The Combined Use of Perineal Ultrasound and MR Imaging in the Evaluation of Stress Urinary Incontinence

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Abstract

Background: Stress Urinary Incontinence (SUI), can be due to intrinsic sphincter deficiency or hypermobility of the bladder neck or urethra.

Aim of Work: This study aimed at assessing the complementary role of Ultrasound (US) and Magnetic Resonance Imaging (MRI) in those patients.

Material and Methods: Thirty female patients (mean age: 42 years old) with an established clinical diagnosis of SUI and 5 female volunteers (mean age: 43 years old) underwent perineal US and MRI (static and dynamic). The US evaluation included measurement of the bladder wall thickness, detrusor muscle thickness, urethral length and thickness and assessment of the retrovesical angle at rest and with strain. At MRI, descent of the bladder below the pubococcygeal line, levator plate orientation, vaginal configuration, puborectalis muscle and levator hiatus width were assessed.

Results: MRI study showed that there was statistically significant ($p<0.05$) elongation of H line at rest and with pelvic strain (mean: 6.43 versus 4.71cm in controls at rest and 7.69 versus 5.20cm with strain respectively), widening of the elevator hiatus (4.17cm versus 3.20cm in controls) and puborectalis abnormalities (in 55% of patients). On transvaginal US, there was statistically significant increased detrusor muscle thickness (mean: 0.16 versus 0.12cm in controls), shortened urethral length (2.74 versus 3.17cm in controls) and increased retrovesical angle with strain (140º versus 121º in controls).

Conclusion: A combined approach of 2D perineal US and MRI assessment can lead to more successful management of patient with SUI and subsequently decreases the rate of postoperative recurrence.

Key Words: Stress incontinence – Pelvic floor muscles – Magnetic resonance imaging – Ultrasound.

Introduction

THE pelvic floor is a complex system, with passive and active components that provide pelvic support, maintain continence, and coordinate relaxation during urination and defecation [1].

The Pelvic Floor Muscles (PFM) form the floor of the pelvic basin. They help maintain continence by actively supporting the pelvic organs and closing the pelvic openings with their anterior and cephalad action when contracting. The PFM comprise the pelvic diaphragm muscles (pubococcygeus, puborectalis, and iliococcygeus, together known as the levator ani), which can be referred to as the deep layer of the PFM; the urogenital diaphragm muscles (ischio cavernosus, bulbospongiosus, and transversus perinei superficialis, together known as the perineal muscles), which can be referred to as the superficial layer of the PFM; and the urethral and anal sphincter muscles [2].

Functional disorders of the pelvic floor are a common clinical problem, the diagnosis and treatment of these disorders are difficult. They frequently manifest with nonspecific symptoms such as constipation, incontinence, or pain [1].

Urinary incontinence is a socio-hygienic problem that causes embarrassment and anxiety, with serious effects on the quality of life of many women. Vaginal childbirth strongly predisposes a patient to urinary incontinence, and menopause is associated with increased frequency. As average longevity increases, urinary incontinence will become an increasingly major health-related economic problem [3].

Ultrasonography was proved to be inexpensive, harmless, and well tolerated by patients. The wealth of information provided by this method in the assessment of the main anatomic and functional alterations of the perineum makes the use of invasive and expensive radiographic techniques unnecessary. Furthermore, its correct use significantly
reduces the need for conventional radiography or MR contrast-enhanced examinations, which should be regarded as second-line examination tools [4].

In several studies MR imaging has been used to assess female pelvic organ anatomy and prolapses. MR imaging provides a global evaluation of the pelvic contents including the uterus and the pelvic floor muscles with high resolution of soft tissue, but this procedure is still costly and not frequently used for routine examinations [5].

MR imaging allows direct visualization of the urethra and its supporting structures and provides superior soft tissue contrast. So MR imaging has a potential to contribute important information that can guide in patient diagnosis and management [4].

The advent of high-quality surface coils and rapid T2-weighted imaging techniques has made Magnetic Resonance (MR) imaging a compelling competitor to voiding cystourethrography, ultrasonography, and defecography for the evaluation of these women [6].

Combined analysis of static and dynamic MR images is equally important. The study of pelvic floor revealed that certain anatomic defects on static images are associated with specific functional abnormalities on dynamic images [7].

The aim of this study is to describe the complementary role of ultrasonography in the assessment of urinary incontinence in females with pelvic floor dysfunction. Also we will describe the role of MRI in the evaluation of those patients and correlate findings at both static and dynamic MRI for quantifying pelvic floor motion with ultrasonographic findings.

Such assessment will help reaching proper diagnosis, guide the choice of management and also help in the post-treatment follow-up.

**Patients and Methods**

This study was conducted at the Radio-Diagnosis Department, Faculty of Medicine, Cairo University between December 2015 and September 2016. The study aimed at comparing ultrasound and MRI findings in females with stress urinary incontinence.

This prospective, case-control study was conducted on thirty female patients complaining from stress urinary incontinence diagnosed clinically. The patients referred from the Gynecology Clinic at Kasr Al-Ainy Hospital complaining from stress urinary incontinence with age range between 24 and 62 years old (mean age: 42 years old). Patients with contraindication to MRI were excluded from the study.

Five normal volunteers nulliparous females not complaining of any lower urinary tract symptoms were included in the study; age range 24-45 years with a mean age of 43 years old; who performed ultrasound to serve as a control group to standardize the normal values.

The ethical committee of our institution approved the study. All patients signed consent of approval.

Each patient included in the study was subjected to:

1- **History and clinical examination:**

- **Personal history:** Name, age, parity, previous abortions, any chronic disease.
- **Symptoms:**
  - SUI: According to patient’s complaint, the incontinence was graded following Ingelman-Sundberg classification into grades I, II or III:
    - Grade I: Incontinence only during coughing or sneezing.
    - Grade II: Incontinence during daily activity such as walking, rising from chair, etc.
    - Grade III: Dripping incontinence in the upright position [8].
  - Sensation or awareness of tissue protrusion from the vagina and palpation of mass.
  - Urgency.
  - Urge incontinence (signifying detrusor instability).
- **Clinical examination:**
  - Examination was performed by a gynecologist. The evaluation included a documentation of the patient’s complaints and the physical findings.
  - Pelvic examination with careful observation of the type and timing of urine loss (stress test).
  - The anterior and posterior vaginal walls were examined for the coexistence of Pelvic Organ Prolapse (POP): Cystocele, rectocele, utero cervical or vaginal cuff prolapse.

**Urine analysis:** To exclude the possibility of Urinary Tract Infection (UTI).
Fasting and 2 hours PP blood glucose: To exclude the possibility of diabetes.

II- MRI examination:

- Patient preparation and positioning:

  All patients had undergone a rectal enema with warm water the night before the MR imaging examination and were asked to void 2 hours before the examination. The rectum was opacified with 90-120mL of ultrasonographic gel.

- Imaging technique:

  MR imaging was performed with the patient supine in a 1.5-T MR imaging unit (Gyroscan PowerTrak 6000; Philips Medical Systems, Best, the Netherlands) by using a pelvic phased-array coil. No oral or intravenous contrast agent was administered. Scout images were obtained to identify a midline sagittal section that shows the pubic symphysis, urethra, vagina, rectum, and coccyx.

  Static images of the pelvis were first acquired in three planes by using T2-weighted turbo spin-echo sequences (repetition time msec/echo time msec: 5000/132; field of view: 240-260mm; section thickness: 5mm; gap: 0.7mm; number of signals acquired: two; flip angle: 90º; matrix: 512 X 512; acquisition time, 3.12 minutes for each sequence). In addition, T2-weighted balanced fast field echo images (9.0/4.0; field of view: 220mm; section thickness: 2mm; number of signals acquired; eight; flip angle; 45º; matrix: 512 X 512; acquisition time: 2.12 minutes) were also obtained.

  Dynamic MR imaging was performed in the sagittal, axial, and coronal planes by using the balanced fast-field echo sequence (5.0/1.6; field of view: 300mm; section thickness: 6-7mm; gap: 0.7mm) in each plane during straining. All participants were trained as regards to Valsalva maneuver. A radiologist attended each MR imaging examination to ensure the compliance of the woman’s response by observing the movement of the anterior abdominal wall, as well as the movement of the pelvic organs, to minimize variations between examinations.

III- Ultrasound examination:

- Patient preparation and positioning:

  No specific preparation was required for perineal sonography. The patients were asked to void 2 hours before the examination. The transducer was covered with a non-powdered glove.

- Imaging technique:

  Ultrasound imaging was performed using LOGIQ 7 PRO, GE (General electric medical system) ultrasound machine. The examination was done by transvaginal approach in all cases using 7-8 MHz endoluminal transducer.

  Patients were appropriately covered with a draw sheet at all times. Imaging was performed in dorsal lithotomy position, with the hips flexed and slightly abducted. The transducer was positioned just beyond the introitus and inserted into the vagina in a neutral position to avoid excessive pressure on surrounding structures, which might distort the anatomy.

  Imaging was performed with the patient at rest and during maximal Valsalva maneuver after explaining to the patient that she has a clinical condition like any other disease with physiological reassurance to decrease the patient's embarrassment from the urine leak during the exam.

Image analysis:

The following parameters were evaluated in all patients:

On MRI images:

- On sagittal images:

  - H line: It is drawn on a midsagittal image from the inferior border of the pubic symphysis to the posterior wall of the rectum at the level of the anorectal junction, which is defined as a focal angulation between the inferior aspect of the levator plate and superior aspect of the puborectalis muscle. It should measure a maximum of 5cm in healthy women and elongates in females with lax pelvic floor [4].

  - M line: It is a vertical line drawn perpendicularly from the PCL to the posterior aspect of the H line. It should measure a maximum of 2cm in healthy women and elongates in females with lax pelvic floor [4].

  - Presence or absence of bladder neck descent below the pubococcygeal line (PCL, a line drawn from the inferior margin of the pubic bone to the last coccygeal joint line).

  - The orientation of the levator plate: It should be parallel to the PCL at rest and straining in healthy continent women; increased caudal orientation indicates loss of posterior muscular support [9].

- On axial images:

  - Configuration of the vagina: The vagina should have an H-shaped configuration, which indicates adequate lateral fascial support [6].

  - The pubo-rectalis muscle sling for thickness, shape and signal intensity. On axial images, the
entirety of the levator sling should be of similar thickness and homogeneous low signal intensity. The right aspect of the puborectal muscle may appear slightly thinner than the left, a finding that is caused by chemical shift artifact in most cases [4].

- **Levator hiatus width on axial images**: Should measure a maximum of 4.5 cm in healthy women and gets wider in females with lax pelvic floor, however it has not been proved to be a significant indication for pelvic floor laxity [6].

- **On US images**:
  - **Bladder wall thickness**: Cut off values of 0.47 ± 0.03 cm have been reported by [10].
  - **Detrusor muscle thickness**: In [10] study, average detrusor wall thickness in the non-detrusor overactivity group was 4.1 ± 1.6 mm. Using a cut-off of detrusor wall thickness of 5.0 mm gave a sensitivity of 37% and a specificity of 79% for diagnosing detrusor overactivity.
  - **Urethral length**: [11] reported normal values of 3.63 ± 0.28 cm.
  - **Urethral thickness**: [12] reported normal values of 0.56 ± 0.05 cm.

**Statistical analysis**:

Data were coded and entered using the statistical package SPSS Version 22. Data was summarized using mean, Standard Deviation (SD), standard error of the mean (SE), minimum and maximum for quantitative variables and frequencies (number of cases) and relative frequencies (percentages) for categorical variables. Comparison of quantitative variables was done using the unpaired t-test. For comparing categorical data, Chi square (χ²) test was performed. Exact test was used instead when the expected frequency is less than 5. Standard diagnostic indices including sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and diagnostic efficacy were calculated. p-value < 0.05 was taken as statistically significant.

**Results**

Clinically, all patients were diagnosed with stress urinary incontinence and graded according to Ingelman-Sundberg grading system [8]. Most (45%) had grade II stress incontinence. There were 10 cases classified as grade I, 14 as grade II and 6 as grade III.

Controls had no symptoms of urinary or pelvic floor dysfunction.

**Ultrasound study**:

Table (1) illustrates the obtained US parameters for the patient population, while (Table 2) illustrates those of the control group.

In the patient group and in contrast to the controls, decreased urethral length (p = 0.037, statistically significant) and increased urethral thickness (p = 0.360, non significant) indicating urethral diamter enlargement were noted. An increased retrovesical angle with straining was also seen (p = 0.001, statistically significant). The mean bladder wall thickness was lower in the patient group however non statistically significant (p = 0.106). Finally mean detrusor muscle thickness was significantly greater in the patient than the control group (p = 0.018).

**MRI study**:

Table (3) illustrates the obtained MRI parameters for the patient population, while (Table 4) illustrates those of the control group.

In the patient group and in contrast to the controls, H line measurements indicated significant pelvic floor laxity both at rest and with pelvic straining (p < 0.001 for both). M lines measurements were not statistically different between the 2 groups (p = 0.186 and 0.623 at rest and with straining respectively). The levator hiatus width was greater in patients (p < 0.001).

There was organ descent below the pubococygeal line in 10 (33%) patients:
- Mild bladder neck descent below the pubococygeal line: 4.
- Cystocele: 6.

No organ descent could be seen in any of the controls.

The levator plate showed increased caudal inclination indicating loss of posterior muscular support in 50% of the patients; while it remained transverse indicating preserved posterior muscular support in 50% of patients and all controls.

Loss of the normal H shape configuration of the vagina was noted in 9 (30%) patients.

Finally, an abnormal puborectalis muscle was found in 17 (56.6%) patients:
- Thinned out left sling: 3.
- Thinned out right sling: 2.
- Torn right sling: 3.
- Torn left sling: 6.
- Torn both slings: 3.

This, in contrast to the control group that showed no abnormality in the puborectalis sling ($p=0.046$, statistically significant).

**Correlation between ultrasound and MRI findings:**

Both MRI and US detected abnormalities pertinent to anterior compartment pelvic floor dysfunction in all patients. Agreement between ultrasound, MRI findings and clinical data (standard reference):

Results of imaging (US and MRI) showed positive agreement with clinical diagnosis of stress urinary incontinence in all patients. Both MRI and US showed 100% sensitivity, specificity, positive and negative predictive values as well as accuracy.

**On follow-up, 12 (40%) patients underwent surgical correction.** Surgical decision was based on the combined clinical profile and following MRI findings:

- Cystocele (in 6 out of 12 cases).
- Puborectalis muscle abnormalities (in 10 out of 12 cases).
- Levator plate abnormal orientation (in 9 out of 12 cases).
- Loss of normal H shape configuration of the vagina (in 9 out of 12 cases).

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### Table (1): Ultrasound study in the patient group.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder wall thickness (cm)</td>
<td>0.48</td>
<td>0.03</td>
<td>0.01</td>
<td>0.43</td>
<td>0.56</td>
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<tr>
<td>Detrusor muscle thickness (cm)</td>
<td>0.16</td>
<td>0.04</td>
<td>0.01</td>
<td>0.12</td>
<td>0.25</td>
</tr>
<tr>
<td>Urethral length (cm)</td>
<td>2.74</td>
<td>0.41</td>
<td>0.09</td>
<td>1.90</td>
<td>3.40</td>
</tr>
<tr>
<td>Urethral thickness (cm)</td>
<td>0.58</td>
<td>0.16</td>
<td>0.04</td>
<td>0.30</td>
<td>1.00</td>
</tr>
<tr>
<td>Retrovesical angle at rest</td>
<td>117.30</td>
<td>6.65</td>
<td>1.49</td>
<td>105.00</td>
<td>130.00</td>
</tr>
<tr>
<td>Retrovesical angle with strain</td>
<td>140.40</td>
<td>5.68</td>
<td>1.27</td>
<td>130.00</td>
<td>150.00</td>
</tr>
</tbody>
</table>

SD: Standard Deviation.  
SE: Standard Error.

### Table (2): Ultrasound study in the control group.

<table>
<thead>
<tr>
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<th>SE</th>
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<th>Maximum</th>
</tr>
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<tbody>
<tr>
<td>Bladder wall thickness (cm)</td>
<td>0.51</td>
<td>0.03</td>
<td>0.01</td>
<td>0.47</td>
<td>0.55</td>
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<tr>
<td>Detrusor muscle thickness (cm)</td>
<td>0.12</td>
<td>0.02</td>
<td>0.01</td>
<td>0.09</td>
<td>0.14</td>
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<tr>
<td>Urethral length (cm)</td>
<td>3.17</td>
<td>0.19</td>
<td>0.09</td>
<td>2.98</td>
<td>3.45</td>
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<tr>
<td>Urethral thickness (cm)</td>
<td>0.52</td>
<td>0.03</td>
<td>0.01</td>
<td>0.49</td>
<td>0.56</td>
</tr>
<tr>
<td>Retrovesical angle at rest</td>
<td>111.20</td>
<td>5.26</td>
<td>2.35</td>
<td>105.00</td>
<td>118.00</td>
</tr>
<tr>
<td>Retrovesical angle with strain</td>
<td>121.20</td>
<td>5.26</td>
<td>2.35</td>
<td>120.00</td>
<td>125.00</td>
</tr>
</tbody>
</table>

SD: Standard Deviation.  
SE: Standard Error.

### Table (3): MRI study in the patient group.

<table>
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<tbody>
<tr>
<td>H line at rest (cm)</td>
<td>6.43</td>
<td>0.78</td>
<td>0.18</td>
<td>4.47</td>
<td>8.03</td>
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<tr>
<td>H line with strain (cm)</td>
<td>7.69</td>
<td>1.05</td>
<td>0.24</td>
<td>6.50</td>
<td>11.00</td>
</tr>
<tr>
<td>M line at rest (cm)</td>
<td>0.90</td>
<td>0.21</td>
<td>0.05</td>
<td>0.50</td>
<td>1.40</td>
</tr>
<tr>
<td>M line with strain (cm)</td>
<td>1.24</td>
<td>0.25</td>
<td>0.06</td>
<td>0.78</td>
<td>1.80</td>
</tr>
<tr>
<td>Levator hiatus width (cm)</td>
<td>4.17</td>
<td>0.44</td>
<td>0.10</td>
<td>3.38</td>
<td>5.40</td>
</tr>
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</table>

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SE: Standard Error.

### Table (4): MRI study in the control group.

<table>
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<th>SD</th>
<th>SE</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>H line at rest (cm)</td>
<td>4.71</td>
<td>0.42</td>
<td>0.19</td>
<td>4.30</td>
<td>5.30</td>
</tr>
<tr>
<td>H line with strain (cm)</td>
<td>5.20</td>
<td>0.21</td>
<td>0.09</td>
<td>5.00</td>
<td>5.50</td>
</tr>
<tr>
<td>M line at rest (cm)</td>
<td>0.76</td>
<td>0.19</td>
<td>0.09</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>M line with strain (cm)</td>
<td>1.30</td>
<td>0.12</td>
<td>0.05</td>
<td>1.20</td>
<td>1.50</td>
</tr>
<tr>
<td>Levator hiatus width (cm)</td>
<td>3.20</td>
<td>0.21</td>
<td>0.09</td>
<td>3.00</td>
<td>3.50</td>
</tr>
</tbody>
</table>

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Discussion

Stress urinary incontinence is the most commonly encountered type of female urinary incontinence. Treatment includes conservative therapy or surgery. Treatment selection is based on the specific anatomic abnormalities in each case, of the muscular, neural, and/or connective tissues involved [14].

Unfortunately, approximately 30% of urinary incontinence operations are repeat surgery. Better understanding of the causative mechanisms underlying the clinical presentations and improved surgical techniques helps to reduce the high failure rate [15].

More recently, there has been increasing interest and research in the use of MRI to evaluate patients with pelvic floor disorders [4].

By ultrasound examination, the results of this study showed that the mean retrovesical angle among incontinent patients duringValsalva was 140.4°±5.68 which was significantly different from the control group (121.20°±2.17; \textit{p}=0.001) as shown in Fig. (1). This is comparable to Al-Kuzaeae et al., [13] findings in which the mean for retrovesical angle among incontinent patients was 170.67°±15.08 compared to 113.97°±32.18 in the control group with \textit{p}-value less than 0.001**.

The mean urethral length among incontinent patients in our study was 2.74cm±0.41 compared to 3.17cm±0.19 in the control group with a \textit{p}-value of 0.037. Decreased urethral length with SUI was also reported by Najjari et al., [11] who stated that women, with genuine stress incontinence, compared with continent controls, had a significantly shorter urethra (mean ± standard deviation 16.9±1.9mm compared with 19.2±3.6mm in the latter, \textit{p}=0.001.

The mean Detrusor muscle thickness among our incontinent patients was 0.16±0.04cm compared to 0.12±0.02 cm in normal volunteers (\textit{p}=0.018) indicating a statistically significant association between detrusor wall thickening and SUI Fig. (2). Detrusor muscle hypertrophy has been described in association with a number of disorders of the lower urinary tract including urinary incontinence. It has been hypothesized that detrusor hypertrophy may be secondary to isometric contraction against a closed sphincter and/or against an obstructed bladder outlet [10].

Dietz et al., [16] also stated that although detrusor wall thickness has probably been overrated as a diagnostic tool in the context of detrusor overactivity, increased detrusor wall thickness seems associated with symptoms of the overactive bladder, and may be a predictor of post-operative de novo urge incontinence and/or detrusor overactivity after anti-incontinence procedures. As opposed to the situation in men, detrusor wall thickness in women is not predictive of voiding dysfunction.

In this study, the remaining evaluated US parameters showed no statistical significant difference between the incontinent and control group:

The mean bladder wall thickness was not increased among incontinent patients (mean: 0.48±0.03cm) in comparison to the control group (mean: 0.51±0.03cm; \textit{p}=0.106). This was unlike Abou Gamrah et al., [17] study where women with urinary symptoms and detrusor instability had significantly thicker bladder walls than did women with SUI. Another study also conducted by Latthe et al., [18] confirmed that bladder wall thickening above 5mm in a patient with the clinical diagnosis of an overactive bladder improves the diagnostic predictive value and makes it more likely that detrusor instability will be demonstrated by urodynamic testing.

In an investigation of the morphologic features of 1049 female patients with a single urodynamic diagnosis of urodynamic stress incontinence, detrusor overactivity, or hypersensitive bladder, conducted by Yang et al., [19], increased mean bladder wall thickness was present in the first 2 conditions but not in the hypersensitive bladder. They stated that age; parity, menopause, bladder neck position, and urethral mobility may all exert different effects on bladder wall thickness at the trigone, dome, or both. Urethral hypermobility may distort the urethral axis and perhaps may result in a thickened bladder wall.

In our patient population the mean urethral thickness was 0.58±0.16cm compared to 0.52±0.03 cm in the control group (\textit{p}=0.360) denoting urethral diameter enlargement in incontinent women Figs. (3,4). Oliveira et al., [12] stated that measurements of urethral diameter greater than 5mm were indicative of urethral diameter enlargement.

Regarding MRI evaluation of the pelvic floor anterior compartment in our study group, the following parameters showed statistical significant difference between the incontinent women and controls Figs. (1-4):

There was a noticeable increase of H line measurements both at rest and with strain confirming pelvic floor laxity. The mean H-line at Valsalva among incontinent patients was 7.69±1.05cm compared to 5.20±0.21cm in the control group (\textit{p}<0.001). These results are comparable with previous literature findings.
Fig. (1): 39-year-old woman with stress incontinence grade I. She had a history of 7 pregnancies, 3 abortions and pelvic floor laxity on physical examination.

MRI Sagittal T2-weighted images of the patient at rest (A) and during pelvic strain (B) show no significant bladder neck descent below the pubococcygeal line with maximal pelvic straining. On the strain image, the H and M lines are elongated (H line=7.7cm versus 6.6cm at rest; M line=1.3cm versus 0.63cm at rest). The H line measurements indicate pelvic floor laxity both at rest and straining. The levator plate shows increased caudal inclination indicating lost posterior muscular support. (C,D) On axial T2-weighted images, the vagina shows loss of its normal butterfly configuration. The puborectalis slings are torn and separated from their bony attachment. The levator hiatus width is increased (5.4cm).

Transvaginal US mid-sagittal images showing (E) decreased urethral length (2.49cm) and increased urethral thickness (0.76cm) indicating urethral diameter enlargement; (F) increased retrovesical angle with straining (123.6°) and (G) bladder wall thickening (0.59cm). Detrusor muscle thickness was 0.15cm.
Fig. (2): 39-year-old woman with stress incontinence grade II: She had a history of 5 pregnancies and pelvic floor laxity on physical examination.

MRI Sagittal T2-weighted images of the patient at rest (A) and during pelvic strain (B) show mild bladder neck descent below the pubococcygeal line with maximum straining (C). On the strain image, the H and M lines are elongated (H line=7.61cm versus 6.2cm at rest; M line=1.07 cm versus 1.01cm at rest). The H line measurements indicate pelvic floor laxity both at rest and straining. The levator plate shows increased caudal inclination indicating lost posterior muscular support. (D,E) On axial T2-weighted images, the vagina shows normal butterfly configuration. The left puborectalis sling shows irregular thinned out fibers. The levator hiatus width is increased (4.47cm).

Transvaginal US mid-sagittal images showing (F) decreased urethral length (2.71cm) and normal urethral thickness (0.62cm) (G) increased retro-vesical angle with straining (146.7º) and (H) normal bladder wall thickness (0.51cm). Detrusor muscle thickness was 0.17cm.
Fig. (3): 56-year-old woman with stress incontinence grade I: She had a history of 8 pregnancies, 3 abortions and pelvic floor laxity on physical examination.

MRI Sagittal T2-weighted images of the patient at rest (A) and during pelvic strain (B) show no significant organ descent below the pubococcygeal line. On the strain image, the H and M lines are elongated (H line=8.15 cm versus 7.69 cm at rest; M line=0.85 cm versus 0.67 cm at rest). The H line measurements indicate pelvic floor laxity both at rest and straining. The levator plate shows transverse orientation indicating good posterior muscular support. (C, D) On axial T2-weighted images, the vagina shows loss of its normal butterfly configuration. The puborectalis sling is intact showing uniform thickness and homogenous low signal. The levator hiatus width is preserved (3.78 cm).

Transvaginal US mid-sagittal images showing (E) decreased urethral length (2.68 cm) and increased urethral thickness (0.99 cm) indicating urethral diameter enlargement; (F) increased retro-vesical angle with straining (134.6º) and (G) bladder wall thickening (0.66 cm). Detrusor muscle thickness was 0.12 cm.
Fig. (4): Control case 18-year-old volunteer G0P0 woman, with no clinical complaint.

MRI Sagittal T2-weighted images of the patient at rest (A) and during pelvic strain (B) show no bladder neck descent below the pubococygeal line. On the strain image, the H and M lines are within normal range (H line=4.91cm versus 4.71cm at rest; M line=0.8cm versus 0.71cm at rest). The levator plate shows normal transverse orientation indicating good posterior muscular support. (C,D) On axial T2-weighted images, the vagina shows normal butterfly configuration. The puborectalis sling is intact, showing uniform thickness and homogenous low signal. The levator hiatus width is preserved (3.72cm).

Transvaginal US mid-sagittal images showing (E) normal urethral length (2.9cm) and normal urethral thickness (1.03cm) (F) normal retro-vesical angle with straining (122.6°) and (G) normal bladder wall thickness (0.54cm). Detrusor muscle thickness was 0.15cm.
The reported normal range of H line is 5.8 ± 0.5 cm according to El-Sayed et al., [7] and 5 cm according to Garcia del Salto et al., [4].

In the current study, the mean levator hiatus width measured at maximum straining among incontinent patients was 4.17 ± 0.44 cm compared to 3.2 ± 0.21 cm in the normal volunteers (p<0.001). This is unlike the results of El-Sayed et al., [7] the mean width of the levator hiatus at maximum straining in 10 patients with SUI was 4.4 ± 0.8 cm, while the normal range was 4.5 ± 0.7 cm.

The width of the levator hiatus has not proved to be significant in the identification of pelvic floor laxity; however it rarely exceeds 4.5 cm in women with intact pelvic floor [6].

In this study, 55% of the patients showed abnormalities of the puborectalis muscle that were classified as thinned out puborectalis sling either right or left, loss of the normal homogenous low signal, irregular appearance or tears. This was in contrast to the intact homogenous low signal slings in the control group (p=0.046).

Kim et al., [21] reviewed MR images obtained using an endovaginal coil in 63 patients with stress urinary incontinence and in 16 continent women. A high degree of asymmetry of puborectalis muscle (>1.5) was more frequent in the group with stress urinary incontinence (29%) than in the continent group (0%) (p=0.015). Perry et al., [22] stated that the puborectalis muscle can be damaged with repeated vaginal delivery and can even be torn off from its pubic insertion. On the other hand, Tasali et al., [23] did not find any significant difference in the mean thickness of the puborectal muscle between the group with SUI and the control group.

In this work, the following MRI parameters showed no statistical significant difference between the incontinent women and controls:

The mean M-line measurements at Valsalva among incontinent patients was 1.24 ± 0.25 cm compared to 1.30 ± 0.12 cm in the control group (p=0.623). In contrast to this, in El-Sayed et al., [7] study, the mean M-line was 2.4 ± 1.1 cm in patients with SUI, and in patients with SUI with bladder and/or genital prolapse, it was 3.7 ± 1.1 cm. The reported normal range is 1.3 ± 0.5 cm according to El-Sayed et al., [7], and 2 cm as reported by Garcia del Salto et al., [4].

In 35% of our patients, there was positive organ descent below the pubococcygeal line classified as mild bladder neck descent (less than 2 cm) below the pubococcygeal line in 3 patients and cystocele in 4 patients. No organ descent could be seen in any of the controls (p=0.274).

Tarhan et al., [24] stated that the bladder neck was above the pubococcygeal line in all patients at rest whereas it was below the pubococcygeal line in 16 patients with SUI during Valsalva’s maneuver. Mobility of the bladder neck was between 3 and 32 mm (mean ± SD, 17.83 ± 8.3 mm). In El-Sayed et al., [7] study the mean bladder neck descent was 0.6 ± 0.3 cm and the mean bladder base descent was 0.7 ± 0.4 cm in 10 patients with SUI. While in group C (16 patients with SUI with bladder and/or genital prolapse) the mean bladder neck descent was 1.9 ± 0.5 cm and the mean bladder base descent was 2.3 ± 0.9 cm.

Fielding [9] stated that in healthy women, there is minimal movement of the pelvic organs even with maximal strain.

In this study, the levator plate showed increased caudal inclination in 50% of the patients; while it remained transverse the other 50% of patients and all controls. This is in agreement with previous literature findings: Gracia Del Salto et al., [4] stated that caudal angulation of the levator plate is present in women with pelvic floor laxity, such that a line drawn on a sagittal image from the levator plate does not cross the pubic bone and is an indicator of loss of posterior muscular support. Fielding [9] mentioned that in healthy women, the levator plate will parallel the pubococcygeal line at rest and during pelvic strain.

Finally there was loss of the normal butterfly or H shape configuration of the vagina in 6 of our patients. It was preserved in all controls.

Weakening of the paravaginal ligaments can alter the normal butterfly shape of the vagina. The vagina may have a flattened appearance because the vaginal wall will be displaced posteriorly as a result of loss of paravaginal attachments. The disruption to the paravaginal ligaments will weaken support to the urethra because the middle and distal thirds of the urethra are closely related to and supported by the anterior vaginal wall. The loss of the normal shape of the vagina is therefore a good indication of paravaginal tears in patients with urinary incontinence [4,7].

Results of both MRI and US showed positive agreement with clinical diagnosis of stress urinary incontinence in all of our patients. Both MRI and US showed 100% sensitivity, specificity, positive and negative predictive values as well as accuracy.
Ultrasound as part of the diagnostic work-up of stress urinary incontinence allows for the morphological and dynamic assessment of the lower urinary tract. Pre-operative ultrasound yields information on the pathomorphology of the continence control system, which should be taken into consideration when planning the surgical approach. It is possible, for instance, to classify sonographically identified changes of the endopelvic fascia as lateral (distraction cystocele) and central defects (distension cystocele, funneling of the urethra) as well as to determine the reactivity of the pelvic floor muscles. The sonomorphological findings in conjunction with the patient’s complaints, the clinical findings, and urodynamic data yield important diagnostic information for selecting the most suitable surgical approach, i.e., transvaginal versus abdominal access or a combination of the two. Post-operatively, ultrasound allows one to evaluate the outcome of surgery as well as voiding problems and morphological causes of recurrent urinary incontinence or of newly occurring urgency symptoms [25].

In our study we agree with the ability of ultrasound to detect quick functional changes for example during cough. However, it has been mentioned in the literature that the anatomic details offered by MRI as regards to ligaments and fascial defects are superior to ultrasound [16]. Moreover, Dietz et al., [16] didn't mention any findings in the context of detecting fascial defects by ultrasound.

Indeed, MRI was superior in detection of anatomical details in our study compared to ultrasound. On follow-up 40% of patients that underwent surgery had anatomical defects on MRI such as cystoceles, puborectalis muscle abnormalities, levator plate abnormal orientation and loss of normal H shape configuration of the vagina.

Similarly, Gracia Del Salto et al., [4] stated that for the anatomical defects, MRI has several advantages despite not being indicated for the routine assessment of all patients with mild symptoms of pelvic floor dysfunction. It allows concomitant visualization of all three compartments of the pelvic floor can help identify specific muscle defects. It is certainly a valuable tool in pre-operative planning because it provides detailed anatomic information as it can directly visualize the muscular and ligamentous pelvic floor support structures and may alter the management of patients.

Gracia Del Salto et al., [4] noted that in a symptomatic patient, organ descent of greater than 1cm below the pubococcygeal line indicates pelvic floor laxity, and organ descent greater than 3cm is often indicative of the need for surgical intervention.

The loss of normal vaginal configuration will be relevant to the surgeon because fascial repair may also be necessary [7].

In already published researches, the ability of MRI to change operative choice and the decision of management was recorded to be 41 .6% of patients El-Sayed et al., [25] and 41% Kaufman et al., [26].

With the detailed information now made available to surgeons by MRI, and its ability to pinpoint the underlying structural abnormality in each individual patient, we think that the recurrence rate can be reduced, especially if the surgeon changes their treatment plan from that of a symptom based approach, to an individualized approach based on the specific anatomical abnormality.

Conclusion:
The combined use of perineal ultrasound and dynamic MRI can help to delineate the pathomorphology of the pelvic floor in patients with SUI, thus can guide better planning of treatment.

References
استخدام الموجات الصوتية في منطقة العجان والتصوير بالرنين المغناطيسي في تقييم السلس البولي الإجهاضي

السلس الإجهاضي يمكن أن يكون راجعا إلى نقص في العضلة العاصرة أو قريحة في عنق المثانة أو مجرى البول. هدفت هذه الدراسة إلى تقييم دور الموجات فوق الصوتية (US) والتصوير بالرنين المغناطيسي (MRI) في هؤلاء المرضى.

ثلاثون مريضة (متوسط العمر: 43 سنة) متعاطي نسيج السلم البولي وخمسة مائة مريضة (متوسط العمر: 42 سنة) ضعاف للفحص بالموجات فوق الصوتية والتصوير بالرنين المغناطيسي (كانت وحيدة). وشمل التقييم بالموجات فوق الصوتية قياس سمك جدار المثانة، سماكة العضلة النافذة، وطول وسمك وقياس زاوية مجرى البول أثناء الراحة ومع السراي. وفي الرنين المغناطيسي، قياس نوز المثانة تحت خط العائمة العصعصية، خطوط قياسات العضلة الرافية، وتكوين المهل، العائمة المستقيمة تم تقييم العضلات وعرض الرايقة توقف.

استخدمت دراسة التصوير بالرنين المغناطيسي أن هناك دالحة إحصائية (0.05<p) إستطالة خط H في الراحة مع سلاسة الحوض (إنه: 0.45 مقابل 0.71 سنة في الراحة و 0.69 مقابل 0.73 سنة مع السراي على التوالي). ووعز فتحة العضلة الرافية (2.17 سنة في الضوابط مقابل 2.40 سنة) وتشوهات العائمة المستقيمة (في 55% من المرضى) وفي الموجات فوق الصوتية عبر المهبل، كان هناك دالحة إحصائية من زيادة سمك العضلة النافذة (بيني: 11.16 مقابل 12.17 سنة في الراحة). وقياس طول مجرى البول (2.74 مقابل 3.21 سنة في الضوابط).

إستخدام الموجات فوق الصوتية مع التصوير بالرنين المغناطيسي يمكن أن يؤدي إلى علاج أكثر مع مرضى السلس البولي وينقل من معدل تكرار الجراحة.