AIM OF THE WORK

The aim of the study is to describe:

The anatomy of the anterior and middle compartments of the pelvic floor, as well as the pelvic floor dysfunction in females of different age groups that might be the reason for stress urinary incontinence using dynamic magnetic resonance imaging.

The DYNAMIC MRI technique used to identify pelvic floor anatomy and anterior compartmental derangement.

SUBJECTS

This study was conducted on 30 females of different age groups and parity status presented or referred to the Diagnostic and Interventional Radiology Department of Alexandria faculty of Medicine and Main University Hospital from June 2013 till October 2014.

The studied subjects underwent through history taking via detailed questionnaire regarding any urinary, genital or rectal symptoms.

The studied subjects' main complaint was involuntary leakage of urine due to stress.

Then they underwent physical diagnosis for provisional diagnosis and lastly all underwent dynamic MRI of the pelvis.

METHODS

All patients were subjected to the following:

1. Informed consent was signed by every patient.

2. Thorough history taking: A short questionnaire to select the females giving a provisional diagnosis of stress incontinence before undergoing imaging containing the following:
   i) Age?
   ii) How many children do you have, and method of delivery?
   iii) Do you have the urge to micturate and accidentally leak urine?
   iv) Do you leak urine during coughing, sneezing, or heavy lifting?
   v) Do your symptoms worsen with stress?
   vi) Do you suffer from itching/ scratching in your vulva?
   vii) Did you undergo pelvic surgeries before?
   viii) Did you take any medical treatment concerning your condition?
   ix) Do you have difficulties emptying your bowel or bladder?

Clinical examination:

The clinical examination should focus on detecting anatomic and neurologic abnormalities that contribute to urinary incontinence. The neurourologic examination begins by observing the patient's gait.

A lax or weakened anal sphincter or the inability to contract and relax the sphincters voluntarily, are signs of neurologic damage. The bulbocavernous reflex is checked by suddenly squeezing the clitoris and feeling (or seeing) the anal sphincter and perineal muscles contract. Alternatively, the reflex may be initiated by suddenly pulling the balloon of the Foley catheter against the bladder neck. The absence of this reflex in men is almost always associated with a neurologic lesion, but the reflex is not detectable in up to 30% of otherwise normal women.

A vaginal examination should be performed with the bladder both empty (to check the pelvic organs) and full (to check for incontinence and prolapse). With the bladder comfortably full in the lithotomy position, the patient is asked to cough or strain in an attempt to reproduce the incontinence. The degree of urethral hypermobility is assessed by the Q-Tip test. The Q-Tip test is performed by inserting a well-lubricated sterile cotton-tipped applicator gently through the urethra into the bladder. Once in the bladder, the applicator is withdrawn to the point of resistance, which is at the level of the bladder neck. The resting angle from the horizontal is recorded. The patient is then asked to strain and the degree of rotation is assessed. Hypermobility is defined as a resting or straining angle of greater than 30 degrees from the horizontal. (Figure 7)[40]

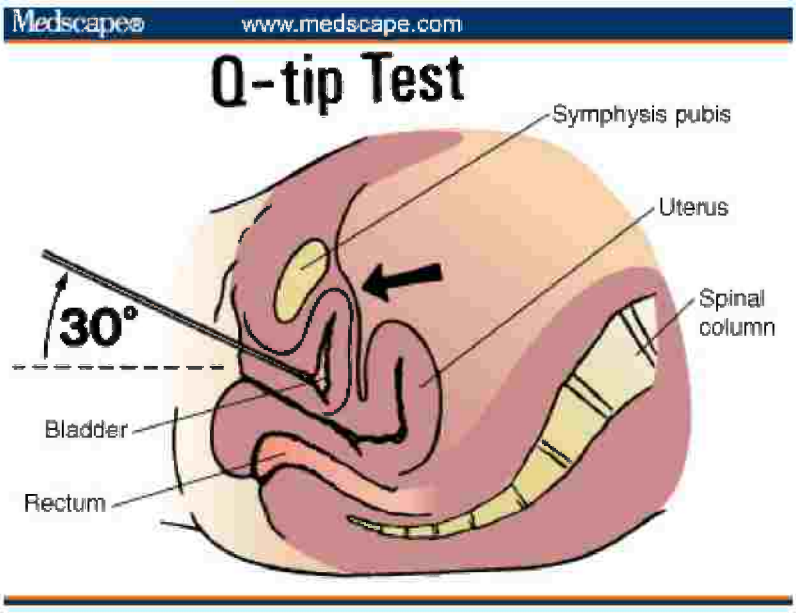

Figure 7: Q- tip Test[40]

The anterior vaginal wall is examined first in the lithotomy position. The patient is instructed to strain and cough to assess for bladder, urethral, and cervical mobility and stress incontinence. Reduction of the cystocele (either manually or with a pessary) in both positions may be necessary to demonstrate stress incontinence. The posterior vaginal wall and vault are examined for the presence of a rectocele or enterocele.

If incontinence is not demonstrated with the patient in the lithotomy position and in a patient with known or suspected prolapse, the examination is repeated in the standing position. The patient should be positioned standing in front of the examiner with one foot elevated on a short stool and again asked to cough and strain.

MRI study of pelvic floor:

1) Preparation:

(a) The patients were instructed not to urinate for at least 2 hours before the examination, as we use the T2 hyperintense signal of urine as contrast to delineate the bladder from the surrounding structures, however they were instructed not to retain urine for long to avoid limited organ movement if the bladder was fully distended as well as to tolerate straining without having fear of urine drippings and soiling themselves. Nothing else was needed.

(b) The patients should be familiar with the intention and course of the examination. The Valsalva maneuver was practiced with the patient before the procedure to ensure an adequate straining during the examination, to make it easier to the subjects to understand what they had to do, they were told to strain as if defecating in their toilets.

2) Technique:

MRI was performed on a 1.5 Tesla closed-configuration Phillips Extended MR workspace 2.6.3.5 system using a surface pelvic array-surface coil. Functional cine MRI of the pelvic floor is a synthesis of an imaging modality (MRI with its distinct features) and an adequate method of examination (capture of movements).

The patients were positioned supine without tilting of the pelvis to either side. Place waterproof pads underneath the buttocks to protect the machinery from unintended leakage and to encourage the patient to strain forcefully. The subject may also flex their knees in order to simulate a sitting position, and hence strain more easily and forcefully.

Next we combined static and dynamic (functional) pulse sequences:

Three-plane scout images were obtained to identify the pubic symphysis, urinary bladder, vagina, rectum, coccyx, sacrum, ischial spine, and ischial tuberosity.

Axial and sagittal slices, respectively, were obtained by means of a T2-weighted turbo spin-echo sequence with the following parameters: repetition time/echo time (TR/TE), 1800msec /100 msec; FOV 290-350 mm with RFOV 100%, 256x256 matrix; and slice thickness 4mm with gap 0.4.

Dynamic (functional) studies were performed with balanced fast field echo (BFFE) at rest and after maximal straining (Valsalva maneuver) producing multiple single slices at the same slice position. The following parameters were used: TR/TE ratio 2:1 mostly in the range of 8-9 msec /4-4.5 msec;flip angle 45, FOV 290-350 mm, 256x256 matrix; slice thickness 10 mm; and section gap1 mm, with a technique that lasted for 3-5 seconds according to the number of acquisitions which shouldn't exceed 5 slices with a range of 1 slice/sec in order not to decrease the quality of the reconstructed dynamic image. Before the start of the dynamic sequences the doctor or the assisting nurse would go in and instruct the subject to start straining when hearing the banging sound of the MR machine which reflects the start of the sequence and start straining till the sound stops, this was the most accurate way to ensure that the subject would perform maximum straining during the acquisition.

The static section included T2-weighted turbo spin-echo sequences of the pelvis in axial and sagittal orientation. The FOV as well as the stack of slices should cover the whole pelvis. These acquired images were essential for a variety of reasons. The high in-plane resolution allowed for a morphological assessment of structures (e.g. pelvic floor muscles).

The dynamic (functional) standard slice orientation included a midsagittal and an axial (lower rim of the pubic bone) alignment. The sagittal images visualized all compartments at the same time. The axial images provided information about the urogenital hiatus ballooning and its contents if any (e.g. enteroceles, rectal descent and descending perineal syndrome). During the measurements the patient was asked to relax the pelvic floor muscles, then asked to increase the intra-abdominal pressure by straining and then relax again. This cycle was repeated twice to a maximum of four times.

Additional slice orientations may be performed to: (a) Evaluate unexpected findings on the standard images. (b) Alternatively, sagittal scan planes can be extended to either side of the midline which became termed para-sagittal planes in cases where measurements couldn't be obtained in the mid-sagittal view as the organs could deviate to either side during straining. (c) To gain more information on the levator ani muscle we could perform T2-weighted coronal stack of slices at rest and straining. Fat suppression sequences could be performed if suspecting recent muscular affection.

The overall time of examination varied between 15 and 20 min. according to the number of performed sequences.

Image analysis was done using a Phillips Workstation (Extended MR workspace 2.6.3.5). The following parameters were used in our study:

a. Bladder descent: through measurement of the vertical distance between the pubococcygeal line (PCL) & the bladder base.

b. Hypermobile urethra.

c. Urethrovesical angle which should be more than 180 degrees during straining in patients with hypermobile urethra

d. H-shaped configuration of the vagina weather preserved or lost.

e. Bladder neck funneling

RESULTS

This study was performed on 30 females of different age range and different parity status.

The females were divided into:

1. clinically diagnosed cystocele- 16 case
2. utero-cervical/vaginal vault prolapse- 8 cases
3. rectal prolapse &/or rectocele- 6 cases

Their age range is from 15-64, with seven of them being nulliparous, the rest were multiparous, of which twenty had NVD (normal vaginal delivary) and three underwent cesarean section (CS). Fifteen of the mulltiparous patients delivered at home which raised the suspicion of developing complications, while one of those who delivered in a hospital had post-partum complications eg. Tear.

Parity status is defined as the number of deliveries, while the number of pregnancies is the gravidy status. The parity status described above reflected the normal vaginal deliveries (NVD) only 3 of the patients had caesarian section (C.S.), these were subtracted from the total times of delivery and only the NVD were enumerated as these were the ones involving potential alteration in the pelvic floor anatomy.

MR Imaging Findings

In our research we divided the pathologies into pelvic floor muscle, ligamentous pathologies, vesico-urethral angle pathologies, cystocele then additional pathologies such as uterine prolapse, posterior compartmental pathologies including rectal descent, prolapse and rectocele.

Seventeen out of the 30 patients showed asymmetry between the two puborectalis muscle slings with 10 patients showing partial tear in the pubic attachment of the pubo-rectalis muscle (Figure 8a).

Twenty six patients show redundant urethral supporting ligaments with 11 of them showing funneled bladder base (Figure 14b). Finally, almost all patients showed loss of the normal position of the perineal plate indicating generalized weakness of the whole pelvic floor muscles as well as urethral hypermotility.

All patients proved to have additional pathologies to those already diagnosed by the static images as well as accurately diagnosing the vesicourethral angle which reflects urethral hypermotility, i.e. on static images it could be classified as mild but after straining it turned out to be severe for example (Figure 9a,b). (Table 5).

Furthermore Q-tip test and straining are usually used on clinical examination as an aid to diagnosis as any of those condition usually start to develop and be observed primarily on straining and stress, therefore we try to mimic the situation during examination for better results aiding to a more accurate diagnosis.

Other pathologies such as three cases of RVF (Figure 12c) uterus and five cases of adenxial cysts were also discovered on MR imaging, because as we hinted before we use a wide FOV to detect any associated pathologies (Table 6).

The technique was easy to perform and well tolerated by all subjects, with an average examination time of 10 minutes. All examinations were successfully completed. None of our subjects and/or patients experienced claustrophobia or difficulties in straining down. All MR images both at rest and during maximum strain were considered technically adequate.

Table 1: Age range of cases. Our patients ages ranged from 15 up to less than 70 years, with the maximum number of patients between 50-60 years.

Age range	No. of patients
15 - <20	1
20 - <30 yrs.	8
30 - <40 yrs.	3
40 - <50 yrs.	3
50 - <60 yrs.	11
60 - <70 yrs.	4
Total	30

Table 2: Parity status. The parity status described below represents the NVD where the number of CS were omitted from the table. The greatest number of patients fall in the group of P2-<P4.

Parity status (NVD)	No. of patients
P_0 - <P_2	7
P_2 - <P_4	19
P_4 - <P_6	4

When submitted the questionnaire: Eight of the patients answered with "yes" to question 9 and turned to have peritoneocele on imaging. Twenty patients suffered from difficulties emptying their bladder, 14 of them had difficulties emptying their bowel too. All of the patients suffered worsening of their condition when exposed to stress such as heavy lifting.

Table 3: The answers to the questionnaire.

Questions	No. of females giving " YES " answers
1. Do you have difficulties emptying your bladder?	20
2. Do you have difficulties emptying your bowel?	14
3. Are your symptoms worse during stress, for example, during heavy lifting?	30
4. Has a doctor, in connection with a gynecologic examination, told you that you have a genital organ prolapse?	8
5. Do you suffer from itching in your vagina/vulva?	16
6. Do you have to do a digital manipulation of the anus to complete voiding?	14
7. Do you suddenly feel the urge to go to the toilet, and then accidentally leak urine?	27
8. Do you leak urine during coughing, sneezing, or heavy lifting?	27
9. Do you have a sensation of vaginal heaviness or pressure?	8

Table 4: MR findings in the patients as regards the points reported. 17 of the patients showed asymmetry in the puborectalis muscle slings, while the other 13 showed diffuse bilateral symmetrical thinning, the H shaped vaginal configuration was lost in 18 patient and preserved in the rest. Urethral supporting ligaments were redundant in most of the patients. 10 out of 30 showed funneling of the urinary bladder. However 27 case showed hypermobile urethra (more than one finding in the same patient).

Points to be reported			No. of patients
Puborectalis ms. Sling	**symmetrical**		13
	asymmetrical		17
	No tears		20
	tears	**partial**	10
		complete	-
H-shape of the vagina	**preserved**		12
	lost		18
Urethral supporting ligaments	**preserved**		4
	redundant		26
Funneling of bladder base	10		
Hypermotile urethra	27		

Table 5: **The difference between imaging diagnosis by static and by dynamic imaging. Only 2 patients showed cystocele in static imaging while 16 showed on dynamic, the rest did not show cystocele. Three patients showed utero-cervical/ vaginal prolapse in static imaging, and 8 showed in dynamic. However twenty-nine patient showed ano-rectal junction descent in static and dynamic imaging. Eight patients showed peritoneocele in dynamic imaging while none shoed in static.**

Associated pathology	Static MR Imaging	Functional MR Imaging
Cystocele	2	16
Utero-cervical / vaginal prolapsed	3	8
Ano-rectal junction descent (rectal prolapse) +/- rectocele	29	29
Peritoneocele +/- entero-/sigmoidocele	-	8

Table 6: **Associated pathologies other than pelvic floor descent as detected by MR imaging, 2 fibroids were incedentaly discovered, 3 RVF uterus were seen, 5 patients showed adenxial cysts and 2 patients showed adenomyosis.**

Associated Pathologies	Patients group
fibroids	2
RVF	3
adenxial cysts	5
adenomiosis	2

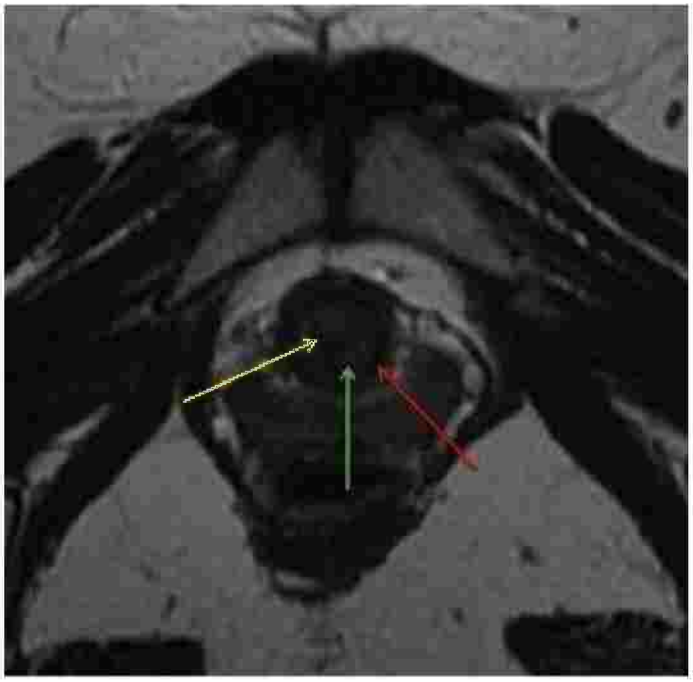

Figure 8a: Normal urethral zonal anatomy. Axial T2-weighted MR image shows a target-like appearance secondary to inner hypointense mucosal layer (yellow arrow), middle hyperintense submucosal layer (green arrow), and outer hypointense muscular layer (red arrow).

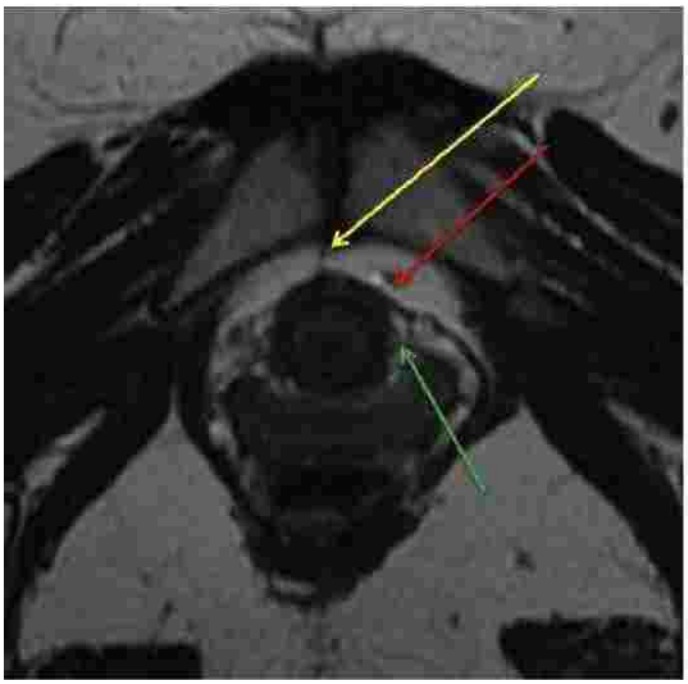

Figure 8b: Normal urethral supporting ligaments. Axial T2-weighted MR image shows pubourethral ligament (yellow arrow), periurethral ligament (green arrow), and paraurethral ligament (red arrow).

Figure 9a: 45 years old patient, multiparous. Midsagittal image at rest showing evidence of peritoneocele (black arrow) still all organs are above PCL (red line).

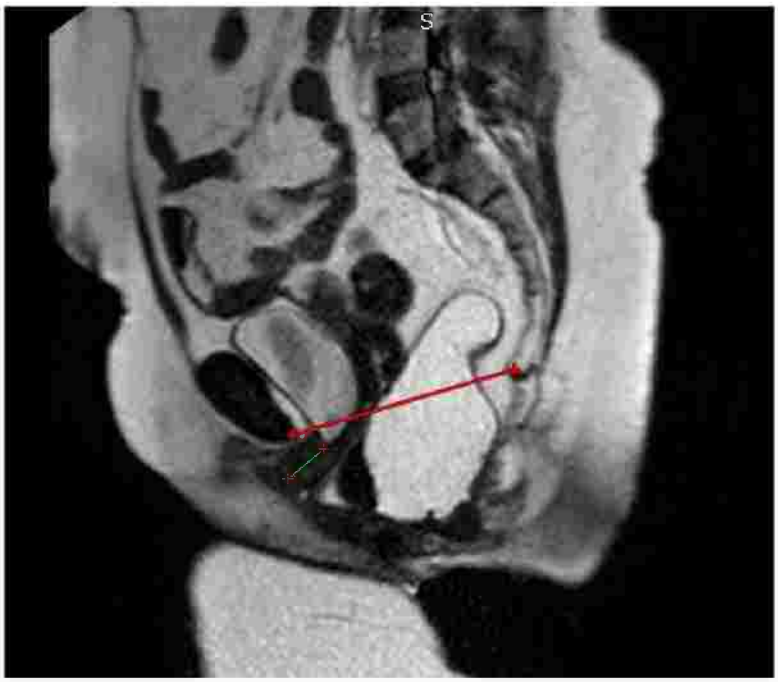

Figure 9b: Midsagittal image of same patient during straining showing evidence of mild cystocele (below PCL), with translation of urethra away from normal axis (green line) anterior rectocele and peritoneocele.

Figure 10a: 60 year old female, multiparous. Axial T2-weighted MR image shows thinning of the puborectalis muscle bilaterally, with diffuse fatty degeneration. Loss of normal configuration of the vagina.

Figure 10b. Axial T2 weighted image of same patient showing left lateral bladder wall herniation reflecting perineal tear.

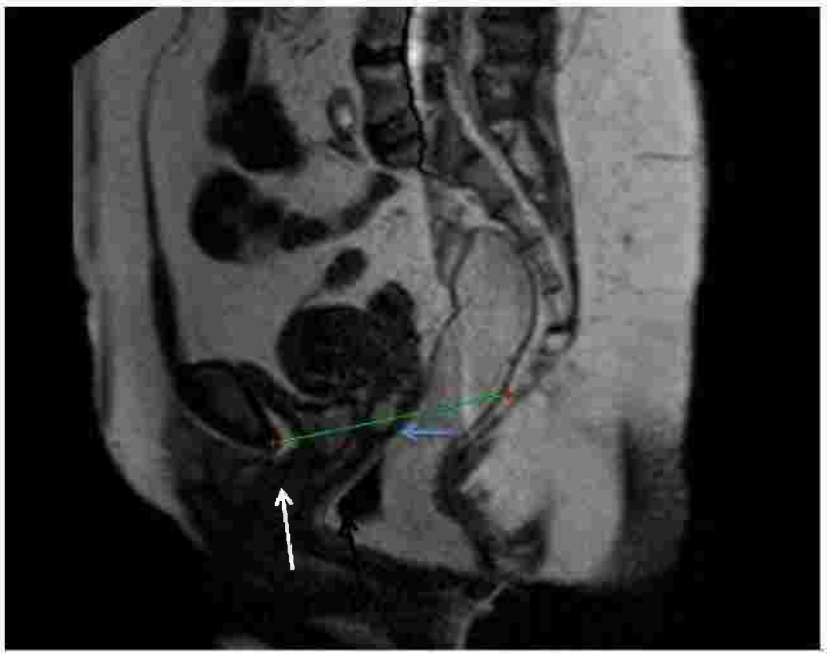

Figure 11a: A 42 years old multiparous patient. Midsagittal image revealing rectocele (black arrow), mild cystocele with hypermotile urethra (white arrow), and mild uterine prolapse (blue arrow)

Figure 11b: Axial T2-weighted image of the same patient showing the bladder protruding through perineal hiatus.

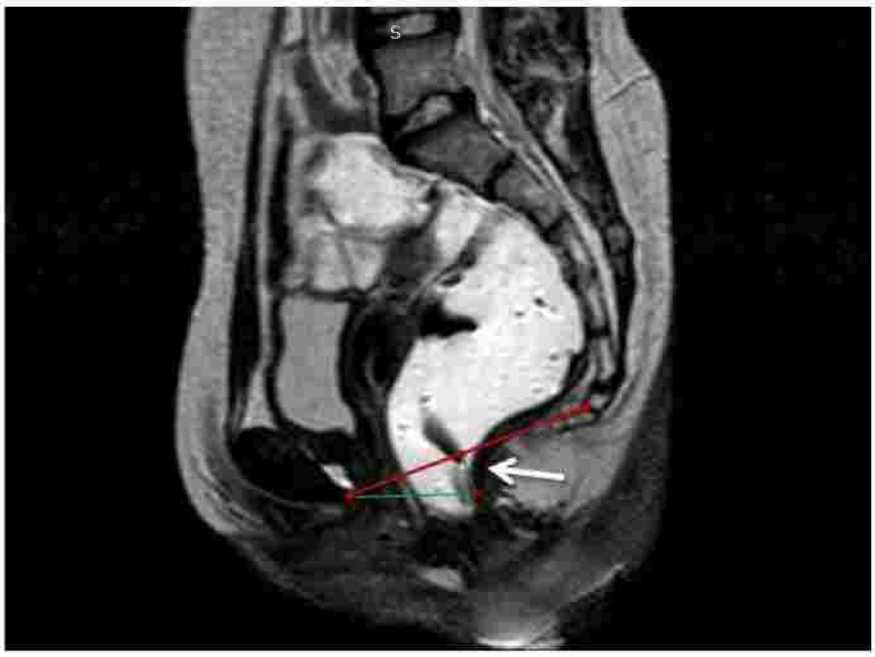

Figure 12a: 15 years old nulliparous female, Midsaggital T2 weighted image showing mild ano-rectal junction descent (white arrow) and secondary mega colon.

Figure 12b: Axial image of the same patient showing flattening of the normal H-shape of the vagina (white line) posteriorly by the descended rectum.

Figure 12c: Midsaggital image of the same patient showing RVF uterus (arrow)

Figure 13a. 23 year old nulliparous female. Midsaggital image showing funneling of the whole anal canal reflecting weak sphincteric mechanism. It also shows hypoplastic uterus, hypermotile urethra and ano-rectal junction descent

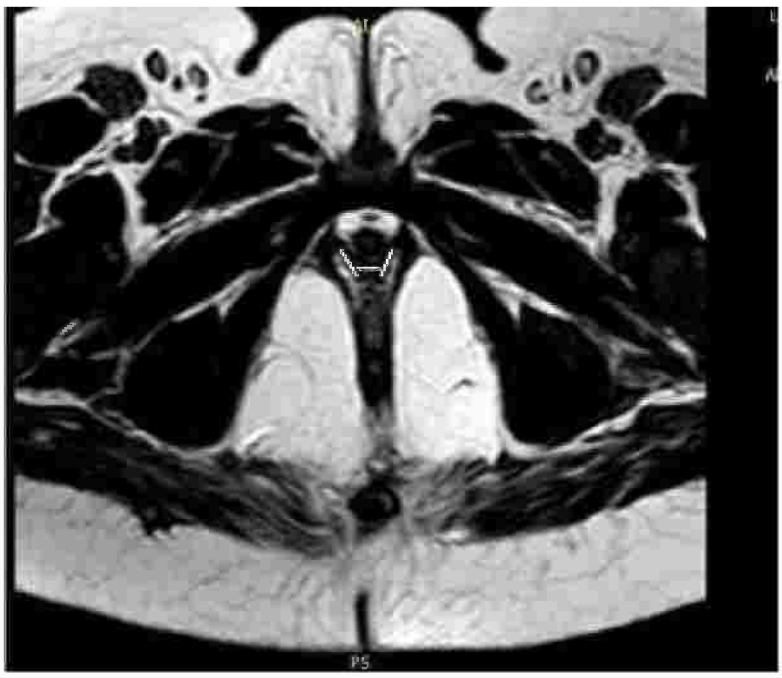

Figure 13b: Axial image of the same patient at rest showing preserved H-shape of vagina (white H)

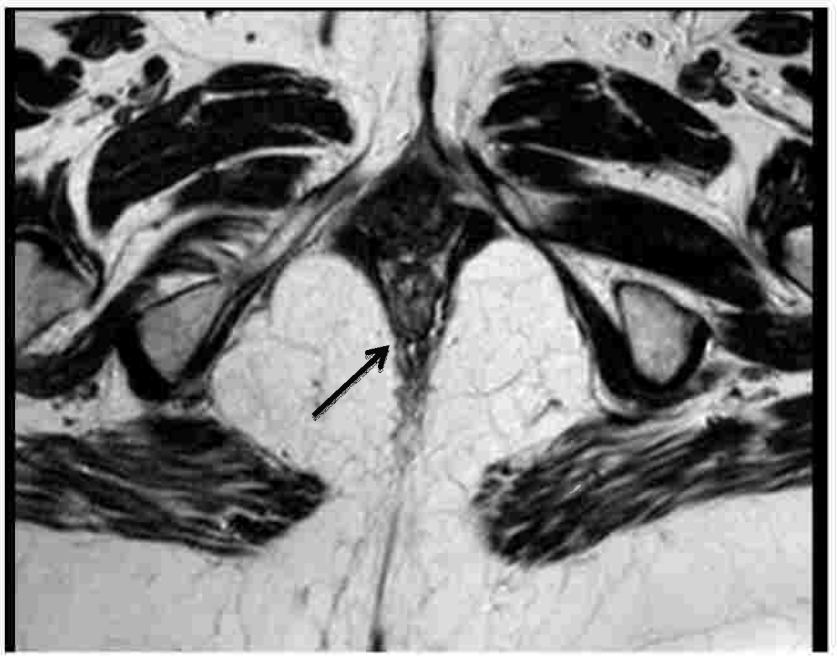

Figure 14a: 45 years old multiparous female showing thinned out puborectalis muscle slings extending from 5-7 clock axis still no frank tears

Figure 14b: Midsaggital image of the same patient at straining showing cystocele and bladder neck funneling (white arrow), rectocele (black arrow), herniating prevesical fat below PCL (green arrow) reflecting endopelvic fascial defect.

Figure 15a: 53 year old multiparous female diagnosed clinicaly with rectocele, showing diffuse bilateral pubo-rectalis muscle thinning with non identification of the right side attachment reflecting partial tear. Peritoneocele is also noticed (star).

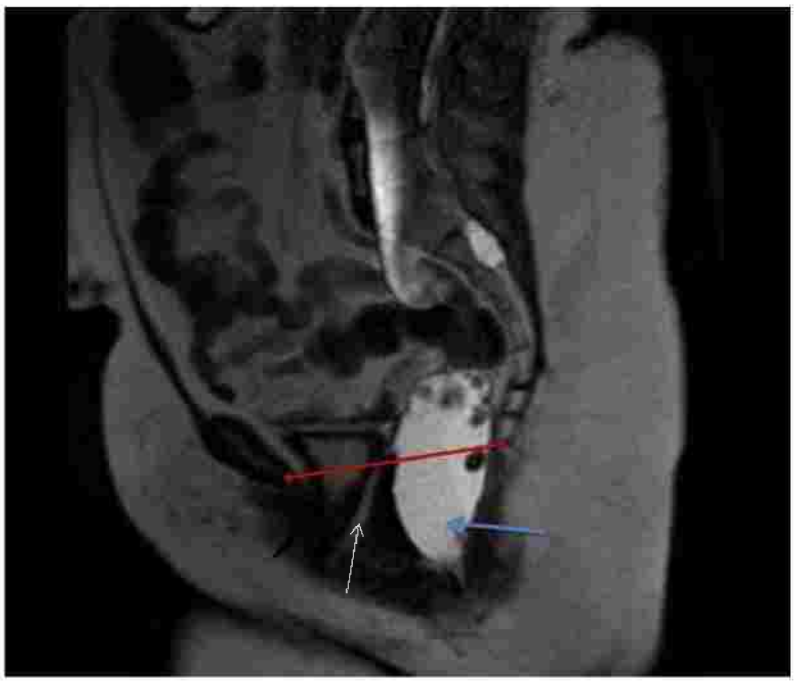

Figure 15b: Midsaggital image of same patient showing mild cystocele (black arrow), anterior rectocele (blue arrow), mild peritoneocele (white arrow)

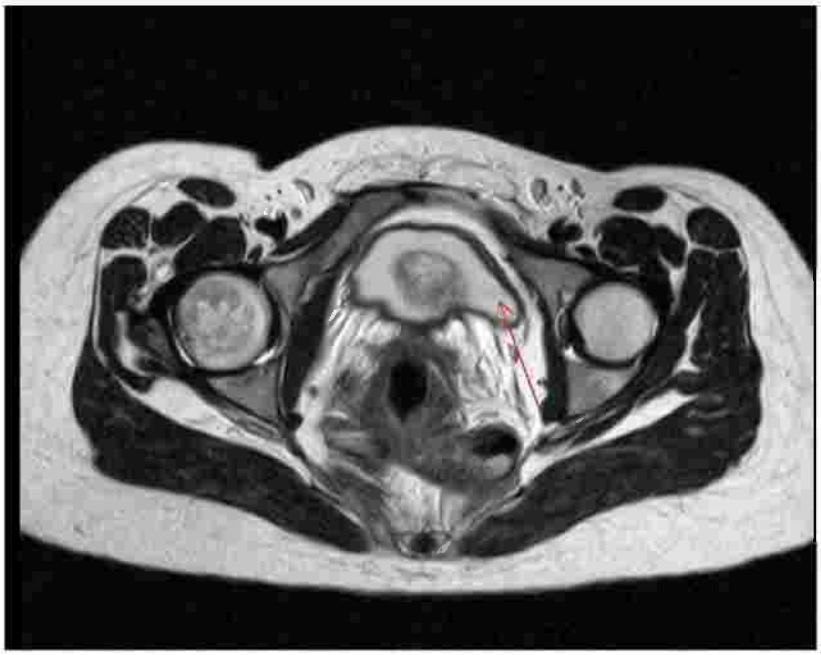

Figure 16a: 23 years old female multiparous, showing posterior herniation of the left lateral wall of the urinary bladder (arrow).

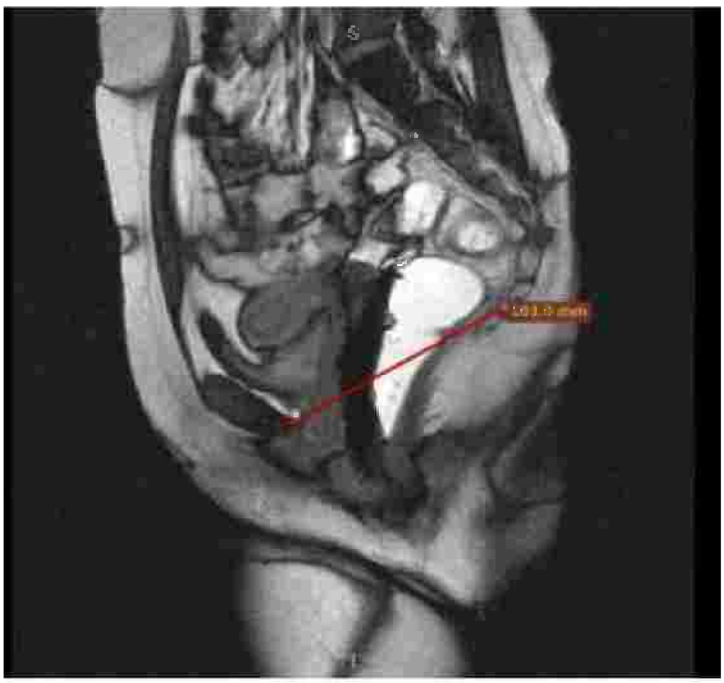

Figure 16b: Midsaggital image of the same patient showing ano-rectal descent.

Figure 17a: a 45 year old multiparous female, midsaggital image at rest showing borderline ano-rectal descent. Hysterectomy is noted with cervical stump shoing nabothian cyst (arrow).

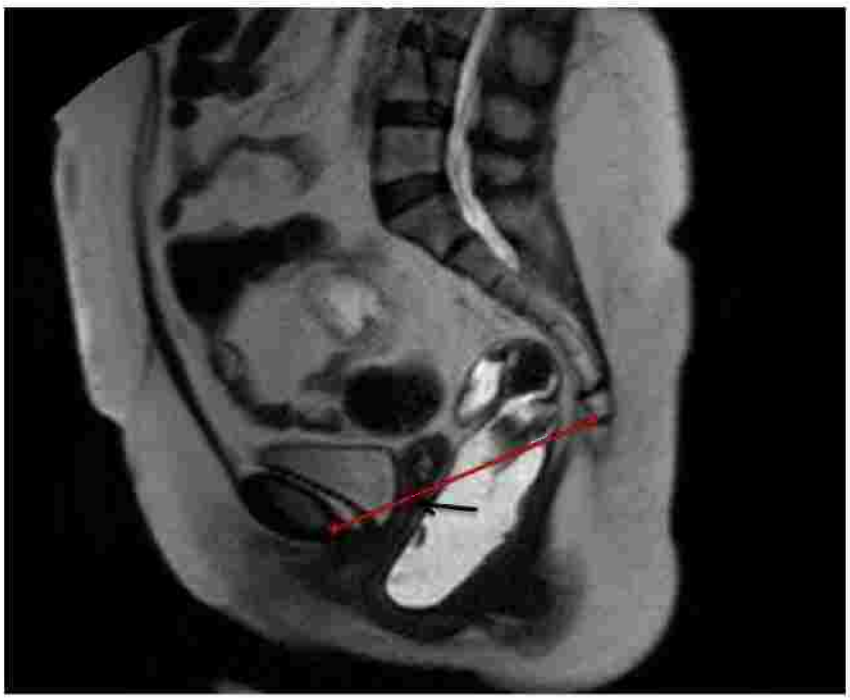

Figure 17b: Midsaggital image of the same patient during straining showing mild cystocele, mild cervical stump prolapse (arrow) and moderate ano-rectal descent.