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Perineal Ultrasound Versus Magnetic Resonance Imaging (MRI) Detection for Evaluation of Pelvic Diaphragm in Resting State

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Study Design A
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Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Background: The aim of this study was to compare the consistency differences between ultrasound and MRI detection methods and the reliability between 2 independent observers.

Material/Methods: Under 2 kinds of states – the resting state and muscle contractions state – intra-class correlation coefficients (ICCs) were calculated and the consistency of 2 diagnostic methods was evaluated by 2 independent observers. We also assessed the interscorer reliability of the 2 observers.

Results: In terms of the evaluation of biological parameters of the pelvic diaphragm, the consistency of the 2 diagnostic methods was moderate. The ICC of pelvic diaphragm area was 0.55 (95% CI 0.35–0.71), anteroposterior diameter was 0.48 (95% CI 0.28–0.64), and transverse diameter was 0.43 (95% CI 0.25–0.63). The ultrasound detection values of the perineal ultrasound were significantly smaller than those of the MRI. In addition, these differences were increased with the rise of the pelvic diaphragm area.

Conclusions: By evaluating the pelvic diaphragm in patients with pelvic organ prolapse in the resting state, it was preliminarily confirmed that the consistency of ultrasound and MRI was only moderate. The comparison of these 2 diagnostic methods under the dynamic muscle contraction state needs to be further explored.

MeSH Keywords: **Diffusion Magnetic Resonance Imaging • High-Intensity Focused Ultrasound Ablation • Pelvic Floor**

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Background

Epidemiologic studies show that pelvic prolapse has a relatively high morbidity rate of approximate 11%. The risks of surgical treatment leading to urinary incontinence are up to 11–20%, with a high recurrence probability [1,2].

Perineal ultrasound detection technology contributes to the identification of the anatomy and physiological function of the anal sphincter muscle, which is bordered by pubic visceral muscle, symphysis ossium pubis, and lower pubic, and goes through the urethral canal, vagina, and rectum [3]. Therefore, this technology is extensively applied to detect pelvic floor dysfunction. Previous studies suggested that the complication of pelvic organ prolapse was greatly increased when the pelvic diaphragm area is expanded after surgery. Investigations on the evaluation of the biological parameters of pelvic diaphragm indicate that both perineal ultrasound 3D image and MRI possess excellent internal visualization and reliability. So, it is necessary to carry out a simultaneous evaluation using these 2 detection methods in the same study. Most of subjects participated in studies were the impuberal healthy volunteers whose pathologically biological parameters were different from each other. It was reported that ultrasound and MRI detection methods had good consistency in the evaluation of the biological parameters of the pelvic diaphragm [4]. Moreover, some studies demonstrated that there was no obvious difference between these 2 detection methods in axial plane imaging. Kruger et al. reported that the inspected parameter of MRI was obviously higher than that of 3D ultrasonic imaging [5]. In the present study, the biological parameters of the pelvic diaphragm of pelvic organ prolapse patients were detected using MRI and ultrasound examination by 2 observers, which could provide significant benefits for clinical treatment of pelvic organ prolapse.

Material and Methods

Study subjects

The study subjects included 50 patients who were diagnosed with pelvic organ prolapse (POP-Q) and received surgical treatment in our hospital between Jan 2015 and Dec 2015 (Table 1). All subjects underwent the conventional anterior vaginal tightening surgery without the application of reticular material. According to quantitative system for POP-Q, the prolapse degrees of all subjects were above the second level.

The corresponding exclusion criteria included: 1) required use of a lattice-like structure; 2) POP-Q surgery treatment had been performed before; 3) incontinence of feces and urine; 4) contraindications such as heart pacemaker, heart bracket, artificial valve, and claustrophobia for MRI examination.

Table 1. General information of subject characteristics.

Basic information	Values	
Age (years old)	56.5±7.2	(32–74)
Baric index (BMI, kg/m^2)	26.1±4.4	(16.3–42.6)
POP-Q staging before operation		
Stage 2	27	(54.2%)
Stage 3	17	(35.0%)
Stage 4	6	(10.8%)

All subjects received 3D pelvic ultrasound and MRI examination before the operation by random sequence. In order to eliminate the influence of the potential error caused by time delay, which probably changed the physical condition of subjects, ultrasound and MRI examination were processed in the same day. All ultrasound and MRI detection results were evaluated independently by 2 experienced doctors who had no knowledge of physical conditions and clinical therapies of all subjects. All patients were informed in advance and the specific treatment protocols were also agreed to by all subjects before any operation. This research was also approved by the Ethics Committee of our hospital.

3D perineal ultrasound examination

First, the patients were instructed to empty their bladders before ultrasonic examination and lay in dorsal decubitus position with slight hip flexion and abduction. A GE Voluson E8 system 4.8MHz abdominal probe was used. The probe was put in the perineal region after covering with conductive gel as the conductor on the head end. The maximum contraction of pelvic floor muscle was detected in the resting state and muscle contraction state during Valsalva movement. Detection results were analyzed and the related parameters of area, anteroposterior diameter, and transverse diameter were evaluated by use of GE Voluson 4D-view software.

MRI examination

Patients lay in the dorsal decubitus way and their legs were parallel and slightly curved during MRI examination. All patients emptied their bladders without any drug administration before examination. MRI images presented high resolution and the regions of the urethra, bladder, vagina, and rectum were all clear. A 3.0-Tesla MRI scanner (Siemens, MAGNETOM Spectra) and Surface Coil were employed for the detection. MRI detection for the pelvis in the sagittal plane was processed by half Fourier single fast spin echo sequence (2000 ms repeat time/90 ms echo time; 150 degree turn angle) or steady state. The scanning scope included the whole pelvis, symphysis ossium pubis, and the second and third lumbar vertebra.

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Table 2. Consistency evaluation of 3D ultrasound examination and MRI examination results of transperineal.

Detection method	Detection state	Area of pelvic diaphragm	Anteroposterior diameter	Transverse diameter
Perineal 3D ultrasound	Resting and	0.74 (0.65–0.84)	0.61 (0.43–0.72)	0.56 (0.39–0.73)
	Valsalva movement	0.78 (0.61–0.80)	0.77 (0.69–0.84)	0.62 (0.47–0.72)
	Pelvic floor muscle contraction	0.63 (0.47–0.78)	0.61 (0.51–0.81)	0.46 (0.33–0.69)
MRI	Resting	0.73 (0.60–0.85)	0.63 (0.54–0.66)	0.60 (0.44–0.78)

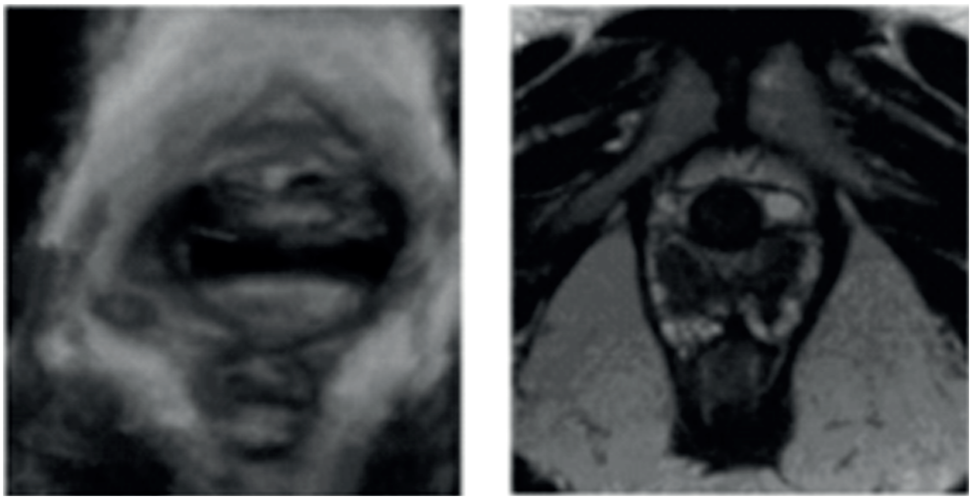

Figure 1. 3D ultrasound and MRI examination of the transverse image, anterior and posterior diameter of pelvic diaphragm, transverse diameter, and area of the pelvic diaphragm in the resting state.

Then, axial and coronal T2 weighted eddy/fast spin echo sequences (>3500 ms, <100 ms doubling time/echo time; 150° flip angle, the thickness of slice at 3 mm, and resolution ratio 0.5×0.5 plane) were collected, covering the entire pelvis from the joint to the fifth lumbar vertebra. Dynamic MR images were acquired using 3D T2-weighted turbine/fast acquisition interleaved spin echo (<1×1×1 mm). The obtained images were analyzed using DICOM viewer software (OsiriX). The axial plane of the angle was used to determine the shortest distance between the pubic and the anterior border of the pubic bone. The parameters of the basin size were evaluated in the same plane.

Data statistical analysis

Statistical analysis was performed using SPSS 18.0 software (SPSS Inc. Chicago, IL). ICC was used for calculating and evaluating the consistency between the reliability and the measured values of ultrasound and MRI examination. Several levels of ICC values were defined to denote this consistency. ICC values lower than 0.2 indicated poor consistency, while ICC value in the range of 0.21–0.40 indicated acceptable consistency. The values located in the range of 0.41–0.60 suggested moderate consistency and the values between 0.61 and 0.80 showed good consistency. Excellent consistency has the requirement that the ICC values should be larger than 0.81.

Results

According to the inclusion and exclusion criteria, 50 patients were recruited in this study. MRI detection data of all patients were eligible for the following analysis in this study.

Results in Table 2 show the reliability of ultrasonic examination in the resting state and pelvic floor muscle contraction state, and MRI detection only at the resting state by the 2 independent observers. ICC was 0.46–0.78, indicating that the consistency of the 2 tests was moderate or good (Figure 1).

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Table 3. At rest, the biological parameter examination results of pelvic diaphragm which was detected by perineal ultrasound and MRI (average values and range).

	Area of pelvic diaphragm (cm^2)	Anteroposterior diameter (cm)	Transverse diameter (cm)
3D ultrasound examination of the perineal	22.4 (14.1–55.7)	6.0 (4.7–8.5)	4.6 (3.2–7.7)
MRI examination	27.3 (15.2–72.7)	6.7 (4.9–11.6)	5.8 (3.3–8.3)
P value	<0.05	<0.05	<0.05

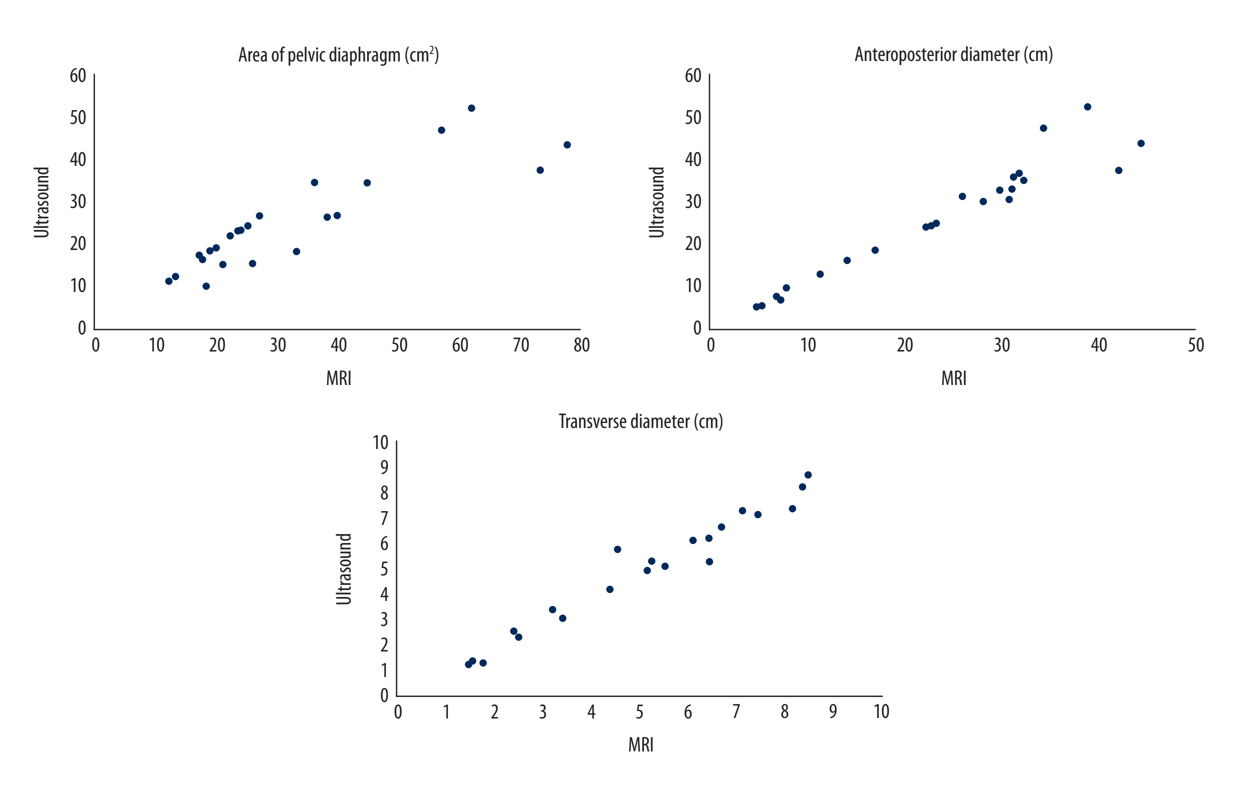

Figure 2. Correlation analysis of ultrasound and MRI detection in pelvic diaphragm area, anteroposterior diameter, and transverse diameter at the resting state.

The comparative analysis results in the biological parameters of the pelvic diaphragm by the 3D ultrasound and MRI examination are shown in Table 3. The data indicated that the area of pelvic diaphragm, anteroposterior diameter, and transverse diameter detected by MRI were higher than those detected by 3D ultrasonic examination, and the differences between them had statistical significance (P<0.05). At the resting state, the consistency of the 2 diagnostic methods was assessed as moderate. Correlation point pattern showed that the area of pelvic diaphragm ICC was 0.547, anteroposterior diameter ICC was 0.478, and transverse diameter ICC was 0.432 (Table 2). The average difference between ultrasound examination and MRI examination results was less than 0 (the area of pelvic diaphragm was –2.08, the anteroposterior diameter was –0.54, and the transverse diameter was –0.51) (Figure 2). These results indicated that the results detected by ultrasound examination were generally lower than those in MRI. This study also found that with the increase of the pelvic diaphragm area, the differences between ultrasound and MRI examination showed an increasing trend.

Discussion

In this study, it was preliminarily confirmed that 3D ultrasound and MRI examination had moderate consistency in terms of

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pelvic diaphragm biological parameters for patients with pelvic organ prolapse, which is basically in accordance with previous research [6,7]. Furthermore, the detection parameters of MRI examination were significantly higher than that of ultrasonic examination. A previous study in 42 non-pregnant women measured the front and back diameter in the sagittal plane, including the area of pelvic diaphragm, front and back diameter of shaft position, and transverse diameter, showing that the detection data of MRI in sagittal plane was higher than that of ultrasonic detection, while in axial position, the related parameters of ultrasound was obviously larger than that of MRI. A potential explanation is that axial reconstruction volume with 2-cm thickness was used to compare and analyze the single axial plane of MRI in ultrasonic testing [8]. In the present study, we used the ultrasonic testing in the axial plane of the smallest hole instead of reconstructed volume, which lead to different results.

In a prospective study, Kruger et al. (2008) compared the differences between ultrasound examination and MRI detection in axial direction and coronal view. Among 19 non-pregnant women, biological parameters of pelvic diaphragm in Valsalva movement were detected by perineal ultrasound and MRI detection. They demonstrated the distortion characteristic of ceasma during Valsalva movement. Also, in the MRI test, measurement results of axial plane in minimum fracture space overestimated the value of fissure coronal diameter. They pointed out that this difference could be modified by reconstructed volume in ultrasonic testing. Due to the distortion of the crack, the minimum diameter of the real coronal plane was not in the same plane as the minimum fracture space [9]. Another explanation for the differences between these 2 detection methods is that the probe position was detected during perineal ultrasound examination, which could reduce prolapse by 3–4 degrees in patients with prolapse, and thus affect data collection [10–12]. However, the patients adopted the resting supine position during the examination, while POP-Q staging was processed in Valsalva movement. So, the effects of 3–4 degrees on prolapse in the measurement process were relatively limited.

In addition, the reliability of the 2 independent observers was moderate or good, with the ICC value in the range of 0.55–0.81 in this study, and ICC value reported in the literature was 0.61–0.97 [13]. Majida et al. (2010) showed that there was a good consistency between MRI and ultrasound examination in 18 healthy female volunteers, and ICCs value were 0.80–0.97. There was only 1 researcher responsible for the collection and evaluation of all data, and ICC values were different from numerous researchers and patients with pelvic organ prolapse; data obtained by MRI were significantly larger than the results of perineal ultrasound [14]. The average difference between the 3 tests was less than 0, which was different from the results of Nardos and other researchers [15]. This difference might due to the wide range of patient sources, patients with various physical conditions, use of different analysis methods between single-center and multi-center studies, and differences in evaluation criteria.

Even though MRI is often regarded as a reference in many investigations to assess the accuracy of the results, MRI examination is not a criterion standard for diagnosis, and it has many potential unknown errors [15-17]. In the present study, we compared ultrasound and MRI detection methods directly, which could avoid some errors driven by MRI. Compare to MRI method, ultrasonic examination had some practical advantages, like shorter examination time, fewer exclusion criteria, less expense, and good patient compliance [18,19]. Under the Valsalva movement or pelvic floor muscle contraction and other dynamic states, it is more convenient to collect data by using the perineal ultrasound examination [20,21]. Furthermore, pelvic diaphragm evaluation in pelvic organ prolapse patients by perineal ultrasound produced higher reliability and practicality. Moreover, with the increase of pelvic diaphragm parameters, pelvic organ prolapse and the probability of recurrence after surgical treatment of prolapse also showed a growing trend [22]. Further research is needed to explore the relationship between biological parameters of the cleft and the increase of pelvic diaphragm.

Conclusions

This study suggests that the consistency of the perineal ultrasound and MRI methods is moderate in evaluating pelvic diaphragm among the patients with pelvic organ prolapse. Therefore, in clinical practice, the results of ultrasound and MRI examination methods cannot be converted to each other, but the reliabilities of the 2 methods were good in most cases. The limitation of this study is that the biological parameters were only detected and evaluated by MRI method in the resting state instead of under the Valsalva movement or contraction period. Hence, it was still not clear whether the difference between ultrasound examination and MRI in non-resting time was more prominent, and this needs further study.

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