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Original Article

Comparison of sensitivity and specificity of three-dimensional pelvic floor ultrasound and conventional ultrasound in pelvic floor assessment after delivery

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Abstract: Objective: This study was designed to investigate the sensitivity and specificity of the three-dimensional (3D) pelvic floor ultrasound and the conventional ultrasound in pelvic floor assessment after delivery. Methods: A total of 108 patients with pelvic floor dysfunction treated in our hospital were selected as the study group, and another 108 healthy subjects were included as the control group. Both groups were diagnosed by conventional ultrasound and 3D pelvic floor ultrasound, and confirmed with pathological findings. The diagnostic results of the conventional ultrasound and 3D pelvic floor ultrasound were compared, and the diagnostic conditions of various indicators in the two groups were compared. Results: The numbers of true positive cases and true negative cases diagnosed by the conventional ultrasound were 84 and 90, respectively, while the numbers of true positive cases and true negative cases diagnosed by the 3D pelvic floor ultrasound were 8 and 102, respectively ($P<0.05$). The accuracy, specificity, and sensitivity of the conventional ultrasound were 80.6%, 83.3%, and 77.8%, respectively, which were lower than 94.4%, 96.3%, and 92.6% of the 3D pelvic floor ultrasound, respectively ($P<0.05$). The study group exhibited greater urethral rotation angle (URA), posterior urethrovesical angles (PUVA) under Vsalva maneuver, area of the pelvic hiatus (APH), cystoscopic descent distance, cervical descent distance, and PUVA at resting state ($P<0.05$), and smaller angle of urethral inclination (UI), anal levator-urethra gap (LUG), cervix-symphyseal distance (CSD), rectal ampulla-symphyseal distance (RSD) and bladder neck-symphysis pubis distance (BSD) compared with the control group ($P<0.05$). Conclusion: The 3D pelvic floor ultrasound is more accurate, specific and sensitive than the conventional ultrasound in the assessment of postpartum pelvic floor function, which is worthy of wide application.

Keywords: Postpartum pelvic floor function, 3D pelvic floor ultrasound, conventional ultrasound, sensitivity, specificity

Introduction

Pelvic floor dysfunction is a gynecological disease with a high incidence, mainly affecting postpartum women. With the promotion of the two-child policy in China, the incidence of pelvic floor dysfunction after delivery is on the rise [1]. In postpartum women, injury, abnormality or degeneration of the supporting structures of the pelvic floor causes relaxation or rupture of the responsible tissues, resulting in changes in the position of the adjacent organs of the uterus [2]. Pelvic floor dysfunction is mainly manifested as urinary incontinence, vaginal prolapse and genital fistula, which seriously affects the quality of life and mental health of patients [3]. Therefore, it is essential to explore early diagnosis methods and to improve treatment efficiency [4]. The pelvic cavity is the main part of female urinary incontinence lesions. At present, the effectiveness of rehabilitation is mainly assessed by pelvic floor muscle strength test, improvements in symptoms and urine pad test [5].

Currently, with the continuous development of imaging technology, ultrasound is mostly used in clinical diagnosis of patients with pelvic floor dysfunction, and two-dimensional ultrasound can provide accurate observation of the transverse section of pelvic floor of patients; nevertheless, this diagnostic technology also has certain limitations [6]. In the past, three-dimensional (3D) pelvic floor ultrasound was mainly used in the diagnosis of obstetrics and gynecology, largely on the observation of fetal structures [7]. However, 3D pelvic floor ultrasound plays an increasing role in the diagnosis of pelvic floor dysfunction. It can provide repeated measures with computer, presenting a new diagnostic model of pelvic floor imaging. Meanwhile, the reconstruction rendering technique of volumetric ultrasound can be applied to improve the resolution of pelvic floor images [8]. However, there are few clinical reports on the comparison of diagnostic value of 3D pelvic floor ultrasound and conventional ultrasound in the assessment of postpartum pelvic floor function [9]. In the present study, 108 patients with pelvic floor dysfunction were selected as the study group and 108 healthy volunteers were included as the control group, and the sensitivity and specificity of diagnosis of 3D pelvic floor ultrasound and conventional ultrasound were analyzed in the assessment of postpartum pelvic floor function, so as to improve the accuracy of diagnostic results.

Materials and methods

General data

A total of 108 patients with pelvic floor dysfunction were selected as the study group, with the age of 20-45 years, mean age of (28.3±1.6) years, body mass index (BMI) of 20-25 kg/m^2, mean BMI of (26.4±1.3) kg/m^2, number of pregnancies 1-3 times, and mean number of pregnancies (1.1±0.3). Another 108 healthy subjects were included as the control group, with the age of 20-44 years, mean age of (28.5±1.5) years, BMI of 20-25 kg/m^2, number of pregnancies 1-3 times, and mean number of pregnancies (1.2±0.4). Inclusion criteria: (1) no participation in other clinical studies during the period of this study; (2) age >18 years; (3) vaginal delivery, single birth; (4) normal gestational week and uterine height; (5) normal coagulation function. Exclusion criteria: (1) patients with diabetes mellitus and hypertension; (2) those with hematological, psychiatric, and hepatic and renal disorders; (3) those with cognitive dysfunction and unable to cooperate with the study; (4) those with a history of miscarriage; (5) those with long-term chronic diseases such as constipation and chronic cough; (6) those with a history of trauma to the external genital system such as perineal injury; (7) those with a history of pelvic surgery or even systemic inflammation; (8) neurological disorders, diabetes mellitus, malignancy; (9) allergy to contrast media. The study participants agreed to join the study, and signed written informed consent was provided by participants or their families. The data of two groups were comparable (P>0.05). The study was approved by the Ethics Committee of the Second Affiliated Hospital of Soochow University (Approval number 2021K41).

Methods

Conventional ultrasound: a color Doppler ultrasound diagnostic instrument (model: VolusonE8, manufacturer: GE, USA) was used to diagnose the patients with two-dimensional ultrasound, with the probe frequency setting at (5.0-9.0 MHz). Before performing examination, the bladder should be moderately full and the rectum should be empty, and the patients were in the truncated position. The gynecological mode was set, a condom was placed on the probe, an appropriate amount of coupling agent was applied, and the probe was placed on the midsagittal section of the perineum. The pubic symphysis was positioned under the midsagittal view, and the horizontal reference line was its lower edge. Two-dimensional imaging modality was selected to visualize the anterior mid-posterior pelvis, urethra, anal canal, bladder, and uterus.

3D pelvic floor ultrasound: the patients were instructed to perform VsIsalva maneuvers with maximum force for 3 consecutive times. The 3D imaging was initiated with a 179° scan angle. The area of interest was the area of the rectoanal angle and the inner lower border of the pubic symphysis, and image was acquired while the patients were under tensed, rest, and retracted state. After image acquisition, the images were analyzed by two specialized physicians [10].

Outcome measurement

Diagnostic results of the conventional ultrasound and 3D pelvic floor ultrasound: the num-

Table 1. Diagnostic results of conventional ultrasound and 3D pelvic floor ultrasound (cases, %)

Examination mode		Gold standard	
		Positive	Negative
Conventional ultrasound	Positive	84	18
	Negative	24	90
3D ultrasound pelvic floor	Positive	100	4
	Negative	8	102

bers of positive and negative cases of both diagnostic methods were compared. True-positive criteria [11]: mobility of the bladder neck was increased at rest and during Valsalva maneuvers, with the bladder neck moving down below the pubic symphysis. The pelvic diaphragmatic fissure is abnormal or dilated, with clinical manifestations of a deformity and an increase of more than 25 cm^2. The morphology of the internal urethral orifice in patients with SUI during Valsalva maneuvers in resting patients appeared bird's beak-like structure with urine leakage, and *vice versa* was negative.

Diagnostic accuracy, specificity, and sensitivity of the conventional ultrasound and 3D pelvic floor ultrasound [12]: accuracy = (true negative + true positive)/total; specificity = true negative/(true negative + false positive); sensitivity = true positive/(false negative + true positive). The higher accuracy, specificity, and sensitivity indicate the higher diagnostic accuracy.

The two groups were compared on various diagnostic indicators: including, urethral rotation angle (URA), posterior urethrovesical angles (PUVA) under Vsalva maneuvesrs, area of the pelvic hiatus (APH), cystoscopic descent distance, cervical descent distance, and number of PUVA at resting state, urethral inclination (UI), anal levator-urethra gap (LUG), cervix-symphyseal distance (CSD), rectal ampulla-symphyseal distance (RSD) and bladder neck-symphysis pubis distance (BSD).

Statistical methods

SPSS19.0 (IBM, Armonk, NY, USA) was uased for data analysis. The statistical data were analyzed by two-sided test. Quantitative data were expressed as (x±s) and compared using t-test. ANOVA was used for comparison between the groups followed by LSD test. Qualitative data were tested by X^2. Graphs were produced using Graphpad Prism 8. $P<0.05$ was considered statistically significant difference.

Results

Diagnostic results of conventional ultrasound and 3D pelvic floor ultrasound

The numbers of true-positive cases and true-negative cases diagnosed by the conventional ultrasound were 84 and 90, respectively, and the numbers of true-positive cases and true-negative cases diagnosed by the 3D pelvic floor ultrasound were 8 and 102, respectively, with statistical significance between the two diagnostic methods ($P<0.05$) (**Table 1**).

Diagnostic accuracy, specificity, and sensitivity of conventional ultrasound and 3D pelvic floor ultrasound

The diagnostic accuracy, specificity, and sensitivity of the conventional ultrasound were 80.6% (174/216), 83.3% (90/108), and 77.8% (84/108), respectively, and those of the 3D pelvic floor ultrasound were 94.4% (204/216), 96.3% (104/108), and 92.6% (100/108), respectively. The 3D pelvic floor ultrasound had higher diagnostic accuracy, specificity, and sensitivity than the conventional ultrasound ($P<0.05$) (**Table 2**).

Comparison of diagnostic indicators

Compared with the control group, the URA (61.8±5.4 vs. 16.1±3.5), PUVA under Vslsalva maneuver (137.2±17.5 vs. 126.8±15.4), APH (17.4±1.6 vs. 13.5±1.7), cystoscopic descent distance (24.5±6.2 vs. 12.6±3.3), cervical descent distance (22.3±5.2 vs. 14.2±3.6), and PUVA at resting state (128.5±16.2 vs. 116.5±13.7) were greater in the study group ($P<0.05$), and UI (24.3±3.3 vs. 40.7±11.4), LUG (18.5±2.7 vs. 29.8±4.3), CSD (37.6±9.2 vs. 47.1±9.5), RSD (19.6±4.3 vs. 24.7±5.9) and BSD (23.7±3.1 vs. 27.4±3.7) were smaller in the study group ($P<0.05$) (**Figure 1**).

Comparison of pelvic diaphragm fissure under Valsalva state and pelvic diaphragmatic fissure under the resting state

The anterior-posterior diameter, transverse diameter, and area of the pelvic diaphragmatic

Table 2. Accuracy, specificity, and sensitivity of conventional ultrasound and 3D pelvic floor ultrasound

Examination mode	Accuracy	Specificity	Sensitivity
Conventional ultrasound	80.6 (174/216)	83.3 (90/108)	77.8 (84/108)
3D ultrasound	94.4 (204/216)	96.3 (104/108)	92.6 (100/108)
X^2	7.638	4.752	5.382
P	<0.05	>0.05	<0.05

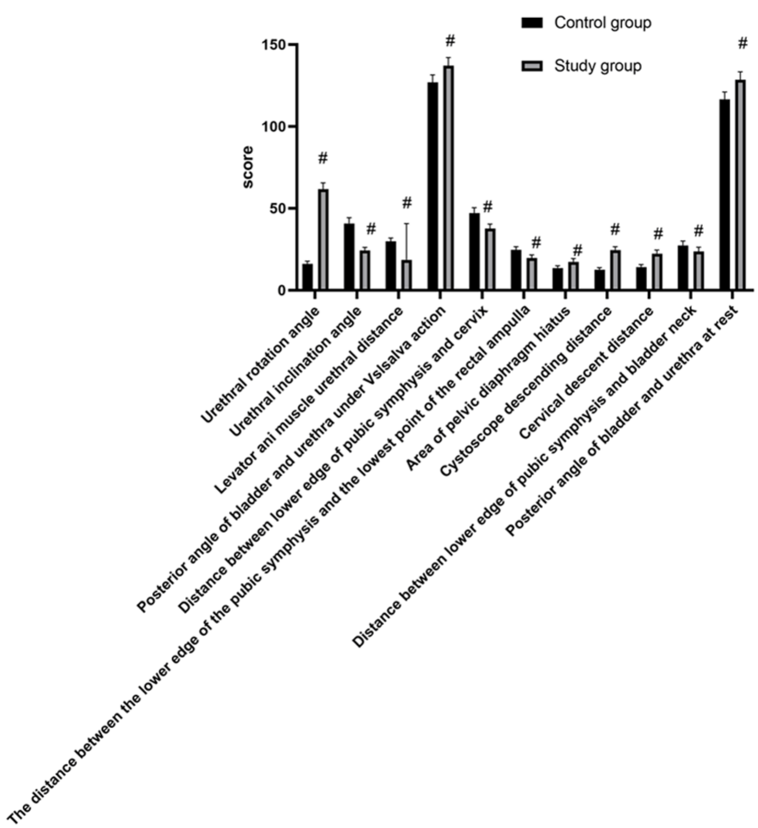

Figure 1. Comparison of the diagnostic results of clinical symptoms between the two groups. Compared with the control group, the URA, PUV, APH, cystoscopic descent distance, cervical descent distance, and PUVA at resting state were greater in the study group ($P<0.05$), and UI, LUG, CSD, RSD and BSD were smaller in the study group ($P<0.05$). #represents comparison with the control group, $P<0.05$.

fissure in the study group were greater in the Valsalva state compared with the control group ($P<0.05$) (**Figure 2**). Compared with the control group, the anteroposterior diameter, transverse diameter, and area of the pelvic diaphragmatic fissure in the study group were greater at rest ($P<0.05$) (**Figure 3**).

Diagnostic ultrasound images of patients

Patients with stress urinary incontinence (SUI) showed increased mobility of bladder neck at rest state and during Valsalva maneuvers, with the bladder neck moving down below the pubic symphysis beyond the normal range. The urethra was closed in resting patients and the morphology of the internal urethral orifice in patients with SUI during Valsalva maneuvers appeared bird's beak-like structure, accompanied by leakage. There were significant differences in tomographic ultrasound imaging between healthy subjects with SUI in the control group and patients with pelvic floor dysfunction in the study group (**Figure 4**).

Discussion

The pelvic floor controls defecation while maintaining the position of the pelvic organs [13, 14]. Data show that incidence of pelvic floor dysfunction has reached 60%, which is related to the increased "psychological stress" of patients [15-17]. Therefore, accurate diagnostic methods should be performed clinically to improve the diagnostic accuracy [18, 19].

Ultrasound diagnosis has the advantages of clear images, easy operation, and high resolution, which is economical and practical [20-22]. Pelvic floor structure refracts and reflects ultrasound waves, and ultrasound diagnosis can provide clear images of dysfunctional structures by dynamically observing sphincter, urethra, and bladder structures [23]. A study has affirmed the accuracy and reliability of the 3D pelvic floor ultrasound [24]. The main reason is that the 3D pelvic floor ultrasound can automatically acquire volumetric data and display

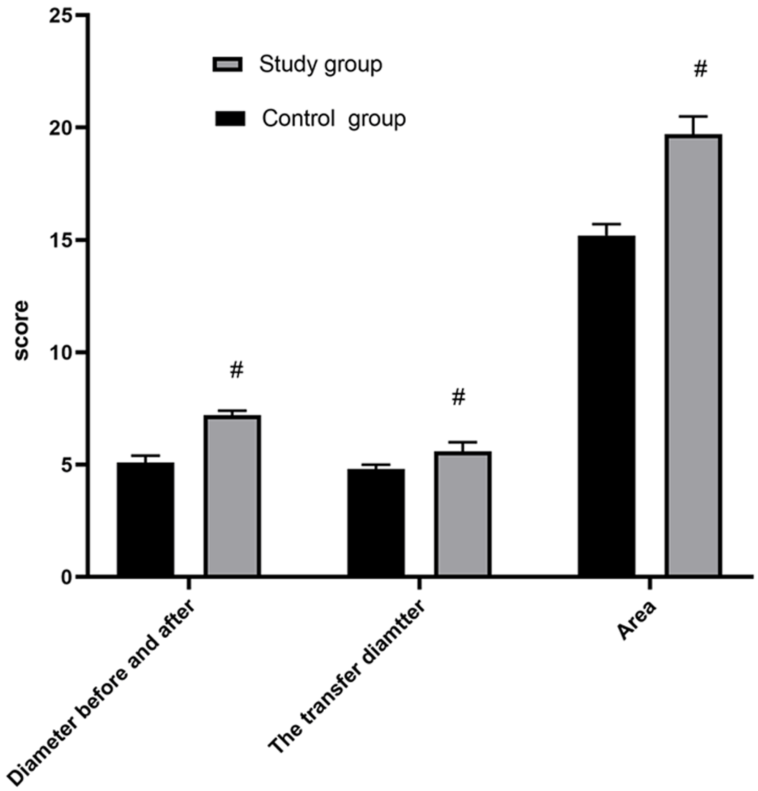

Figure 2. Comparison of pelvic diaphragm fissureunder Valsalva state. The anterior-posterior diameter, transverse diameter, and area of the pelvic diaphragmatic fissure in the study group were greater in the Valsalva state compared with the control group (*P*<0.05). #represents comparison with the control group, *P*<0.05.

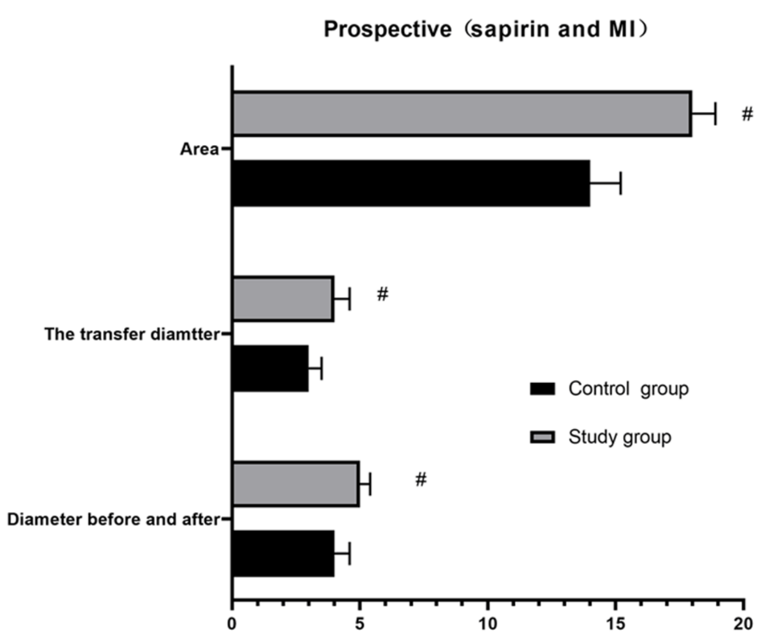

Figure 3. Comparison of pelvic diaphragmatic fissure at rest. Compared with the control group, the anterior-posterior diameter, transverse diameter, and area of the pelvic diaphragmatic fissure in the study group were greater at rest (*P*<0.05). #represents comparison with the control group, *P*<0.05.

transverse, longitudinal and coronal images of the pelvic floor with clear and complete images [25]. The diagnosis of 3D pelvic floor ultrasound in patients with pelvic floor dysfunction allows dynamic multiplanar observation of the pelvic organs and enables accurate and objective evaluation of organ prolapse and structural injury in the pelvic floor [26]. Moreover, this diagnostic modality can observe the performance and position of graft materials and provide an accurate assessment of surgical efficacy [27, 28].

In conclusion, the diagnosis of 3D pelvic floor ultrasound is more accurate, specific and sensitive than the conventional ultrasound in the assessment of pelvic floor function, which can provide a more effective theoretical basis for the clinical treatment of patients. Therefore, the diagnosis of 3D pelvic floor ultrasound is worthy of wide application. Nevertheless, the study has some limitations. The included sample was small and the study period was short, which may affect the accuracy of the study results. Therefore, more samples should be included in next clinical studies, and the study period should be extended to improve the accuracy of the results.

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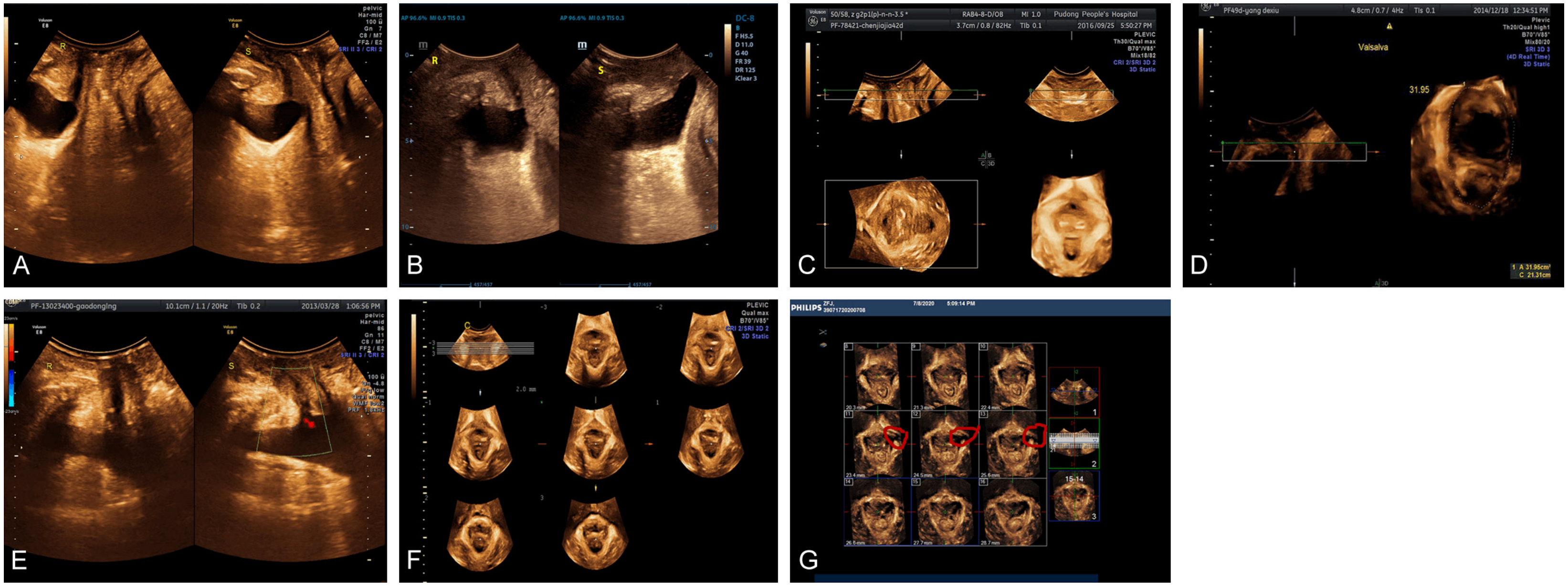

Figure 4. Diagnostic ultrasound. A: Sonogram of the descending bladder at rest and during the Valsalva maneuver. Note: The figure on the left shows the distance from the bladder neck to the lower border of the pubic symphysis in the resting state; the figure on the right shows bladder descent during Valsalva maneuvers. B: Sonogram of the descending bladder at rest and during the Valsalva maneuver state. Note: The bladder neck mobility increased and the bladder neck moved below the symphysis pubis, beyond the normal range. C: Three-dimensional sonogram of a normal pelvic diaphragmatic fissure. D: Three-dimensional sonogram of abnormal pelvic diaphragmatic fissure. Note: Abnormal or dilated pelvic diaphragmatic fissure with clinical manifestations of deformity and abnormal increase in area to 31.95 cm^2, which should be less than 25 cm^2 in normal condition. E: Diagram of resting state and urethral closure during Valsalva maneuvers. Note: The figure on the left shows the urethral closure in the resting state, and on the right, the morphology of the internal urethral orifice in the SUI patient during Valsalva maneuvers shows bird's beak-like structure, accompanied by urine leakage. F: Sonogram of anal raphe fissure in TUI (tomographic ultrasonography). G: Trans-perineal 3D ultrasound TUI imaging of the left anal raphe (puborectalis) muscle injury (the circle).

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Disclosure of conflict of interest

None.

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