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Role of dynamic MRI in assessment of Pelvic Floor Dysfunction in Females

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ABSTRACT

Introduction: Pelvic floor dysfunction is a major medical and social problem. Dynamic MR imaging of the pelvic floor is an excellent tool for assessing functional disorders of the pelvic floor. Findings reported at dynamic MR imaging of the pelvic floor are valuable for selecting patients who are candidates for surgical treatment and for choosing the appropriate surgical approach.

Aim of the work: To highlight the role of dynamic MRI as a non-invasive method in the assessment of pelvic floor dysfunction in females. **Methods:** Dynamic and static MRI were performed in 20 female patients complaining of pelvic organ prolapse and/or stress urinary incontinence or defecation disorder. Full history was taken and clinical examination performed and findings compared with MRI results.

Results: Good concordance was found between dynamic MRI and clinical examination in all three compartments, it was 75% in the anterior compartment, 80% in the posterior compartment, 65% in enteroceles and 75.0% in the middle compartment.

Conclusion: MR imaging provides excellent soft tissue contrast to ensure adequate diagnosis of the muscular and fascial defects responsible for pelvic floor dysfunction.

Keywords: Dynamic MRI, Pelvic organ prolapse, Incontinence, Pelvic floor.

INTRODUCTION

Pelvic floor dysfunction (PFD) is a term applied to a wide variety of clinical conditions, including Stress urinary incontinence (SUI), pelvic organ prolapse (POP), defecatory dysfunction, sensory and emptying abnormalities of the lower urinary tract, sexual dysfunction, and several chronic pain syndromes. The first three are the most common clinical conditions [1].

Whereas exact mechanisms are subject to debate, risk factors include age, multiparity, complicated vaginal deliveries, obesity, collagen-related disorders, hysterectomy, and menopause. Possible causes include injury to the pelvic floor from surgery or childbirth, denervation of the musculature, fascial defects, and abnormal synthesis or degradation of collagen [2].

It has been attributed both to damage to the levator ani muscle and to an endopelvic fascial defect, however, some believe that it is still unclear which of these factors is more responsible. Similarly, SUI has been attributed to urethral hypermobility, to unequal movement of the urethral walls, and to defects in the urethral supporting structures. Because of these controversies, treatment is often started regardless of the specific anatomic lesion involved [3].

Evaluation of women with pelvic floor failure requires a comprehensive approach that includes clinical assessment, physiologic testing, and counseling about conservative versus surgical treatment. Clinical evaluation based on detailed physical, neurologic, and digital rectal examination is the cornerstone of diagnosis. However, clinical examination is limited in several ways: *(a)* it can lead to underestimating or misdiagnosing the site of prolapse; *(b)* it does not permit assessment of evacuation disorders; and *(c)* it cannot detect a peritoneocele, a finding that indicates the need for abdominal rather than vaginal surgery [4].

Several imaging techniques may be used as adjuncts to physical examination. Traditional imaging procedures (e.g., urodynamic study, voiding cystourethrography, and fluoroscopic cystocolpodefecography) remain practical and cost-effective methods for evaluating uncomplicated anorectal and pelvic dysfunction [5]. Magnetic resonance (MR) imaging of the pelvic floor is a two-step process that includes analysis of anatomic damage on axial fast spin-echo (FSE) T2-weighted images and functional evaluation using sagittal dynamic single-shot T2-weighted sequences during straining and defecation [4].

PATIENTS AND METHODS

Patients:

This study is a diagnostic prospective study which was carried out in the Department of Radio-diagnosis at Ain Shams University Hospital from August 2017 to February 2018. Twenty women with pelvic organ prolapse / stress urinary incontinence and/or defecatory disorder were

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included. Patients were recruited from Department of Obstetrics and Gynaecology, Urosurgery and General Surgery, Ain Shams University. **The study was approved by the Ethics Board of Ain Shams University.**

METHODS

- All participants signed an informed consent after explaining to them the objective of the study.
- Full patients' history of pelvic floor disorder was taken prior to scanning.
- The patients were subjected to detailed physical examination.

Type and degree of pelvic organ prolapse were assessed by the clinician at rest and during maximum straining. The degree of prolapse was graded according to the Bader - Walker Half-Way Grading system as follows [6]**:**

Grade	0	→ No Prolapse.
Grade	1	→ Halfway to hymen
Grade	2	→ To hymen
Grade	3	→ Halfway past hymen
Grade	4	→ Maximum descent

- Urodynamic studies: to differentiate stress from urge incontinence.

Patient preparation

All patients had enemas on the night before and in the morning of the exam and all were asked to void urine 1 h before the study.

MRI technique

The patient was positioned supine during the procedure without tilting the pelvis. 120 – 200 ml of ultrasound gel was used to opacify rectum. Sagittal, small field of view axial T2WI (to obtain high-resolution images of the muscles and fascial condensations of the pelvic floor) and coronal turbo spin-echo sequences were performed. The static images were reviewed to check for motion or wrap around artifacts. We choose the midsagittal slice showing the urinary bladder, urethra, uterus, vagina, rectum and the anal canal, dynamic images were taken with ultra-fast T2 weighted sequences (single – shot fast spin – echo sequence) (SSFSE), with the patients instructed to perform squeezing, mild, moderate, maximum straining and defecation

Imaging parameters

Sagittal T2W: TR 3000, TE 100, slice thickness 4 mm, gap 1.5 mm, field of view (FOV) 220. Axial T2W: TR 3500, TE 80, slice thickness 2 mm, gap 1 mm, FOV 225. Axial T1W: TR 420, TE 10, slice thickness 2 mm, gap 1 mm, FOV 255. Coronal T2W: TR 3500, TE 80, slice thickness 2 mm, gap 1 mm, FOV 220. Dynamic SSFSE: TR 3000, TE 160, FOV 290, number of dynamic scans 60, time 3 min.

Image analysis

The images were interpreted by drawing the following lines (on the chosen midsagittal slice showing the urinary bladder, urethra, uterus, vagina, rectum and the anal canal):

1. Pubococcygeal line (PCL) drawn from the lower border of the symphysis pubis to the last visible coccygeal joint.
2. Hiatal (H-line) drawn from the lower border of the symphysis pubis to the anorectal junction.
3. Muscular pelvic floor relaxation (M-line) drawn from the end of the hiatal line perpendicular to the pubococcygeal line.

- These lines were drawn at rest and during maximum straining, and were used to assess the degree of hiatal enlargement and muscular pelvic floor relaxation of the HMO grading system (H line, M line, organ prolapse).

The type and degree of organ descent below the pubococcygeal line (PCL) at maximum straining were assessed by measuring the vertical distance between each of the bladder base, uterine cervix and anorectal junction from the PCL **(Table 1, Fig. 1).**

Organ descent: [7]

	0	→	No prolapse	
Mild	1	→	0 - 3	cm
Moderate	2	→	4 - 6	cm
Severe	3	→	> 6	cm

Statistical Analysis

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data were presented as mean, standard deviations and ranges when their distribution found parametric while non-parametric data were presented as median with inter-quartile range (IQR). Also qualitative variables were presented as number and percentages .

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as following :

- $P > 0.05$: Non significant
- $P < 0.05$: Significant
- $P < 0.01$: Highly significant

Table (1): Grading of Pelvic Floor Relaxation using H-Line and M-Line as Measured during Maximal Straining or Defecation [8].

Stage	H-Line, cm	M-Line, cm
0 (Normal)	<6	0–2
1 (Mild)	6–8	2–4
2 (Moderate)	8–10	4–6
3 (Severe)	≥10	≥6

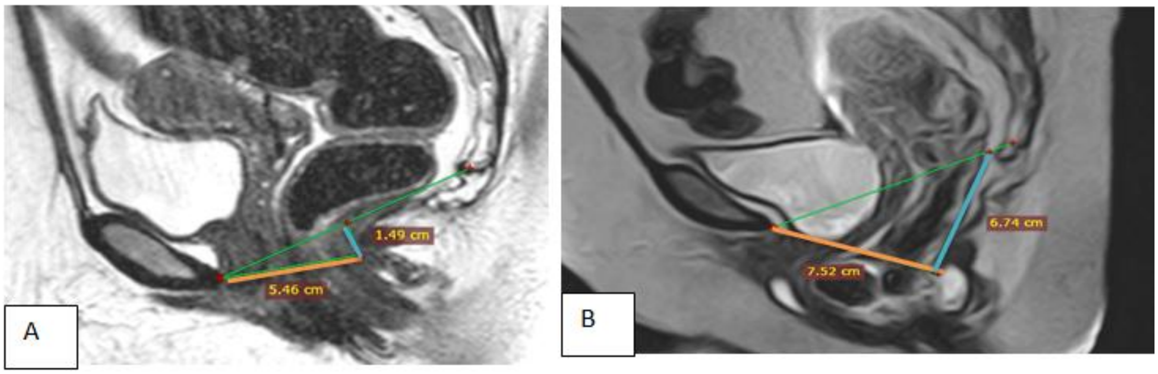

Fig 1. 51 year old patient , Para 3 . Complaining of sensation of vaginal mass . Previous surgery for SUI. Figure A (right) and B (left) , Midsagittal static (A) T2 WI and dynamic (B) during maximum straining , revealing mild increase in H line (orange line)with straining (Figure B) measuring 7.52 cm (max increase with straining should be 6 cm) and marked increase in M line (blue line) during straining measuring 6.74 cm (normally up to 2 cm) denoting pelvic floor relaxation .

RESULTS

A total of 20 women were included in the study, with mean age 42.75+13.27 years. 1 was nulliparous and the other 18 had a median parity of 3 **Fig. 2.** Delivery events are summarized in **Table 2**. Of the 20 included women, 12 (60%) were premenopausal, while 8 (40%) were postmenopausal. Five patients (25%) had a previous surgery for PFD. The patients' complaints were variable, ranging between organ prolapse, urinary, fecal incontinence or a combination. **Table 3** summarizes patients' complaints. Regarding physical examination, 15 (75%) had cystocele, 14 (70%) had rectocele, 11 (55%) had uterine descent, while 2 (10%) had enterocele. **Table 4** highlights physical examination findings and its grading. Regarding MRI findings, **cystocele** was detected in 18 (90%) women [7 (35%) were grade 1, 9 (45%) were grade 2, 2 (10%) were grade 3], **rectocele** in 16 (80%) women [3 (15%) were grade 1, 11 (55%) were grade 2, 2 (10%) were grade 3]; **Uterine descent** in 14 (70%) women [5 (25%) were grade 1, 4 (20%) were grade 2, 4 (20%) were grade 3 and 1 (5%) was grade 4] and **enterocele** in 9 (45%) women [3 (15%) were grade 1, 5 (25%) were grade 2]. **Fig. 3.**

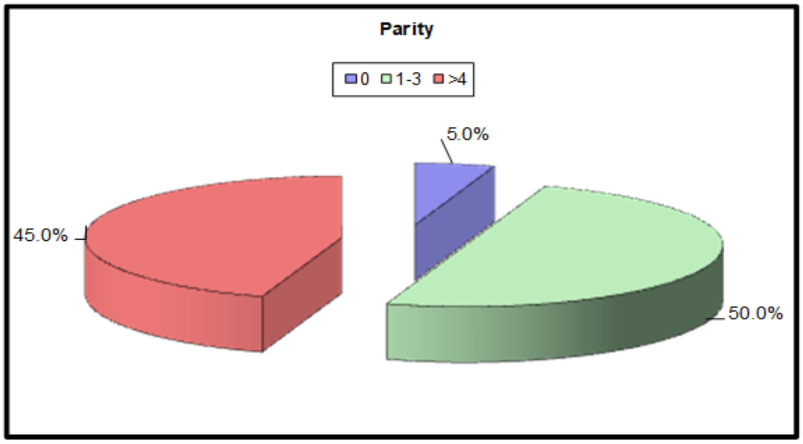

Fig.2 Pie-Chart showing Parity Distribution in Included Women

Table (2): Previous Delivery Events in Included Women.

Obstetric and Natal History		No. = 20
Mode of delivery	Nulliparae	1 (5.0%)
	Vaginal	18 (90.0%)
	C.S	1 (5.0%)
Place of delivery	Nulliparae	1 (5.0%)
	Home	4 (20.0%)
	Hospital	15 (75.0%)
Obstructed labor	No	13 (65.0%)
	Yes	7 (35.0%)
Episiotomy	No	7 (35.0%)
	Yes	13 (65.0%)
Instrumental delivery	No	17 (85.0%)
	Yes	3 (15.0%)
High BW	No	14 (70.0%)
	Yes	6 (30.0%)
Successive deliveries	No	11 (55.0%)
	Yes	9 (45.0%)

Table (3): Complaint of the included patients.

Patient complaint		No.	%
SUI	No	7	35.0%
	Yes	13	65.0%
Genital prolapse	No	10	50.0%
	Yes	10	50.0%
Defecatory disorder	No	6	30.0%
	Yes	14	70.0%
Combined	No	8	40.0%
	Yes	12	60.0%

Table (4): Physical Examination Findings in Included Women.

Physical examination		No.	%
Cystocele			
No		5	25.0%
Yes		15	75.0%
Grade 1		**7**	**35.0%**
Grade 2		**6**	**30.0%**
Grade 3		**2**	**10.0%**
Rectocele			
No		6	30.0%
Yes		14	70.0%
Grade 1		**7**	**35.0%**
Grade 2		**4**	**20.0%**
Grade 3		**3**	**15.0%**
Enterocele	No	18	90.0%
	Yes	2	10.0%
Uterine descend			
No		9	45.0%
Yes		11	55.0%
Grade 1		**5**	**25.0%**
Grade 2		**4**	**20.0%**
Grade 3		**1**	**5.0%**
Grade 4		**1**	**5.0%**

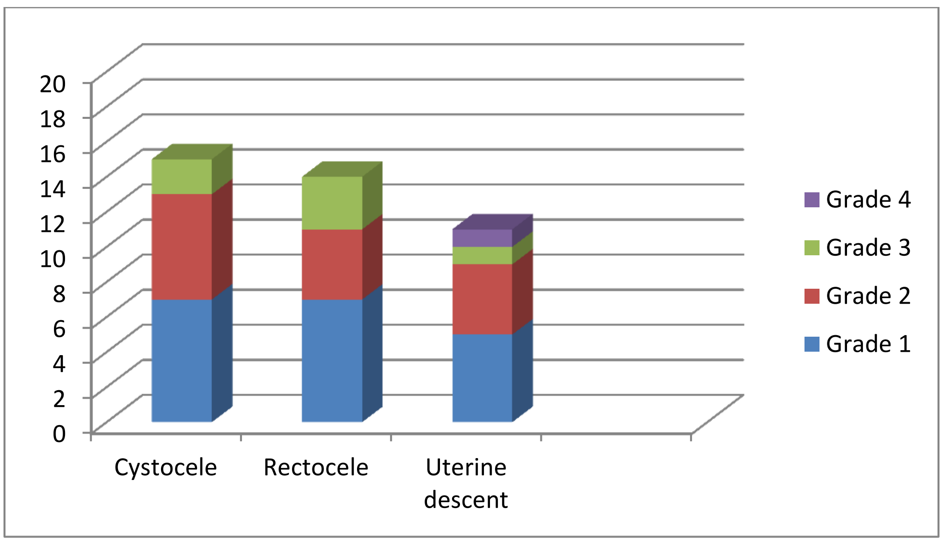

Fig. 3 Bar-Chart showing Physical Examination Findings regarding Anterior, Posterior and Middle Compartments in included patients.

Comparing dynamic MRI findings to physical examination findings:

There was non-significant agreement between MRI and physical examination findings regarding presence or absence of cystocele [κ=0.167, p=0.389] (Table 5). Of the included 20 women, 15 (75%) had similar findings (whether positive or negative for cystocele), while in 4 (20%) women MRI detected cystocele that was missed by physical examination, and in 1 (5%) MRI missed cystocele that was diagnosed by physical examination (Table 5, Fig. 4).

Table (5): Agreement between Physical Examination and MRI Findings Regarding Anterior Compartment in included patients.

MRI finding	Physical examination				Percentage of agreement	κ	P-value
	Normal		Cystocele				
	No.	%	No.	%			
Normal	1	5.00%	1	5.00%	75.00%	0.167	0.389 NS
Cystocele	4	20.00%	14	70.00%			

Data presented as number (percentage) MRI = magnetic resonance imaging
κKappa = coefficient of agreement NS = non-significant

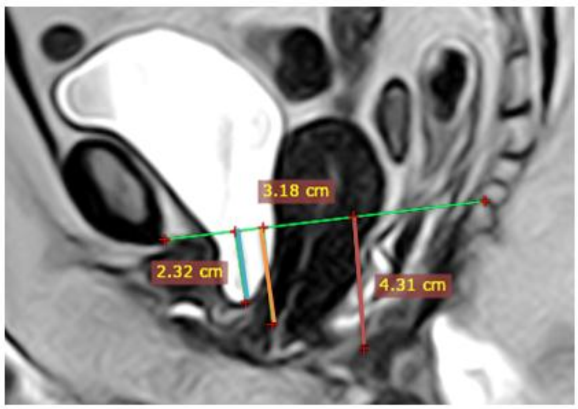

Fig 4. A 53 year old patient , Para 5+1 , Vaginal delivery . Complaining of stress urinary incontinence and sensation of vaginal mass.

Midsagittal dynamic image during maximum straining revealing descend of bladder base (blue line) , anterior cervix (orange line) and Ano-rectal junction (red line) relative to PCL (green line) by 2.32 , 3.18 and 4.31 cm denoting grade I cystocele , grade II uterine descent and grade I ARJ descent respectively.

There was a significant agreement between MRI and physical examination findings regarding presence or absence of rectocele [κ=0.474, p=0.028]. Of the included 20 women, 16 (80%) had similar findings (whether positive or negative for rectocele), while in 3 (15%) women MRI detected rectocele that was missed by physical examination, and in 1 (5%) MRI missed rectocele that was diagnosed by physical examination (Table 6, Fig. 5)

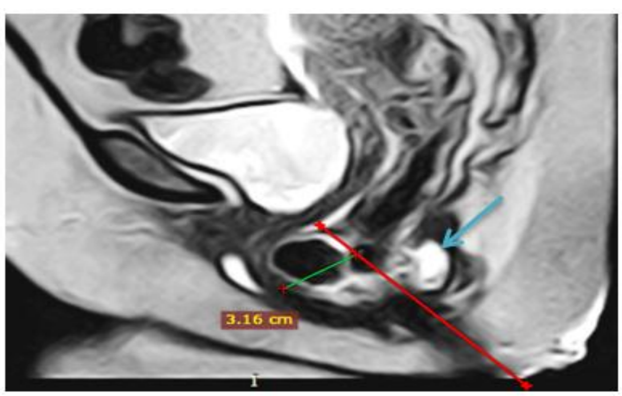

Fig 5. A 40 year old patient, Para 4. Complaining of sensation of vaginal mass. Midsagittal dynamic image revealing grade II anterior rectocele. Posterior rectocele is also noted (blue arrow).

Table (6): Agreement between Physical Examination and MRI Findings Regarding Posterior Compartment in Included Patients.

MRI findings	Physical examination				Percentage of agreement	κ	P-value
	Normal		Rectocele				
	No.	%	No.	%			
No	3	15.0%	1	5.0%	80.00%	0.474	0.028 S
Yes	3	15.0%	13	65.0%			

Data presented as number (percentage) MRI = magnetic resonance imaging
κKappa = coefficient of agreement S = Significant

There was a non-significant agreement between MRI and physical examination findings regarding presence or absence of enterocele [κ=0.239, p=0.099]. Of the included 20 women, 13 (65%) had similar findings (whether positive or negative for enterocele), while in 7 (35%) women MRI detected enterocele that was missed by physical examination (Table 7, Fig 6)

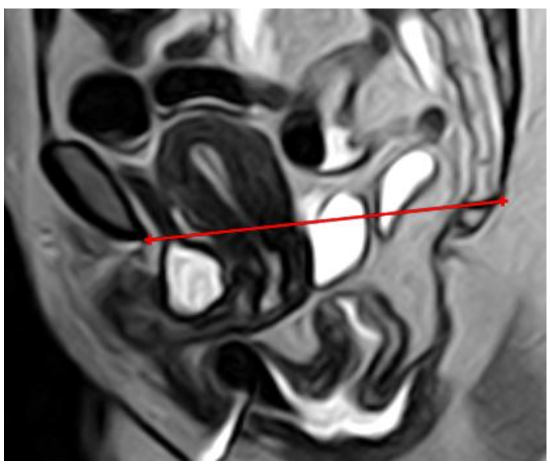

Fig 6. A 38 year old patient, Para 3+2. Complainig of sense of incomplete defecation . Midsagittal dynamic image during maximum staining showing enterocele evident by descent by bowel loops below PCL. Anoanal intussusception is also seen.

Table (7): Agreement between Physical Examination and MRI Findings Regarding Enterocele in Included Patients.

MRI findings	Physical examination				Percentage of agreement	κ	P-value
	Normal		Enterocele				
	No.	%	No.	%			
No	11	55.0%	0	0.0%	65.0%	0.239	0.099 NS
Yes	7	35.0%	2	10.0%			

Data presented as number (percentage) MRI = magnetic resonance imaging
κKappa = coefficient of agreement NS = non-significant

There was a significant agreement between MRI and physical examination findings regarding presence or absence of uterine descent [κ=0.479, p=0.024]. Of the included 20 women, 15 (75%) had similar findings (whether positive or negative for uterine descent), while in 4 (20%) women MRI detected uterine descent that was missed by physical examination and in 1 (5%) MRI missed uterine descent that was detected by physical examination (Table 8).

Table (8): Agreement between Physical Examination of Middle Compartment Defect and MRI Findings of Uterine Prolapse in Included Patients.

MRI findings	Physical examination				Percentage of agreement	κ	P-value
	Normal		Uterine descent				
	No.	%	No.	%			
Normal	5	25.0%	1	5.0%	75.0%	0.479	0.024 S
Uterine descent	4	20.0%	10	50.0%			

DISCUSSION

PFD affects approximately 50% of women older than 50 years worldwide. In one study involving women with PFD, the estimated lifetime risk of undergoing a single surgical intervention for PFD was 11.1%, and two or more surgical procedures were required in 30% of cases [7]. In our study, 5 of the 20 examined women, (25%), had undergone previous surgery for genital prolapse or stress urinary incontinence. This result is close to a report from **Oslen *et al*. [9],** which indicates that 29% of the procedures performed for incontinence and prolapse are repeat surgeries **.**

Traditional imaging procedures (e.g., urody-namic study, voiding cystourethrography, and fluoroscopic cystocolpodefecography) remain practical and cost-effective methods for evaluating uncomplicated anorectal and pelvic dysfunction.

Dynamic magnetic resonance (MR) imaging of the pelvic floor is a well-established modality for pelvic floor evaluation, with high-resolution images yielding detailed anatomic information and dynamic sequences yielding functional data [10]**.**

The findings of this study illustrate the added clinical benefit of performing dynamic pelvic floor MRI as part of an interdisciplinary approach to the treatment of pelvic floor dysfunction.

To gain insight in the underlying pathology so that radiologists can accurately define the structural defect, we must adopt a new, more function-based classification of the pelvic organ support system that groups all of the structures that contribute to the same function under one system. Therefore, all of the structures that maintain urinary continence can be grouped under the term urethral support system, the supporting elements that prevent prolapse can be grouped under the term vaginal support system, and the anal sphincter complex is the main component responsible for anal continence [3]**.**

Gupta *et al*. [10] found that dynamic MR imaging correlated poorly with clinical examination in all the three compartments, which was also not matching the results of this study except for the middle compartment. This could be due to the use of a different MRI staging system which was the HMO grading system, but they referred to ‘‘H’’ line representing the puborectalis hiatus. They also used the POP-Q system for clinical grading of prolapse. Therefore, the diversity of the clinical systems as well as the MRI reference lines used could be responsible for different results. However, **Gupta *et al*. [10].**found that the main advantage of MRI was the better detection of enteroceles missed on clinical examination which correlated well with intra operative findings. This was also noted in this study where MRI detected enteroceles in six patients but missed by physical examination. This could be interpreted as a better detection of enteroceles by MRI, which could have a positive impact on the surgical outcome of patients. In our study, we did not correlate MRI findings with operational data. This did not allow the assessment of the sensitivity and diagnostic accuracy of MRI. We tried to emphasize the good relation between dynamic MRI grading of pelvic organ prolapse and clinical examination grading which could affect the surgical decision, i.e. upgrading or downgrading of pelvic organ prolapse, the presence or absence of interracial discovered by dynamic MRI will change the operative decision taken.

SUMMARY AND CONCLUSION

Despite the potential limitation, and the ongoing debates concerning a common reference line for the MRI grading of prolapse, the position of the patient in the magnet, the monitoring of abdominal pressure, the bladder volume, the use of intravaginal or intrarectal contrast agent, we strongly think that these debates will be solved only after collaborative research work to standardize the technique, and the criteria for evaluation.

However, the above debates at the end don't obviate the facts that dynamic MRI for evaluating pelvic floor dysfunction, besides being rapid, non-invasive, and cost effective, what is most important, it allows clinicians to survey the whole pelvis by a single dynamic study that offer exquisite anatomical details. And at the same time wide spectrum of gynecological pathology of the adnexa and uterus may be imaged with significant accuracy upon which certain changes were made in patient care.

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