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FULL PAPER

Interobserver agreement of multicompartiment ultrasound in the assessment of pelvic floor anatomy

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Objective: To assess the interobserver agreement of pelvic floor anatomical measurements using multicompartiment pelvic floor ultrasound.

Methods: Females were recruited from the urogynaecology/gynaecology clinics between July and October 2009 and underwent multicompartiment pelvic floor ultrasonography (PFUS) using two-dimensional (2D) transperineal ultrasound (TPUS), high-frequency 2D/three-dimensional (3D) endovaginal ultrasound (EVUS) using a biplane probe with linear and transverse arrays and a 360° rotational 3D-EVUS. PFUS measurements were independently analysed by two clinicians.

Results: 158 females had PFUS assessment. Good-to-excellent interobserver agreement was observed for bladder-symphysis distance at rest and valsalva, urethral thickness, urethral length, urethral volume, levator hiatus

area and width, anteroposterior diameter and anorectal angle. Lins Correlation was used to calculate the interobserver agreement and Bland-Altman plots were created to demonstrate the agreement between the researchers. There was also a good-to-excellent agreement between the two clinicians for the assessment of pelvic organ prolapse (POP) in the anterior, middle and posterior compartment.

Conclusion: Multicompartiment PFUS is a reliable tool in the anatomical assessment of pelvic floor measurements and POP.

Advances in knowledge: We found a good-to-excellent agreement between the two assessors in the assessment of pelvic floor measurements for all three pelvic floor compartments and suggest that multicompartiment PFUS could be considered as a systematic integrated approach to assess the pelvic floor.

INTRODUCTION

Pelvic floor assessment is of importance in clinical practice and research relating to pelvic floor dysfunction (PFD).¹ Clinicians are increasingly adopting a more holistic approach to managing dysfunction that affects various compartments of the pelvic floor.

The most common type of PFD is pelvic organ prolapse (POP), which affects approximately 50% of females who are parous and over 50 years of age, with a lifetime prevalence risk of 30–50%.² The International Continence Society recommends a pelvic organ prolapse quantification (POPQ) system for the clinical assessment of POP.³ However, concerns have been raised regarding decisions based on clinical assessment alone, as this may have a limited role in evaluating the morphological and structural changes leading to PFD.^{4,5}

A review of the literature revealed that the majority of morphologic features of the female genital tract can be

identified using ultrasound^{6–11} and MRI.^{12,13} Dietz et al⁶ first described the use of translabial ultrasound to quantify POP and demonstrated a good correlation between imaging, clinical staging and POPQ. Santoro et al⁹ highlighted the benefits of an integrated approach to pelvic floor ultrasonography (PFUS). It has been suggested that to provide a holistic approach to the PFD, researchers and clinicians should use different ultrasound techniques to provide adequate and complete information of all pelvic floor compartments.⁶ That said, further validation of ultrasound techniques is needed prior to global acceptance.

The aim of this study was to evaluate the interobserver agreement of pelvic floor anatomical measurements and POP assessment using multicompartiment PFUS.

METHODS AND MATERIALS

Ethics approval

The study was approved by the National Research Ethics Service, Bromley Local Research Ethics Committee, South

London Research Ethics Committee office (ethics study number: 08/H0806/115). All females gave written informed consent.

Between July and October 2009, females were recruited from urogynaecology and gynaecology clinics. Females with symptoms of POP and/or urinary incontinence (UI) were referred by general practitioners, after having received conservative management (pelvic floor physiotherapy, lifestyle modification and bladder retraining), to a urogynaecology clinic. These females were eligible to participate as study patients, and females with other gynaecological symptoms (dysfunctional uterine bleeding, lower abdominal pain etc.) were referred by general practitioners to a general gynaecology clinic and were included as controls. We excluded females who presented with pelvic masses such as ovarian cysts or fibroids, which may have an impact on pelvic floor assessment. A detailed history was obtained and demographic data were collected including age, parity, body mass index and previous surgery for prolapse and UI. This study population also formed a part of another study evaluating the value of pre-operative multicompartiment PFUS.¹⁴

Prior to the examination, patients were asked to empty their bladder if it was felt full or uncomfortable. POPQ assessment was conducted by an independent examiner (either RT or AHS) in the left lateral and standing position as per unit protocol and examination was completed using bimanual pelvic palpation. The measurements of POPQ points Ba, Bp and C in centimetres were used as they describe the maximum descent of the anterior, posterior and middle compartment, respectively.³

Comprehensive PFUS was performed with the use of ProFocus™ Ultraview™ (B-K Medical, Herlev, Denmark) ultrasound scanner on the same day as POPQ assessment in an outpatient setting, by two research fellows (AS and FL), who were not aware of the POPQ findings. Prior to study initiation, FL has completed a training session dedicated to two-dimensional (2D) transperineal ultrasound (TPUS) and three-dimensional (3D) (endovaginal ultrasound) EVUS analysis, pelvic floor structure identification and measurements. The patients were scanned in the supine position and without using any rectal or vaginal contrast.^{9,15}

PFUS consisted of 2D-TPUS and high-frequency 2D-/3D-EVUS. For interobserver agreement, 2D-TPUS images at rest and during dynamic valsalva manoeuvre were assessed independently by FL and AS. Analyses were conducted with the readers blinded to each other's measurements.

Two-dimensional transperineal ultrasound

TPUS was performed with the patient placed in the dorsal lithotomy, with the hips flexed and abducted. All examinations were performed using 6 MHz convex transducer (Type 8802, ProFocus™ Ultraview™; B-K Medical) positioned in the mid-sagittal line on the perineum between the mons pubis and anal canal (transperineal approach) to visualize the pubic symphysis, urethra, vagina, anal canal and rectum. The location of the relevant structures was assessed, and the following measurements were taken in the sagittal plane:

- bladder–symphysis distance (BSD): at rest and at maximum valsalva—the distance between the bladder neck and the lowest margin of the symphysis pubis (SP)

- prolapse descent: ultrasound was performed at rest (Figure 1a) and on three maximal valsalva manoeuvres. For the valsalva manoeuvre, patients were asked to perform a forcible exhalation effort against the closed mouth and to bear down as if they were having a bowel evacuation. These captured images were stored for offline analysis. A maximum of three valsalva images was used for analysis. We used a software called “Virtual Dub 1.9.4”, which slices the image into multiple frames. Each image was sliced into approximately 140–160 frames and each frame was individually analysed by the two research fellows to identify the frame with the maximum pelvic floor descent, which was used to measure the prolapse (Figure 1b). A reference line was drawn parallel to the inferoposterior margin of the SP,¹⁵ perpendicular to which the leading edge of descent was measured in millimetres.

Three-dimensional high-frequency endovaginal ultrasound (9–16 MHz) using a 360° rotational probe 3D-EVUS was performed with the convex endovaginal transducer, using high multifrequency (9–16 MHz) 360° rotational mechanical probe with a built-in 3D automatic acquisition system (Type 2052, ProFocus Ultra view; B-K Medical). 3D-EVUS provides an additional dimension—axial section, enabling better visualization of pelvic floor structures. The transducer was inserted into the vagina in a neutral position with the patient lying in the supine position with knees partially flexed. The EVUS was performed according to the protocol previously reported by Santoro et al.⁸ The acquisition began from the bladder neck and terminated beyond the transverse perinei muscles. The reference point of the symmetry was fixed at the junction of the rami of the SP (Gothic arch) located at 12 o'clock on the screen. 3D acquisition allows visualization of the relevant structures of the pelvis, namely SP, urethra, levator ani muscle (LAM) and anal canal. On this axial section, the levator hiatus (LH): anteroposterior (AP) diameter, left–right width and area were taken (Figure 2) and registered as audio-video interleave files and stored on the computer disc for offline analysis.

Biplane (transverse and linear beam) endovaginal transducer (5–12 MHz) using 180° rotational probe

A biplane transducer with a transverse and linear beam formation (Type 8848; B-K Medical) with a frequency range of 5–12 MHz was used. The assessment of the anterior and posterior compartments was performed separately. The linear array of this transducer has a 90° imaging orientation to the longitudinal axis. A computer-controlled acquisition was obtained by connecting the probe to a 180° rotational mover (UA0513 B-K Medical). For the assessment of the anterior compartment, rotation was performed from the right side (9 o'clock position) to the left side (3 o'clock position) of the patient and the following measurements were taken:

- urethral length, volume, width and thickness (Figure 3a).

For the assessment of the posterior compartment, rotation was performed from 3 to 9 o'clock position. The following measurements were taken:

- anorectal angle (ARA)—the angle between the posterior wall of the rectum and the axis of the anal canal (Figure 3b).

Figure 1. Two-dimensional transperineal ultrasound assessment at rest (a) and cystocele demonstrated on maximal valsalva manoeuvre (b). SP, symphysis pubis; U, urethra; V, vagina.

Statistical analysis

For statistical analysis, the POPQ point measurement was converted to millimetres. Measurements on TPU were rounded to the nearest 0.

Descriptive statistics for continuous data were calculated. The relationships among different variables were assessed with a *t* test for dependent samples. Levene test was used, and $p < 0.05$ was considered statistically significant. For the interobserver agreement, interclass correlation coefficients (ICC) of measurements were calculated (Lins Correlation) using Stata 11.3 and correlation coefficients (*r*) were presented. An *r* value of 0.0–0.20 was interpreted as none—slight agreement; 0.21–0.40, fair; 0.41–0.60, moderate; 0.61–0.80, good; and 0.81–1.00, excellent agreement. Levels of agreement (LOA) were also measured between the two investigators. Bland–Altman plots were generated for each set of continuous variables to demonstrate the agreement between the two clinicians.

Figure 2. Levator hiatus dimensions measured on three-dimensional endovaginal ultrasound. A, area; AC, anal canal; AP, anteroposterior; LA, levator ani; L-R, left-to-right width; SP, symphysis pubis; U, urethra; V, vagina.

RESULTS

A total of 158 females had PFUS assessment. 20 (12.6%) scans were not analysable (18 poor-quality images, 2 missing images). 140 females were included for analysis (89 females with prolapse and 51 controls). 48 females had prolapse of more than 1 compartment (19 females had isolated anterior compartment prolapse, 17 females had isolated posterior and 5 females had middle compartment prolapse). The mean age was 49.2 years (standard deviation 14 years), body mass index 29.3 (standard deviation 6.5) kg m^{-2} and median parity of 2 (range 0–6). 22 (10.7%) females had previously undergone a hysterectomy, 13 (9.2%) females had previous POP surgery and 16 (11.4%) females had previous surgery for UI. Results of interobserver analysis of pelvic floor measurements acquired in 2D-TPUS at rest and during valsalva manoeuvres are shown in Table 1.

Interobserver agreement of bladder–symphysis distance (at rest and valsalva)

Excellent interobserver agreement (ICC > 0.8) was seen for BSD at valsalva. ICC on interobserver agreement analysis revealed excellent correlation (0.984). This is also reflected in the narrow LOA (LOA = $-2.99 \rightarrow 4.03$). Good interobserver agreement (ICC = 0.6–0.8) was observed for BSD at rest (ICC = 0.748), indicating the accuracy of measurements by observers.

Interobserver agreement of urethral measurements (thickness, length, volume and width)

Good–excellent interobserver agreement was seen for urethral thickness, urethral length and urethral volume (ICC = 0.882, 0.949 and 0.862, respectively). This can also be shown in the narrow LOA of these measurements. Lack of agreement was observed for urethral width (ICC = 0.036). On interobserver agreement analyses, LOA for urethral width is very wide ($-18.14 \rightarrow 19.30$), which implies that this measurement does not appear to be reliably measured between the two investigators.

Interobserver agreement of the levator hiatus (anteroposterior, width and area)

Good–excellent interobserver agreement was measured for the LH AP, LH width and LH area (ICC = 0.894, 0.886 and 0.903, respectively) and narrow LOA for all three measurements, suggesting the reliability of these measurements.

Figure 3. Urethral length (L) and width (W) measurements using biplane (transverse and linear beam) endovaginal transducer for the anterior compartment (a). At assessment of the posterior compartment, the measurement of the anorectal angle (ARA) was taken as the angle between the posterior wall of the rectum (R) and the axis of the anal canal (AC) (b). LA, levator ani; RVS, rectovaginal septum; SP, symphysis pubis; U, urethra.

Interobserver agreement of the anorectal angle ICC on interobserver agreement analysis revealed excellent correlation (0.916) along with narrow LOA, implying that this measurement can be reliably measured on PFUS.

Interobserver agreement of measurements of prolapse of anterior, middle and posterior compartments

These measurements performed using dynamic 2D-TPUS are shown in Table 2. There was a good-to-excellent agreement for POP measurements between the two researchers. The correlation coefficients measured were:

anterior compartment : R-squared = 0.77 (95% CI 0.71–0.83)

middle compartment : R-squared = 0.87 (95% CI 0.82–0.90)

posterior compartment: R-squared = 0.93 (95% CI 0.91–0.95).

LOA for these measurements are included in Table 2. Bland–Altman plots were created as shown in Figure 4 (a–c). These scatter plots represent this graphically, with scatters tending to concentrate in the vicinity of the middle horizontal line, revealing acceptable agreement between the two researchers for the measurements of prolapse of anterior, middle and posterior compartment using PFUS.

DISCUSSION

This study suggests that multicompartiment PFUS has a good–excellent interobserver agreement for BSD at rest and valsalva, urethral thickness, urethral length, urethral volume, LH AP, LH width, LH area, ARA and for POP measurements. This implies that these measurements are reliable and accurate.

Table 1. Interobserver analysis of the pelvic floor measurements obtained in two-dimensional transperineal ultrasound at rest and during valsalva manoeuvres ($n = 140$)

Parameter (mm)	EVUS ^a Mean ($\pm$ SD)	EVUS ^b Mean ($\pm$ SD)	ICC	95% CI	δ	SDd	95% LOA
BSD rest	−21.53 ($\pm$ 9.27)	−22.60 ($\pm$ 8.33)	0.748	0.680–0.816	1.07	6.19	−11.05→13.20
BSD valsalva	−10.33 ($\pm$ 10.10)	−10.85 ($\pm$ 10.78)	0.984	0.979–0.989	0.52	1.79	−2.99→4.03
Urethral width	15.21 ($\pm$ 9.61)	14.72 ($\pm$ 1.76)	0.036	−0.019–0.092	0.49	9.60	−18.14→19.30
Urethral thickness	10.35 ($\pm$ 1.51)	10.49 ($\pm$ 1.58)	0.882	0.848–0.917	−0.16	0.74	−1.59→1.32
Urethral length	35.11 ($\pm$ 5.64)	36.04 ($\pm$ 6.27)	0.949	0.935–0.964	−0.92	1.68	−4.21→2.36
Urethral volume	4.24 ($\pm$ 0.93)	4.17 ($\pm$ 1.17)	0.862	0.826–0.899	0.08	0.55	−1.00→1.16
LH AP	55.24 ($\pm$ 6.12)	55.94 ($\pm$ 7.02)	0.894	0.864–0.924	−0.70	2.96	−6.50→5.10
LH width	39.42 ($\pm$ 5.11)	40.35 ($\pm$ 5.70)	0.886	0.853–0.918	−0.93	2.43	−5.70→3.84
LH area	16.29 ($\pm$ 3.16)	15.93 ($\pm$ 3.58)	0.903	0.876–0.931	0.36	1.45	−2.48→3.19
ARA	141.75 ($\pm$ 9.56)	142.06 ($\pm$ 11.50)	0.916	0.894–0.934	−0.31	4.28	−8.69→8.08

δ , mean difference between measurements; AP, anteroposterior; ARA, anorectal angle; BSD, bladder–symphysis distance; CI, confidence interval; EVUS, endovaginal ultrasound; ICC, interclass correlation coefficient; LH, levator hiatus; LOA, level of agreement; SD, standard deviation; SDd, standard deviation of differences.

^aExaminer 1.

^bExaminer 2.

Table 2. Interobserver repeatability of measurements of prolapse of anterior, middle and posterior compartments using dynamic two-dimensional transperineal ultrasound

Prolapse (mm)	Mean ^a ($\pm$ SD)	Mean ^b ($\pm$ SD)	ICC	95% CI	δ	SDd	95% LOA
Anterior compartment	-5.32 ($\pm$ 14.0)	-4.15 ($\pm$ 17.9)	0.767	0.708–0.827	0.793	10.92	-22.6→20.2
Posterior compartment	-3.04 ($\pm$ 16.0)	-2.44 ($\pm$ 18.5)	0.930	0.911–0.950	0.939	6.42	-12.9→12.2
Middle compartment	-13.4 ($\pm$ 23.2)	-13.4 ($\pm$ 26.9)	0.863	0.824–0.902	0.872	13.18	-25.9→25.8

δ , mean difference between measurements; CI, confidence interval; ICC, interclass correlation coefficient; LOA, level of agreement; SD, standard deviation; SDd, standard deviation of differences.

^aExaminer 1.

^bExaminer 2.

Comprehensive assessment of the pelvic floor may provide useful information regarding PFD.^{5,16} The role of PFUS in the diagnosis of coexisting abnormalities, in planning reconstructive procedures² and providing information which may affect operative decisions has been shown in previous publications.^{5,6} A recent publication demonstrated that the coexisting abnormalities identified on ultrasound do not change the initial surgical management or the management at 1-year follow-up.¹⁴ Clinicians and researchers are increasingly using PFUS as part of the work-up of PFD;^{1,5–7,17} therefore, it is important to assess the interobserver agreement of pelvic floor anatomical

measurements using multicompartment PFUS. In order to determine the relevant clinical application of PFUS, long-term studies are needed.

We are aware that females with PFD may have symptoms of varying compartments and one imaging technique may not be sufficient to address the anatomical or functional pathology.

Technique

Prior to PFUS, study participants were advised to empty their bladder if it was felt uncomfortable or full. Both observers

Figure 4. Bland-Altman plots of prolapse measurements (in millimetres) of the anterior (a), middle (b) and posterior (c) compartments comparing the two observers. The x-axis represents the mean measurement for each compartment of the two investigators (AS and FL) per subject. The y-axis represents the absolute difference in the measurements between the two investigators. The middle of the horizontal lines represents the mean difference between the two investigators and the top and bottom horizontal lines represent the limit of agreement.

performed measurements on the images with the same level of bladder distension/emptying. Therefore, even if pelvic floor descent might have been different with different bladder distension, it would have not changed our interobserver reliability, as these were taken at the same bladder distension in each patient.

For 2D-TPUS, the transducer was gently positioned on the perineum.^{9,15} The reference line drawn to measure prolapse has been previously published.^{15,18} The sonographical definition of a clinically significant cystocele and rectocele (15 mm and 10 mm below the reference line, respectively)¹⁷ and 10 mm below reference line for middle compartment prolapse have been previously used.¹⁸ In this study, we performed POP measurements using similar methodology, allowing consistency of use of this imaging technique.

We used two different endovaginal probes *i.e.* 3D high-frequency EVUS using 360° rotational probe and a biplane (transverse and linear beam) EVUS using 180° rotational probe. Combined use of these probes allowed us a thorough anatomical assessment and measurements for anterior and posterior pelvic floor compartments. Again, an interobserver agreement using these detailed techniques has not been performed in prior studies on PFD.

The high-frequency 3D-EVUS that has been described as useful and reliable in providing details of the female pelvic floor⁹ for both identifying and measuring specific anatomic structures. High-resolution 3D-EVUS is also easy to use in outpatient settings, and images are acquired at rest. We used a standardized technique which has been described by Santoro et al.⁸ Detection of LAM avulsion is possible using 2D-TPUS.¹⁹ Maximum valsalva manoeuvre can be used to identify an enlarged hiatus. Cut-off points for the association with symptoms and signs of POP have been suggested.²⁰ However, anatomical understanding of the pelvic floor and its complex spatial arrangement may not be possible in its entirety by using TPUS. This can be explained by low frequency of TPUS probes (4–8 MHz) whereas EVUS with its high frequency (9–16 MHz) has a superior resolution aiding identification of LAM fibres. Moreover, the EVUS transducer has a built-in 3D motorized system that is completely housed within the probe. This allows computer-controlled, automatic acquisition of images over a distance of 6 cm in 60 s at the touch of a button without any external movement of the probe. The biomechanical properties (compliance or elasticity) of LAM have been proposed to be described by LH measurements.²¹ We minimized bias by allowing the plane in which the measurements were taken to be decided upon by each investigator independently.

Interobserver agreement

LOA of 2D-TPUS for POP measurements was good-excellent. Dynamic TPUS is widely used technique in the diagnostics of UI,^{22–24} POP^{4,6} and defaecatory disorders in adults.^{11,17} TPUS enables not only the assessment of the urethra and surrounding structures, but also allows the evaluation of the morphology of the anorectal area with anal canal, anorectal junction, ampulla recti and anal sphincters. An Additional feature of 2D-TPUS is the possibility of performing dynamic examination during valsalva manoeuvre and squeeze, which provides information about the mobility and function of the urethra, bladder, vagina

and anorectum. Moreover, Perniola et al²⁵ reported that TPUS is comparable with defecography as the initial imaging examination in the identification of patients with various defaecatory disorders. In addition, it enabled the assessment of not only the anorectum, but also the surrounding structures.

The role of pelvic floor MRI and MRI proctogram has been continuously increasing in the recent years. MRI, with its good contrast resolution, allows for precise tissue differentiation. Cadaveric studies have demonstrated a correlation between pelvic anatomy seen on MRI and on fresh cadavers.²⁶ Fast sequences at MRI enable the visualization of pelvic organs during dynamic manoeuvres, such as valsalva, straining and defaecation, and allow the detection of certain pelvic floor disorders. High-resolution sequences allow for precise assessment of the pelvic floor musculature and supportive system. MRI is an important tool in the diagnostic work-up in patients with pelvic floor disorders, allowing for identification of occult abnormalities such as vaginal intussusceptions or enterocoels.²⁷ However, limitations of the pelvic floor MRI include under-reporting of pelvic floor abnormalities in patients with poor rectal emptying²⁸ and a dearth of guidelines regarding imaging and reporting. MRI performed in the supine/sitting position gives variable results,²⁹ with increased detection of anterior and posterior abnormalities.^{30,31} There is also a variation in the use of contrasts such as vaginal/bladder/nil contrast,^{32–35} ultrasound gel as the rectal contrast,³⁶ mashed potatoes with gadolinium³⁷ or air balloon.³⁸ There have been also variations in the use of a reference line to measure pelvic floor descent such as using the pubococcygeal line, mid-pubic line, perineal line or H-line (levator hiatus width line). Good agreement was found for all the lines of the anterior and posterior compartments in patients who were nulliparous and in patients who were symptomatic with and without prolapse, while for the posterior compartment, good agreement between all the lines was found only in the prolapse group.³⁵ The study of Lakeman et al³⁵ showed excellent interobserver agreement of MRI-based POP staging, which did not associate with clinical findings and pelvic floor symptoms. Moreover, MRI proctogram is not commonly performed owing to lack of expert radiographers and radiologists with interest in PFD, and the patient needs to keep still during static sequences to avoid artefacts and improve image quality. In many places, conventional defaecating proctogram remains the first and only imaging tool available for specialists in PFD. TPUS provides global imaging of pelvic floor compartments and allows for diagnosis of abnormalities in these compartments. Scanning time is significantly reduced as compared with MRI and the scan can be immediately repeated in case of non-appropriate acquisition or presence of artefacts etc. TPUS can therefore be used as an important screening tool in investigating patients with PFD.

Using EVUS, we found good-excellent interobserver agreement for BSD at rest and valsalva, urethral thickness, urethral length, urethral volume, LH AP, LH width, LH area and ARA. We performed interobserver agreement using EVUS, as we are aware that EVUS provides detailed information on pelvic floor structures. Studies have shown that images obtained using EVUS have good-to-very good correlation in cadaveric sections for pelvic floor muscle subdivisions.^{10,39} Post-processing of the images

acquired on 3D-EVUS facilitates the evaluation of LAM in the plane of minimal hiatal dimensions, and good-to-excellent correlation has been reported in the LH measurements.⁸

A recent publication has studied the change in LH dimensions using 3D high-frequency EVUS 1 year before and after treatment for POP and found that in contrast to conservative management, there is a significant decrease in LH dimensions 12 months following surgery.⁴⁰ Recently, the association between LAM avulsion and POP was made using EVUS.⁴¹ Van Delft found that 3D-EVUS is a reliable tool in the assessment of LAM biometry and avulsion in antenatal and post-natal females.⁴² They also found that LOA for LH area and AP measurements allows for identification of an enlarged LH.

Strengths and weaknesses

A strength of our study is the inclusion of large numbers. Moreover, females who are asymptomatic as well as females with POP and UI were included, which confirms that interobserver agreement of multicompartiment ultrasound is excellent. All examinations were performed in the same order during the same visit as per a standardized protocol.^{9,15,17,43–45} PFUS was performed on the same day as POPQ assessment by two researchers who were blinded to the POPQ findings, reducing bias. Technique variability was minimized by rigorous training of research fellows. Using this standardized technique, we acquired images, which were stored and were then assessed offline by the two research fellows independently. Obtaining measurements using offline analysis ensures that each investigator uses the protocol to obtain the measurements in the correct plane. Analyses were conducted with the readers blinded to each other's measurements, again reducing bias.

Furthermore, we assessed agreement using ICC and limits of agreement, to establish agreement between measurements rather

than correlation.⁴⁶ This study was conducted using various different ultrasound techniques in one appointment to enable a more comprehensive and complete assessment of the pelvic floor. A known limitation of 3D-EVUS is that dynamic studies are currently not possible to perform a valsalva while acquiring the image. This could possibly be investigated in future using rapid sequence imaging. Not all scans were analysable owing to artefacts or poor quality. This mainly occurred in females with prolapse, and landmarks were not clearly visible. However, similar scans were declared as non-analysable by both investigators.

CONCLUSION

Multicompartiment PFUS encompasses a few ultrasound techniques which are used to visualize the pelvic floor.⁹ PFUS is a reliable tool in the anatomical measurements of BSD at rest and valsalva, urethral thickness, length and volume, LH in AP, width and area as well as ARA measurements. Measurements of POP of all three compartments were also found to be reliable using PFUS. PFUS and TPUS could be used to visualize all three compartments of the pelvis as the initial "screening" examination.²⁵ If posterior compartment descent is identified, EVUS during valsalva is to be performed to distinguish rectocele from enterocele and to visualize/exclude intrarectal intussusception. When cystocele is identified, 360° EVUS is performed to assess levator anti attachment to the SP. 360° EVUS can also be used as follow-up imaging in patient after reconstructive pelvic surgeries, to assess its effects on LH.⁴⁰ This methodology of PFUS can be used in research studies with assurance of its reliability.

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