | 0.7 |
| Position along urethra | | | |
| Proximal or middle | 46/140 (33) | 1.0 | 0.9 |
| Distal | 11/32 (34) | 1.1 (0.5–2.4) | |
| Placement in rhabdosphincter | | | |
| No | 48/161 (30) | 1.0 | 0.003 |
| Yes | 9/11 (82) | 10.6 (2.2–50.9) | |
| Curling/folding | | | |
| No | 46/137 (34) | 1.0 | 0.8 |
| Yes | 11/35 (31) | 0.9 (0.4–2.0) | |
| MUS shape§ | | | |
| Type 1 | 20/56 (36) | 1.0 | < 0.001 |
| Type 2 | 14/80 (18) | 0.4 (0.2–0.9) | |
| Type 3 | 23/36 (64) | 3.2 (1.3–7.6) | |
| <i>Recurrent urinary tract infection</i> | | | |
| Distance to urethral lumen | — | 0.9 (0.7–1.1) | 0.2 |
| Distance to symphysis pubis† | — | 1.2 (0.8–1.7) | 0.4 |
| Position along urethra | | | |
| Proximal or middle | 33/140 (24) | 1.0 | 0.01 |
| Distal | 15/32 (47) | 2.9 (1.3–6.3) | |
| Placement in rhabdosphincter | | | |
| No | 43/161 (27) | 1.0 | 0.2 |
| Yes | 5/11 (45) | 2.3 (0.7–7.9) | |
| Curling/folding | | | |
| No | 39/137 (28) | 1.0 | 0.8 |
| Yes | 9/35 (26) | 0.9 (0.4–2.0) | |

Table 2 Continued

| Symptom/ ultrasound finding | Presence of symptom (n/N (%)) | Unadjusted odds ratio (95% CI)* | P |
|------------------------------------|-------------------------------------|---------------------------------------|-----|
| MUS shape§ | | | |
| Type 1 | 16/56 (29) | 1.0 | 0.4 |
| Type 2 | 19/80 (24) | 0.8 (0.4–1.7) | |
| Type 3 | 13/36 (36) | 1.4 (0.6–3.5) | |
| <i>Vaginal pain</i> | | | |
| Distance to urethral lumen | — | 1.0 (0.9–1.2) | 0.7 |
| Distance to symphysis pubis† | — | 0.9 (0.6–1.2) | 0.4 |
| Position along urethra | | | |
| Proximal or middle | 51/140 (36) | 1.0 | 0.9 |
| Distal | 12/32 (38) | 1.1 (0.5–2.3) | |
| Placement in rhabdosphincter | | | |
| No | 60/161 (37) | 1.0 | 0.5 |
| Yes | 3/11 (27) | 0.6 (0.2–2.5) | |
| Curling/folding | | | |
| No | 51/137 (37) | 1.0 | 0.8 |
| Yes | 12/35 (34) | 0.9 (0.4–1.9) | |
| MUS shape§ | | | |
| Type 1 | 21/56 (38) | 1.0 | 0.7 |
| Type 2 | 27/80 (34) | 0.9 (0.4–1.7) | |
| Type 3 | 15/36 (42) | 1.2 (0.5–2.8) | |
| <i>Back/groin/abdomen/leg pain</i> | | | |
| Distance to urethral lumen | — | 1.0 (0.9–1.2) | 0.9 |
| Distance to symphysis pubis† | — | 1.1 (0.8–1.6) | 0.6 |
| Position along urethra | | | |
| Proximal or middle | 93/140 (66) | 1.0 | 0.6 |
| Distal | 23/32 (72) | 1.3 (0.6–3.0) | |
| Placement in rhabdosphincter | | | |
| No | 108/161 (67) | 1.0 | 0.7 |
| Yes | 8/11 (73) | 1.3 (0.3–5.1) | |
| Curling/folding | | | |
| No | 92/137 (67) | 1.0 | 0.9 |
| Yes | 24/35 (69) | 1.1 (0.5–2.4) | |
| MUS shape§ | | | |
| Type 1 | 40/56 (71) | 1.0 | 0.6 |
| Type 2 | 51/80 (64) | 0.7 (0.3–1.5) | |
| Type 3 | 25/36 (69) | 0.9 (0.4–2.3) | |
| <i>Dyspareunia</i> | | | |
| Distance to urethral lumen | — | 1.1 (0.9–1.3) | 0.3 |
| Distance to symphysis pubis† | — | 0.9 (0.6–1.3) | 0.6 |
| Position along urethra | | | |
| Proximal or middle | 68/140 (49) | 1.0 | 0.2 |
| Distal | 12/32 (38) | 0.6 (0.3–1.4) | |
| Placement in rhabdosphincter | | | |
| No | 75/161 (47) | 1.0 | 0.6 |
| Yes | 6/11 (55) | 1.4 (0.4–4.7) | |
| Curling/folding | | | |
| No | 62/137 (45) | 1.0 | 0.3 |
| Yes | 19/35 (54) | 1.4 (0.7–3.0) | |
| MUS shape§ | | | |
| Type 1 | 28/56 (50) | 1.0 | 0.7 |
| Type 2 | 38/80 (48) | 0.9 (0.5–1.8) | |
| Type 3 | 15/36 (42) | 0.7 (0.3–1.7) | |

*Adjusted analysis for confounders (age, previous prolapse repair, history of MUS extrusion, time since MUS insertion, presence of prolapse and type of tape) did not affect results. †Odds ratio given for 5-unit increase in variable. ‡Unable to calculate odds ratios owing to no occurrences of outcome in one category; unadjusted analysis using Fisher's exact test. §Type 1, flat MUS shape at rest and remains flat on Valsalva maneuver; Type 2, flat MUS shape at rest and C-shaped on Valsalva maneuver; Type 3, C-shaped MUS at rest and remains C-shaped on Valsalva maneuver.

position to be at 40–70% of the urethral length. Using 3D EVUS to assess MUS failures, Bogusiewicz *et al.*²⁵ found positioning in the proximal half of the urethra to be associated with MUS failure. Our study did not find similar associations; this could be owing to the low number ($n = 4$) of cases with proximally located MUS in our cohort and because our study involved a different cohort of women. We did however find that placement in the distal third of the urethra is associated with recurrent urinary tract infection, which has previously not been reported and needs further exploration in larger cohorts. This information could guide a decision to surgically intervene when a patient presents with recurrent urinary tract infections and their MUS is distally placed. Other authors, using 3D pPFUS, have found no association between MUS position in relation to the urethral length and complications, symptoms or success^{8,10}.

Our finding that MUS shape Type 3 (C-shaped at rest and on Valsalva) is associated with voiding dysfunction corroborate those previously described by Kociszewski *et al.*²² using translabial ultrasound. We did not find an association between stress urinary incontinence and MUS shape Type 1 (flat shape at rest and on Valsalva maneuver). This may be owing to our varied follow-up period, as opposed to the 42-month follow-up in the study of Kociszewski *et al.*²² and the differing study populations and presenting complaints.

The effect of proximity of the MUS to the urethral lumen on symptoms of voiding and stress incontinence is theoretically plausible. Similarly to Kociszewski *et al.*⁹, we also found reduced voiding dysfunction with MUS further from the urethral lumen. This is also supported by our finding of MUS location within the rhabdosphincter (which encircles the urethral lumen) being associated with voiding dysfunction, suggesting undue compression of the urethral lumen. This could influence a decision to offer division of the MUS if a patient presents with voiding dysfunction. Although we did not find an association between symptoms and distance of the MUS to the symphysis pubis on 2D perineal ultrasound, it has previously been reported that a narrower gap between the MUS and the symphysis pubis on 3D/4D perineal ultrasound is associated with a greater cure of stress urinary incontinence²⁶.

Logically, folding of the MUS would suggest reduced tension in the tape and therefore persistent stress urinary incontinence, however, surprisingly, we did not find this. To date, no studies have been able to find such an association.

Our study has some limitations. The retrospective nature of ascertaining patient history may have introduced recall bias, particularly as mesh is a topical issue in the media. We were not able to corroborate surgical history with hospital records, as most women had their primary surgery in other hospitals. In addition, those with severe symptoms, such as urinary retention, may have had their MUS partially excised, and as these patients were excluded from the analysis of association between symptoms and sonographic findings, this may have skewed the results. It

is therefore unlikely that these results will be generalizable to asymptomatic women with MUS. We did not assess symptoms by validated questionnaires or confirm them using objective tests, therefore, patients' reported histories and symptoms are subjective. Physical examination was not performed, therefore localized vaginal pain is difficult to confirm and confounding variables such as levator spasm or prolapse may have been present. Owing to the high prevalence of pain in our cohort, it was difficult to determine an association between ultrasound findings and pain, which is a multifactorial, subjective and diffuse symptom. Therefore, to distinguish sonographic findings attributable only to pain would require comparison with a cohort of asymptomatic women in a larger study. It has been suggested that migration of the MUS can occur with time, both towards the bladder neck²⁷ and the urethral lumen⁹. Our ultrasound examination was performed at a single timepoint, but more complex associations affected by time since surgery may be possible.

This study reiterates the potential clinical use of 2D pPFUS and 3D EVUS in identifying the presence and location of MUS, MUS remnants and exposure/extrusion, particularly to guide surgical planning, need for additional investigations and patient counseling. This is particularly the case as most women will present with their complications to a clinician other than their primary surgeon²⁸.

Our findings suggest an association between voiding dysfunction and recurrent urinary tract infections and certain ultrasound findings. This study could lead towards the standardization of measurements made during pelvic floor ultrasound, when performed for MUS complications.

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