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ASSESSING PELVIC FLOOR DYSFUNCTION: COMBINED ANALYSIS OF STATIC AND DYNAMIC MAGNETIC RESONANCE IMAGING FINDINGS

<u>Hypothesis / aims of study</u>

To prospectively analyze static and dynamic magnetic resonance (MR) images simultaneously to determine whether stress urinary incontinence (SUI), pelvic organ prolapse (POP), and anal incontinence are associated with specific pelvic floor abnormalities.

<u>Study design, materials and methods</u>

Fifty-nine women—15 nulliparous study control women (mean age, 25.6 years) and 44 patients (mean age, 43.4 years)—were divided into 4 groups according to chief complaint. Static T_2-weighted turbo spin-echo images were used to evaluate structural derangements; functional dynamic (cine) balanced fast-field echo images were used to detect functional abnormalities and to record 5 measurements of supporting structures which include the H-line, M-line, levator plate angle in the sagital plane. In the axial and coronal planes, the width of the levator hiatus and the iliococcygeus angle were measured, respectively, at rest and during maximum straining. These 5 measurements were all considered to reflect the status and the weakness of the levator ani. Findings of both types of MR images were analyzed together to determine the predominant defect. Analysis of variance and the Bonferroni *t*-test were used to compare groups.

Table 1. Findings Obtained on Static and Dynamic MR Images of the Patient Groups

Static Axial Images (Defects of the Pelvic Organ Support System)									
Groups[a]	Urethral Supporting Structures			Vaginal Supporting Structures				Anal Sphincter	
	Ligament	Level III Fascia	Puborectalis Muscle	Level I and II Vaginal Endopelvic Fascia			Iliococcygeus Muscle	External Anal Sphincter	Internal Anal Sphincter
				Paravaginal	Central	Paravaginal and Central			
Group A (n = 10) POP	0/10	0/10	0/10	6/10[a]	1/10	2/10	1/10	0/10	0/10
Group B (n = 10) SUI	0/10	9/10	0/10	3/10	1/10	4/10	0/10	0/10	0/10
Group C (n = 16) SUI + POP	4/16	8/16	1/16	9/16	1/16	6/16	0/16	1/16 Thinning	0/16
Group D (n = 8) Anal Inc + POP, SUI in 3 patients	0/8	2/8	1/8	4/8	0/8	2/8	2/8	6/8 Defects Two patients had intact sphincter	3/8 Scarring

<u>Results (Table 1)</u>

In the 4 patient groups, POP was associated with levator muscle weakness in 16 of 34 (47%) patients, with level I and II fascial defects in 7 of 34 (20.6%), and with both defects in 11 of 34 (32.3%). SUI was associated with defects of the urethral supporting structures in 25 of 29 (86.2%) patients but not with bladder neck descent. Levator muscle weakness may lead to anal incontinence in the absence of anal sphincter defects. Measurements of supporting structures were statistically significant ($p < 0.05$) in identification of pelvic floor laxity.

<u>Interpretation of results</u>

1. Combined analysis of static and dynamic magnetic resonance images of the pelvic floor reveal that certain anatomic defects on static images are associated with specific functional abnormalities on dynamic images.
2. It is possible to differentiate whether prolapse is due to defects in the endopelvic fascia, to levator muscle weakness, or to abnormalities in both fascia and muscles (Fig. 1)
3. Stress urinary incontinence is associated with structural defects in the urethral supporting structures rather than with bladder neck descent.
4. In the absence of an anal sphincter defect, anal incontinence is associated with marked levator muscle weakness.

Implications for Patient Care: The association between precise anatomic defects in the pelvic organ support system and specific pelvic floor dysfunction allows for a defect-specific approach to pelvic floor dysfunction for each patient. This is because the suggested MR images analytic approach allows integration of static and dynamic MR imaging findings so that clinician can more precisely identify the underlying anatomic defect responsible for symptoms in individual patients with PFD (even allows differentiation of underlying anatomic defect when any 2 patients had the same symptoms), and thus decide on a more tailored treatment of the underlying abnormality.

<u>Concluding message</u>

Combined analysis of both static and dynamic MR images of patients reporting SUI, POP, and anal incontinence provides complementary information and allows identification of certain structural abnormalities and their association with specific pelvic floor dysfunctions. This analytic approach gives insight into the diagnosis of these complex pathologies and may also allow for a defect-specific approach to disease management and surgical technique.

Dynamic (Cine) Images (Dysfunction and Measurements of Supporting Structures)											
SUI	Mean and SD of Pelvic Organ Descent (cm) in Sagittal Plane at Maximum Straining				Mean and SD of Supporting Measurements						
					Sagittal Plane			Axial Plane		Coronal Plane	
Loss of Urine at Maximum Straining	Bladder Neck	Bladder Base	Uterus	Others[b]	H-Line (cm)	M-Line (cm)	Levator Plate Angle	Width of Levator Hiatus (cm)		Iliococcygeus angle	
								At rest [b]	At maximum straining	At rest[b]	At maximum straining
0/10	1 (± 0.7) 7/10[a]	1.4 (± 1) 7/10	3.1 (± 1) 6/10	Detected in 7/10	7 (±0.7)	2.9 (±1.2)	40.6° (±16.9)	4.2 (±0.6)	7.2 (±1.7)	24° (±1.8)	57.95° (±14)
7/ 10	0.6 (±0.3) 5/10	0.7 (± 0.4) 5/10	No uterine descent	No other	5.95 (±0.7)	2.4 (±1.1)	17.9 (±1.1)	3.2 (±0.3)	4.4 (±0.8)	25.1° (±1.8)	35.9° (±9.2)
12/16	1.9 (±0.5) 16/16	2.3 (±0.9) 16/16	1.7 (±0.7) 11/16	Detected in 4/16	7.9 (±0.6)	3.7 (±1.1)	50.5° (±16.8)	4.2 (±0.5)	7.4 (±0.8)	24.8° (±20)	61° (±7)
2/8	2 (±0.8) 8/8	2.9 (±1.2) 8/8	4.1 (±1.7) 8/8	Detected in 5/8	10.9 (±1.9)	5.98 (±2.1)	77.6° (±18.9)	4.5 (±0.4)	7.95 (±0.8)	27.5° (±5.2)	73.2° (±10.4)

MR = magnetic resonance; POP = pelvic organ prolapse; SD = standard deviation; SUI = stress urinary incontinence.
[a]Numbers indicate in how many patients urethral defects, vaginal defects, and anal sphincter defects were detected and in how many patients the mean pelvic organ descent was calculated.
[b]Others include peritoneocele, enterocele, rectocele, and anorectal junction descent.

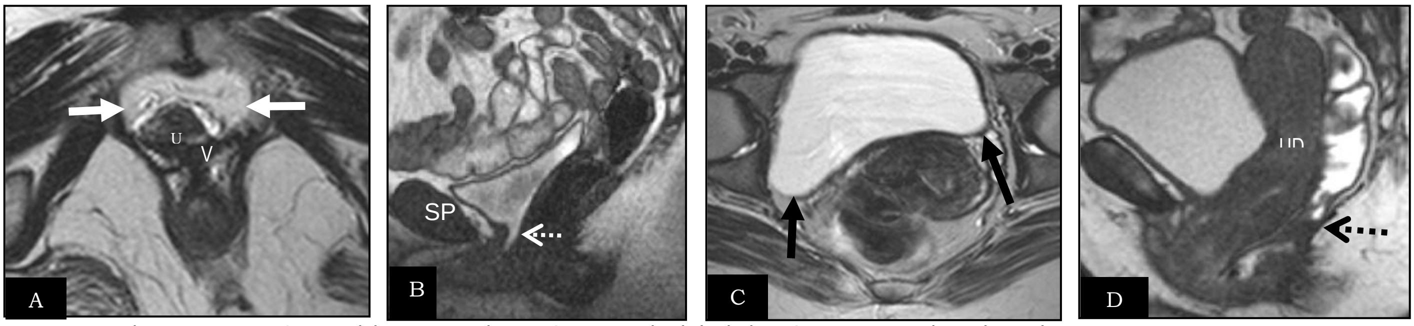

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Fig 1: Combined analysis of Static and dynamic magnetic resonance (MR) images to determine the predominant defect in different PFD. Static axial T_2-weighted turbo spin-echo MR image (5000/132) **(A)** and dynamic **(B)** sagittal balanced fast-field echo MR image (5/1.6) from a 48-year-old patient presenting with SUI. **A,** at the level of the proximal urethra shows a level III endopelvic fascial defect, indicated by the “drooping mustache” sign which is formed by fat in the prevesical space against the bilateral sagging of the detached lower third of the anterior vaginal wall from the arcus tendineus fascia (arrows) (U),urethra; (V),vagina. **B,** shows loss of urine during straining; the bladder neck movement was noted to be in a vertical (dashed arrow) and not in a rotational direction. This type of movement was frequently associated with level III endopelvic fascial defects.SP, symphysis pubis. **(C)** Static axial T2-weighted turbo spin-echo MR images (5000/132) from patient, age 23 years, with pelvic organ prolapse (POP) **(D)** the corresponding dynamic sagittal balanced fast-field echo MR images (5/1.6) at maximum straining. In **C**, a bilateral asymmetrical level I paravaginal fascial defect (arrows) is more severe on the right visualized as sagging of the urine-filled posterior urinary bladder wall due to the detachment of the vaginal supporting fascia from the lateral pelvic wall, known as the “saddlebags sign”. In **D**, a sagging levator plate (dashed arrow) and uterine descent (UD) can be seen. Combined analysis of static and dynamic imaging findings for this patient revealed a predominant fascial defect.

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Was this study approved by an ethics committee?	**Yes**
Specify Name of Ethics Committee	**Cairo University Hospitals**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**