Pelvic organs dysfunction (pod) and reconstructive surgical repair

Abdel Karim M. A. El Hemaly
FRCS-MRCOG, Ibrahim M. Kandil
MD, Laila A. E. S. Mousa MD,
Ahmad G. Serour MD

ABSTRACT

Objective: By imaging with 3-dimension ultrasound (3DUS); MRI and by histopathology studies, we try to prove these three novel concepts.

Materials & Methods: We chose three hundreds women suffering from stress urinary Incontinence (SUI), fecal incontinence (FI) and vaginal prolapse. In addition, we included 30 nulliparous infertile women who have no pelvic floor dysfunction as control.
All patients and control were have their clinical history recorded, and were clinically examined and had been imaged with 3DUS and MRI. In addition, we took specimens from the IUS, IAS and the vagina and were prepared, examined microscopically, and compared to normal tissues.

Results: Imaging with 3DUS and MRI proved the novel concepts and histopathological examinations proved that the IUS, IAS are cylinders of collagen-muscle tissues that surround the urethra and the anal canal. Rupture of the collagen layer lead to weakness of the sphincters and SUI and FI ensues. In addition, rupture of the collagen layer of the vagina leads to vaginal prolapse.

Conclusion: Pelvic organs dysfunction is the main factor that leads to SUI, FI and vaginal prolapse, and not pelvic floor dysfunction. In addition, more than one trouble can be present in the patient simultaneously.

Key words: Collagen; Urinary Continence; Fecal Incontinence (FI); Vaginal Prolapse; Three Dimension Ultra Sound (3DUS); MRI.

INTRODUCTION

Urinary continence depends on high urethral pressure gained by two factors; high wall tension due to the collagen layer constituent of the internal urethral sphincter. In addition, it depends on an acquired behavior gained by learning and training in early childhood how to keep high alpha-sympathetic tone at the IUS maintaining its closure all the time until there is a need or a desire to void. In this work, we put a novel concept on the physiology of defecation.

We can divide the process of Defecation into 2 stages. The first stage, in infancy and early childhood before training: as the rectum is full, sensation of fullness travels along the pelvic para-sympathetic to the spinal cord (S. 2, 3 &4). Then efferent excitatory para-sympathetic impulses cause rectal muscle contraction pushing the rectal contents to the anal canal where the external anal sphincter relaxes finishing the defecation. Then the mother starts to teach her child how to hold up himself until social circumstance allow. Then we gain the second stage by keeping high alpha-sympathetic tone at the internal anal sphincter (IAS) maintaining its closure all the time until there is a need or a desire to empty and social circumstances allow. Sensations of rectal distension travel along the pelvic para-sympathetic nerves to the CNS. Controlled by the high CNS centers, the person has the choice to retain or empty rectal contents according to social circumstances available. If he chooses to empty, this will be either for a moment only to release flatus, or for a longer time to pass stool. When social circumstances allow passage of stool, then six synergistic neuro-muscular actions take place. The IAS is a cylinder of collagen-muscular tissues that surround the anal canal, innervated with alpha-sympathetic nerves from T10-L2.

The vagina is a cylinder of collagen-elastic-muscular tissues. The strong tough collagen sheet is the one responsible for the upright position of the vagina. Childbirth trauma injuries the collagen layer due to overstretching of the vagina and leads to flabby and redundant vaginal walls with subsequent vaginal prolapse. It will also leads to lacerations in the IUS, and IAS leading to their weakness and cannot stand against rise of abdominal pressure.

Correspondence
Abdel Karim M. El Hemaly. FRCS, MRCOG,
Prof. of OB/GYN, Al Azhar University,
3 Emad El Din Kamel St. Nasr city,
11371, Cairo, Egypt
E-mail: profakhemaly@hotmail.com
Phone: +202 0100 1577969
Fax: +202 25893755

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Running title: Surgical repair of pelvic organs dysfunction

The female pelvis contains three major tracts that lie on and traverse the pelvic floor. These are the urinary bladder and the urethra anteriorly, the genital tract in the middle, and the rectum and anal canal posterior. We put forward three novel concepts on the pathophysiology of the anatomy and functions of these three tracts.

The urinary bladder (UB) stores the urine, which is voided through the urethra. Voiding has two stages: First stage, before training, in infancy and early childhood; sensation of bladder fullness travels along the pelvic parasympathetic nerves to the spinal cord, through spinal cord' center reflex parasympathetic activity (S 2, 3 &4) leads to contraction of the detrusor muscle voiding the urine through an open urethra irrespective of time or place.

Second stage after training: the mother starts to teach and train her infant-child how to hold up till proper social circumstances are available. This is gained by maintaining high alpha-sympathetic tone (T 10-L 2) at the internal urethral sphincter (IUS) keeping it closed all the time till favorable social circumstances allow. Urinary continence depends on a closed urethra with high urethral pressure (Pura), (Pura > 60 cm water) 5. High Pura is due to two factors: the first factor is structural or inherent, and the second factor is behavior or acquired factor.

The inherent factor is the presence of an intact and strong IUS (Figure 2, 3 & 4). The IUS is a collagen tissue cylinder that extends from the urinary bladder neck down to the perineal membrane in both sexes. It is lined with urothelium, with a muscle layer that lies on top and intermingles with the collagen fibers in the middle of the cylinder's thickness. The muscle layer, has a connection above with the detrusor muscle, and has nerve supply from alpha-sympathetic nerves (T 10-L 2). The collagen, is the strongest tissue in our body, gives the IUS the high wall tension that is responsible for the high Pura. The muscle layer is responsible for closing and opening the urethra.

We put forward a recent concept on the Patho-physiology of defecation. There are two (2) stages of the mechanism of defecation.

First Stage of Defecation:
In infancy and early childhood, before training: Stretch receptors in the rectum, impulses of rectal fullness travel along pelvic parasympathetic, S. 2, 3&4, leads to:

1- The rectal muscles contract.
2- The external anal sphincter (EAS) relaxes allowing defection to occur.

The internal anal sphincter (IAS): The IAS is a collagen-muscular tissue cylinder that surrounds the anal canal; surrounded externally by the EAS. Its nerve supply is alpha-sympathetic nerves from the hypogastric plexus.
Its function is:

1- On contraction, to keep the anal canal Closed and empty.
2- On relaxation to open the anal canal.

According to these Novel Concepts, SUI is the result of: a weak, torn IUS. Vaginal Prolapse is: a consequence of weak, flabby, redundant torn vaginal walls. FI is caused by a weak, torn IAS. Therefore, we innovated an operation to treat SUI by exposing the rupture in the IUS & mending the torn sphincter. In addition, we treat vaginal prolapse at the same time by this new operation. In addition, we treat FI at the same time by this novel operation: " Urethro-Ano-Vaginoplasty" "Al Azhar Repair operation" 7; figures 9, 10, 14 & 15. Urethro-Ano-Vaginoplasty, (Al Azhar) repair operation consists of Anterior and Posterior sections. In the anterior section, we correct the SUI and the anterior vaginal wall descent through the following steps:

1- Expose the IUS (we dissect the IUS clear from the anterior vaginal wall).
2- Mend the torn posterior wall of the IUS.
3- Strengthen the anterior vaginal wall by overlapping the two vaginal flaps, by this way; we also add extra support to the mended IUS.

In the posterior section we do:

1- Expose the IAS (by dissecting the torn IAS clear from the posterior vaginal wall).
2- Mend the torn sphincter.
3- Approximate the two levator ani muscles.
4- Strengthen the posterior vaginal wall by overlapping the two vaginal flaps; also, we add extra support to the mended IAS.
5- Repair the perineum.

PATIENTS AND METHODS

Three hundreds women suffering from vaginal prolapse, SUI, and FI were chosen from the gynecology clinics at Al Azhar University hospitals for two years 2009-2010. Consent was taken, after explaining to each patient the nature of the trouble, the investigations that will be done, and the nature of the surgery she will have.

They are all multiparous women, who had vaginal deliveries, ranging from 4 to 10, average 6 labors. Their age ranged between 40 to 50 years, average 44 years. Detailed history and clinical examination were done and proved vaginal prolapse, SUI and fecal incontinence. Three Dimension Ultrasound (3DUS) was done for each patient; Magnetic Resonance Imaging (MRI) was done for 44 patients of them. 300 patients with vaginal prolapse, SUI and FI were assessed clinically and by imaging using 3DUS, and also 30 normal women not suffering from vaginal descent, nor from SUI nor from FI as a control. Three Dimension Ultrasound (3DUS) assessment of the IUS, IAS and vaginal walls was done for the 10 continent women as control and for each patient of the 300 study cases using trans-vaginal route and trans-perineal route by a vaginal probe multi-frequent 5-7.5 MHz, General Electric, integrated 3D-4D Unit (GE Volosone) 730 Pro V machine. In addition, we took specimens from the IUS, IAS and the vagina and were prepared, examined microscopically, and compared to normal tissues.

Each patient had pre-operative evaluation and all necessary investigations e.g. blood (CBC, blood sugar...etc) and urine tests…etc. Any urinary tract infection, the patient was treated according to the result of urinary culture and sensitivity lab test.

RESULTS

Imaging with 3DUS and MRI proved the novel concepts (figures 5, 6, 7, 11, 12 & 13); and histopathological examinations proved that the IUS, IAS are cylinders of collagen-muscle tissues that surround the urethra and the anal canal. Rupture of the collagen layer lead to weakness of the sphincters and SUI and FI ensues. Figures 3-12. In addition, rupture of the collagen layer of the vagina leads to vaginal prolapse. Figures 7 & 13.

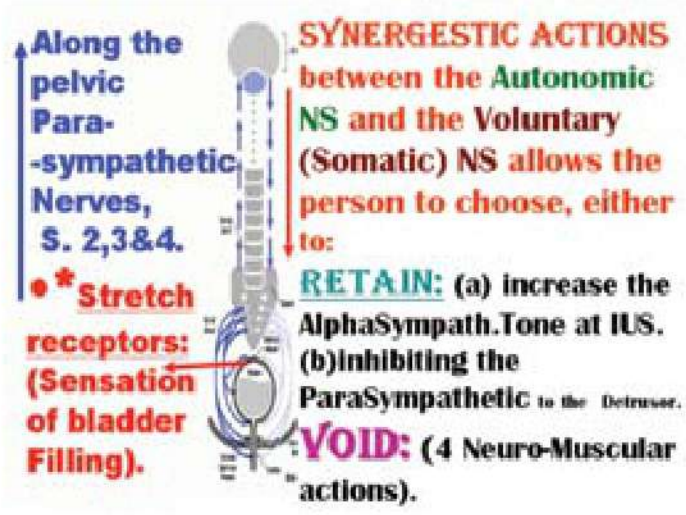

Figure 1

Diagram that shows the CNS control of the steps taken in the second stage of micturition. Sensations of bladder filling travels along the pelvic parasympathetic nerves S.2, 3 &4. Controlled by the CNS, depending on the social circumstances, synergistic neuromuscular actions take place. If time and place do not allow voiding, the person will increase the alpha sympathetic tone at the IUS. He will also inhibit the pelvic parasympathetic preventing detrusor contractions. In addition, he will confirm closure of the external urethral sphincter (EUS). When social circumstances allow, he will inhibit the high alpha sympathetic tone at the IUS, thus opening the urethra. He will activate the pelvic parasympathetic inducing detrusor contractions. He will relax the EUS thus allowing voiding. The EUS tone increase to allow propulsion and ejection of the stream of urine and at the end of micturition to squeeze the urethra from the last few amount of urine.

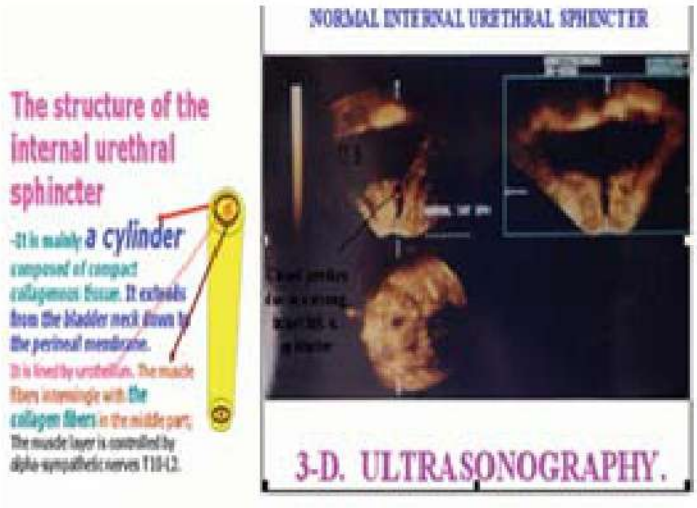

Figure 2

On the left, a diagram of the IUS as a cylinder of collagen-muscular tissue cylinder lined by urothelium is shown. On the right 3DUS image of a normal continent woman with the IUS seen as a cylinder that extends from the urinary bladder neck downwards with 2 echoes overlying each other, and a closed urethra.

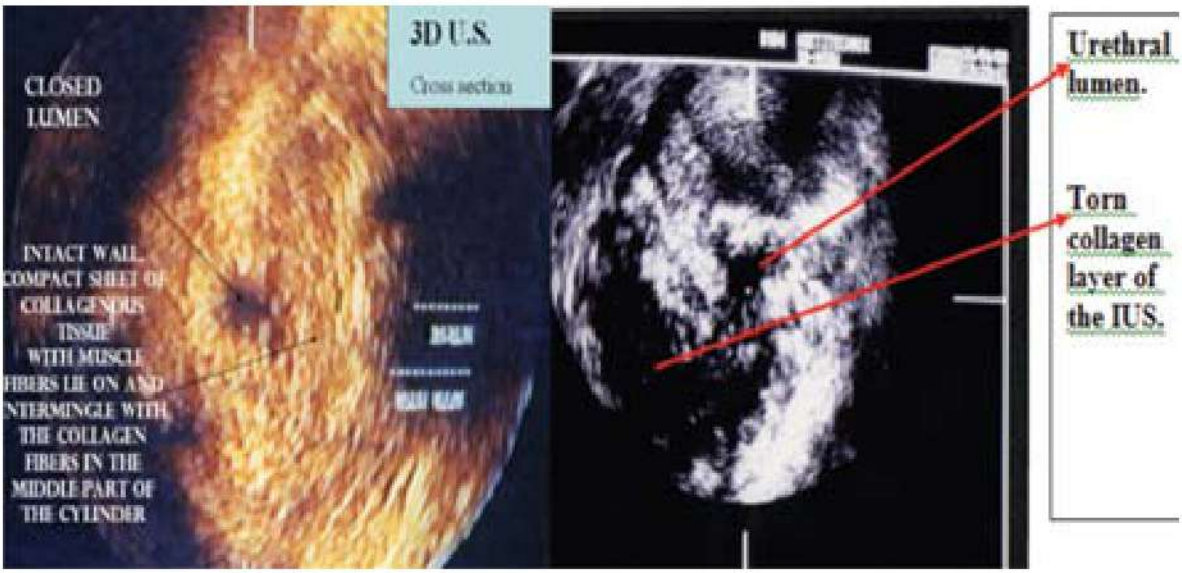

Figure 3
Cross sections of the IUS as seen by 3DUS image; on the left it shows a closed urethral lumen, surrounded by a cylinder of collagen with superimposed muscle on top and intermingling with the collagen fibers in the mid thickness of the cylinder. On the right it shows torn IUS, with wide open urethral lumen.

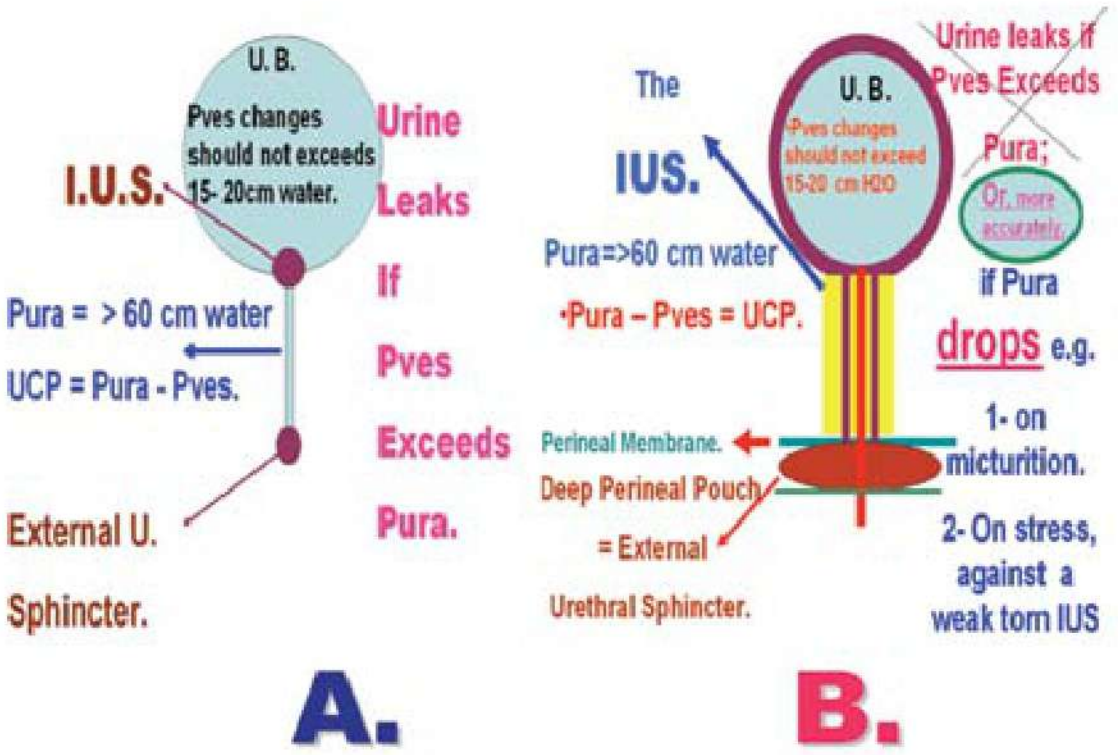

Figure 4

A diagram to explain the site, extent and structure of the IUS and the EUS. On the left, (A) the IUS is a muscular ring at the bladder neck as described classically, on the right (B), the IUS as described in the new way

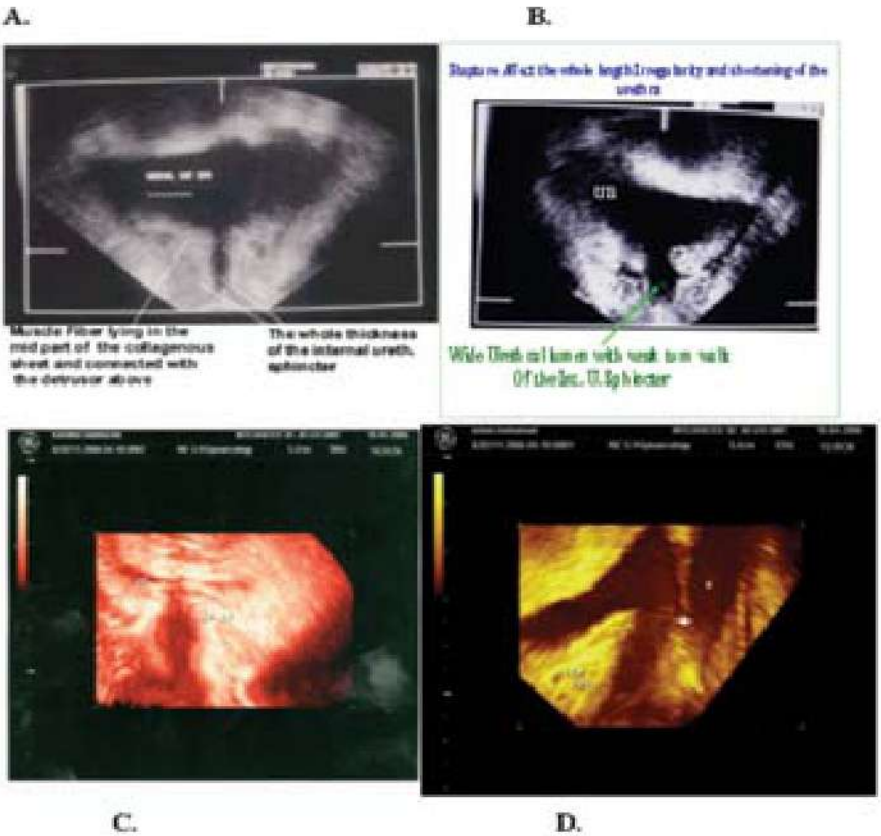

Figure 5
Images by 3DUS, picture (A) a normal IUS, compared to torn IUS (B, C & D). The whole length is torn in (B); the rupture is mainly in the lower part in (C) leading to genuine SUI and flask-shape appearance. There is a loss of Posterior U-V angle in (D) with widely open urethra.

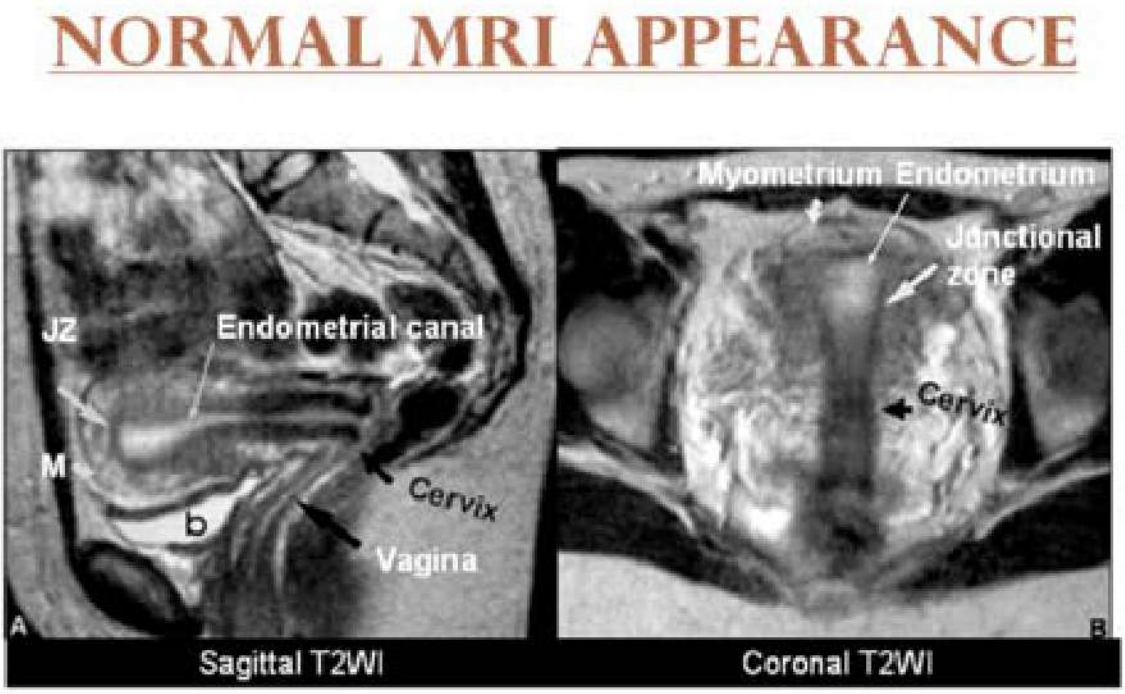

Figure 6

MRI pictures, sagittal and coronal sections, of the urinary bladder, the urethra and the uterus and the vagina. Kindly notice the uniform thickness of the IUS that extends from the bladder neck down to the perineal membrane. Kindly notice the vaginal wall thickness, it is standing up due its tough collagen sheet. Collagen also constitutes the organ capsules, like the urinary bladder and the uterus.

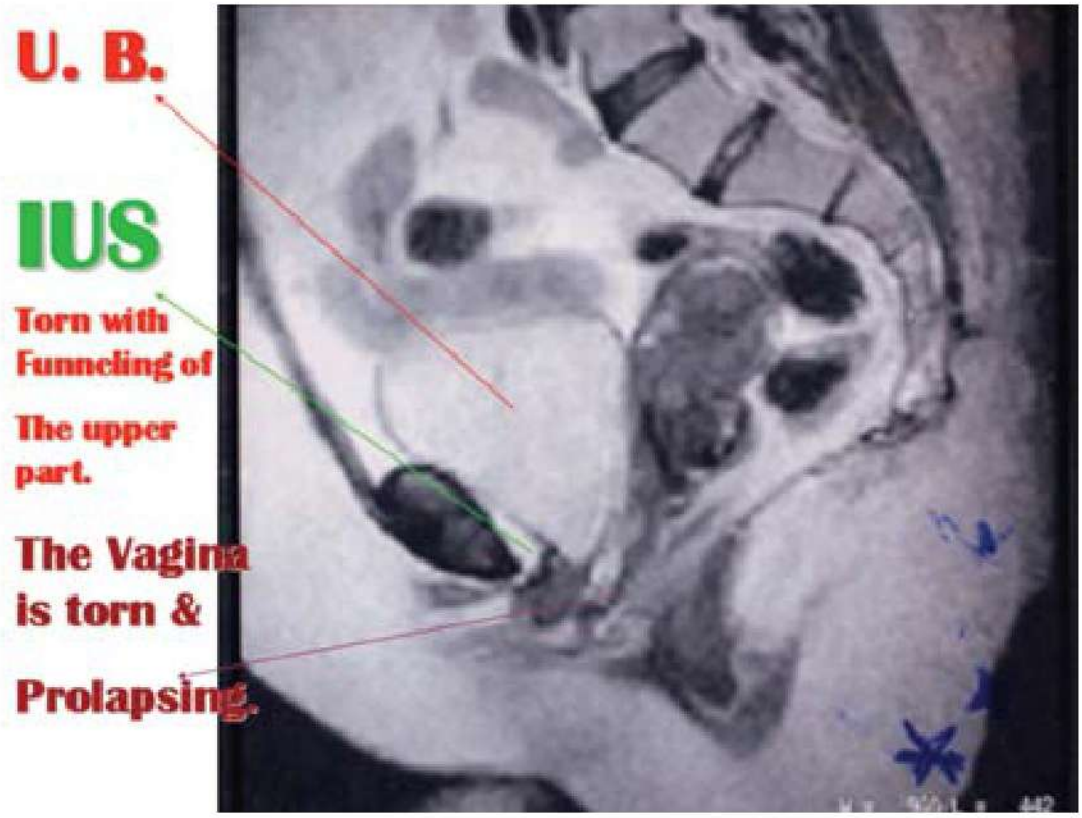

Figure 7

MRI, sagittal view of a patient with DO that shows torn upper part of the IUS with funneling. The IUS is seen clearly as a compact tissue cylinder that extends from the bladder neck downwards.

Figure 8

Diagrammatic representation of the physiology of defecation and its nervous control

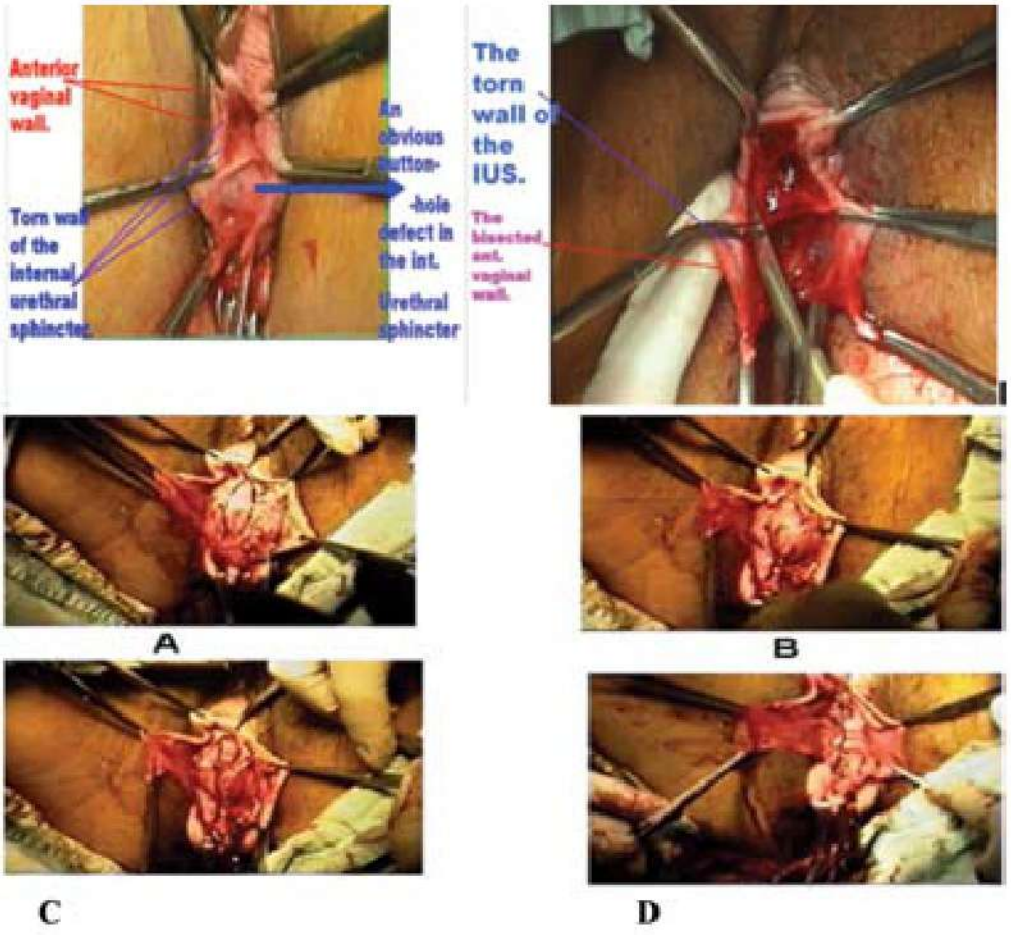

Figure 9

Kindly notice there are 2 edges, first is the edge of the bisected vagina; the second is the edge of the torn IUS. After carefully dissecting and separating the torn posterior wall of the torn IUS, it is mended with simple interrupted sutures.

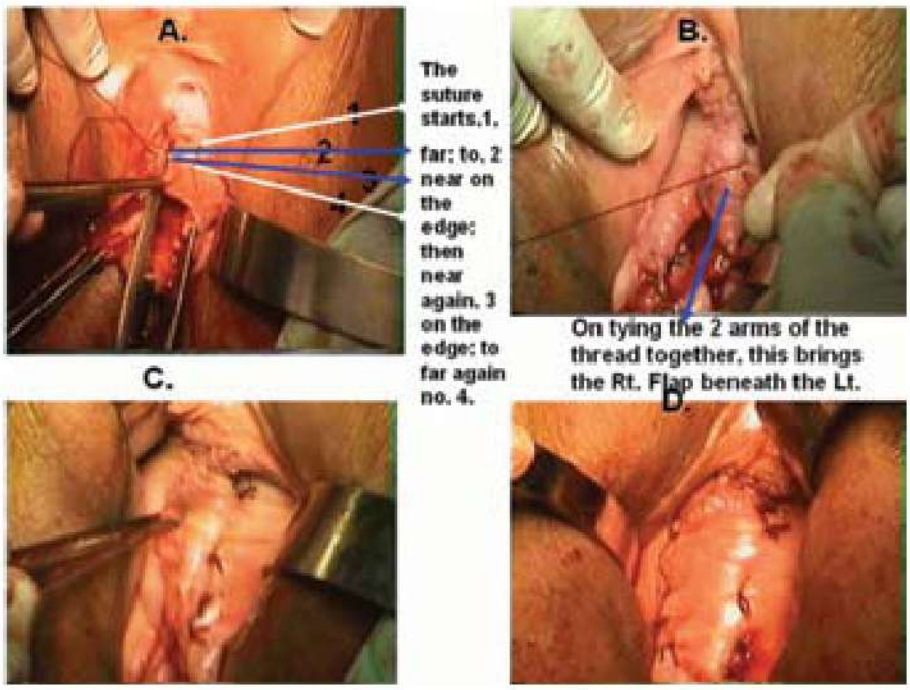

Figure 10

Overlapping the two vaginal flaps is done by a new "dragging" suture that brings the right flap beneath the left one. Then the free edge of the left flap is sutured as far laterally as possible on the right. This will narrow the vagina, preserve the natural collagen to keep the vagina in its upward position and add extra support to the mended IUS.

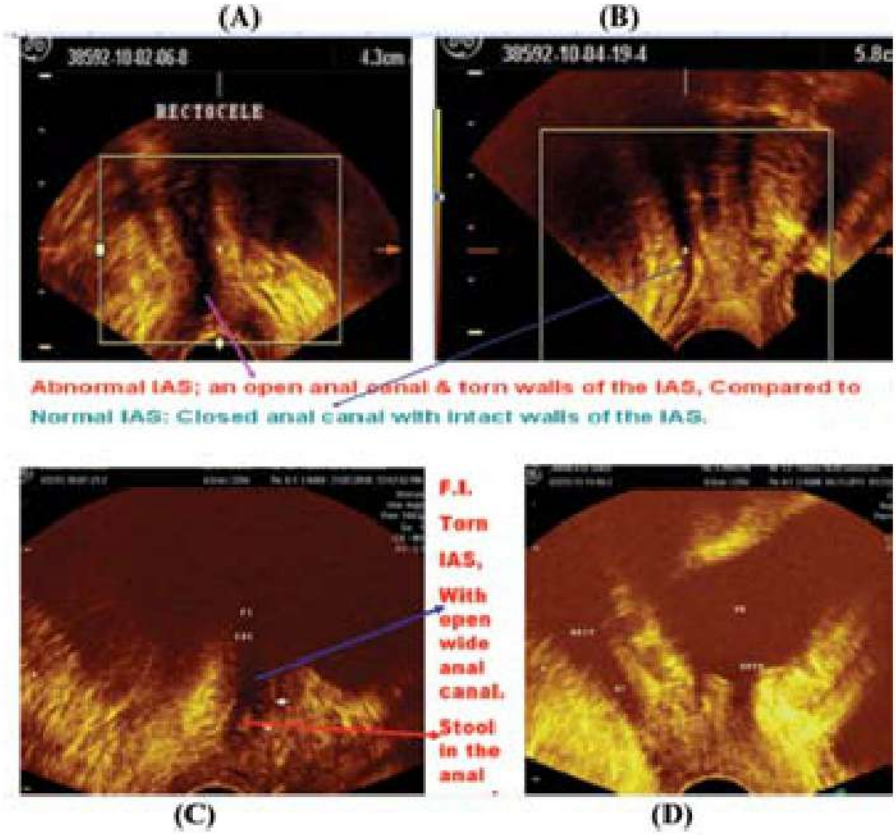

Figure 11

Comparison between torn IAS with an opened anal canal (A), as compared with an intact IAS with a closed anal canal (B) as seen by 3D US images. The anal canal is open and contains stool (C) as is seen by 3DUS; D shows an image by 3DUS of a patient suffering from SUI & FI at the same time with torn IUS and IAS.

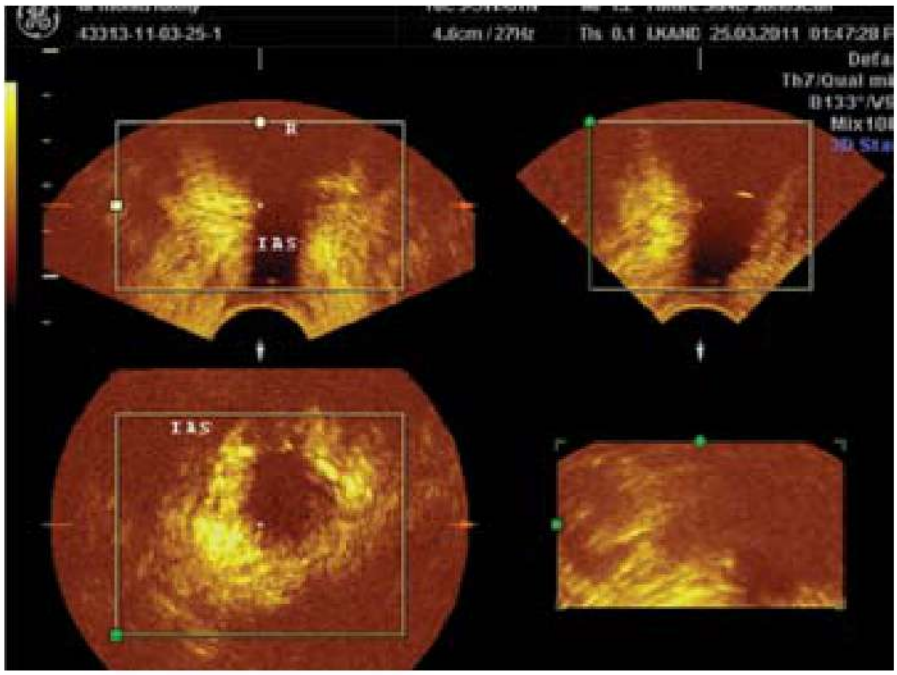

Figure 12

An image with 3DUS of a patient with FI, that show an open anal canal with torn IUS, the cross section looks like a horse-shoe appearance of defective IAS.

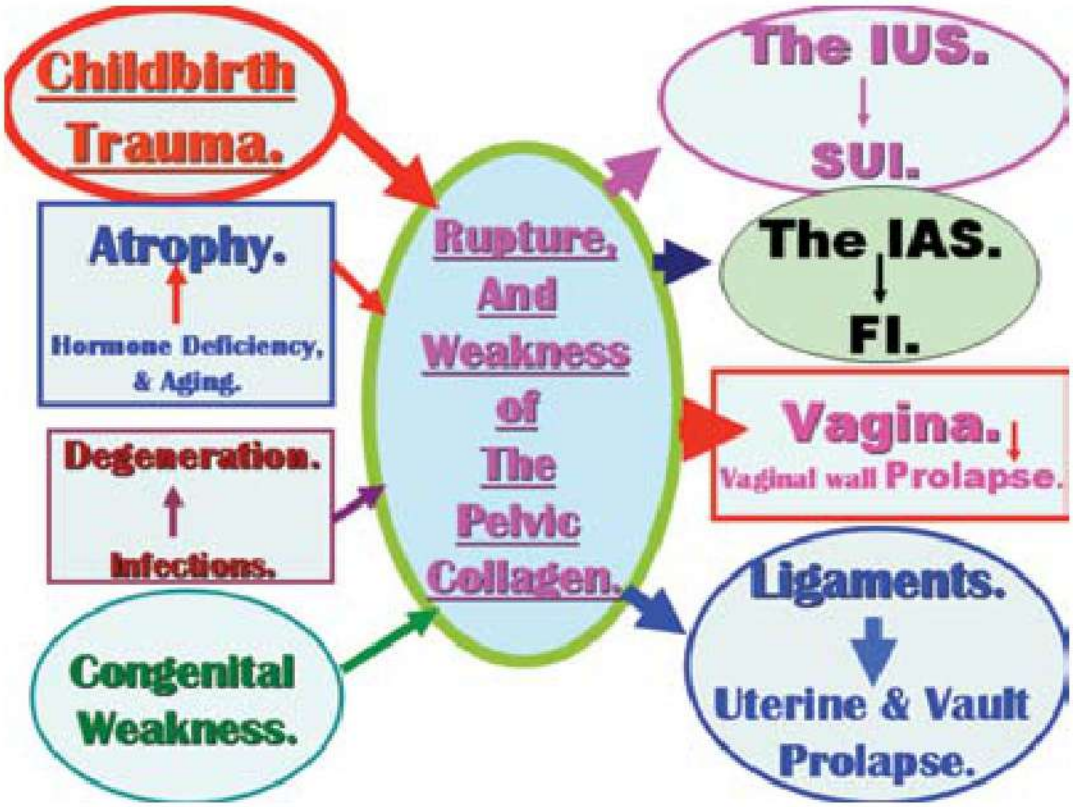

Figure 13

Diagrammatic representation of causes of weakness of the pelvic collagen and its sequels.

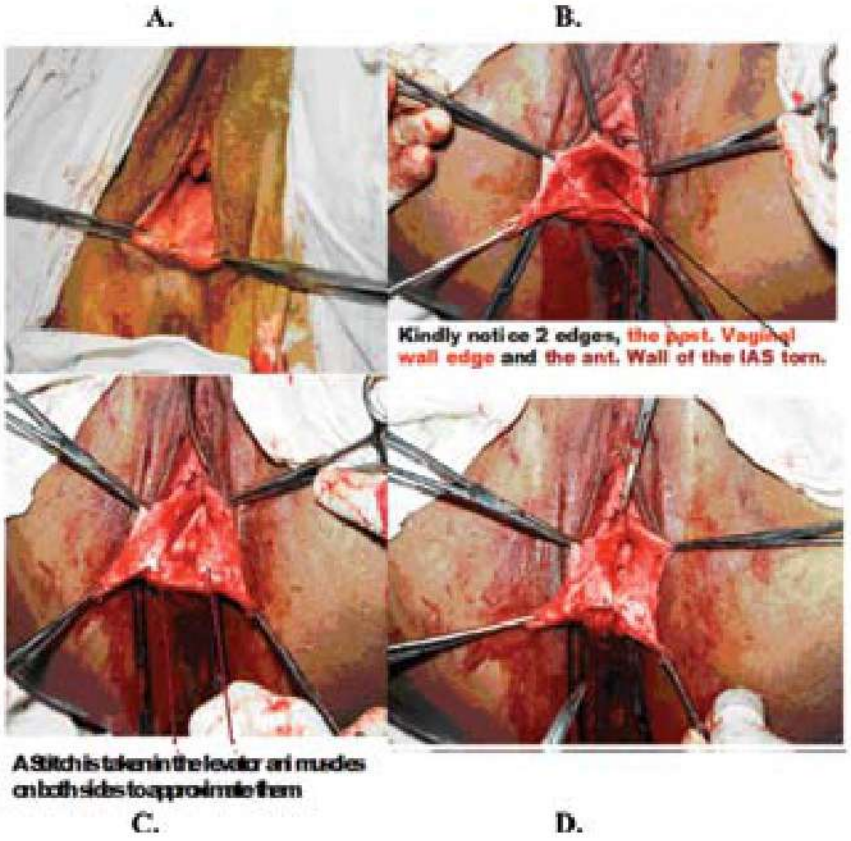

Figure 14

The IAS is torn with its torn anterior wall attached to the posterior vaginal wall. After carefully dissecting and separating the IAS from the posterior vaginal wall, simple interrupted sutures mend it. The sutures are taken in the collagen layer, which is very tough and thick. Sutures, 2-3, are taken in the levator ani muscles and left untied till finishing the mending of the torn IAS, and overlapping the vaginal flaps.

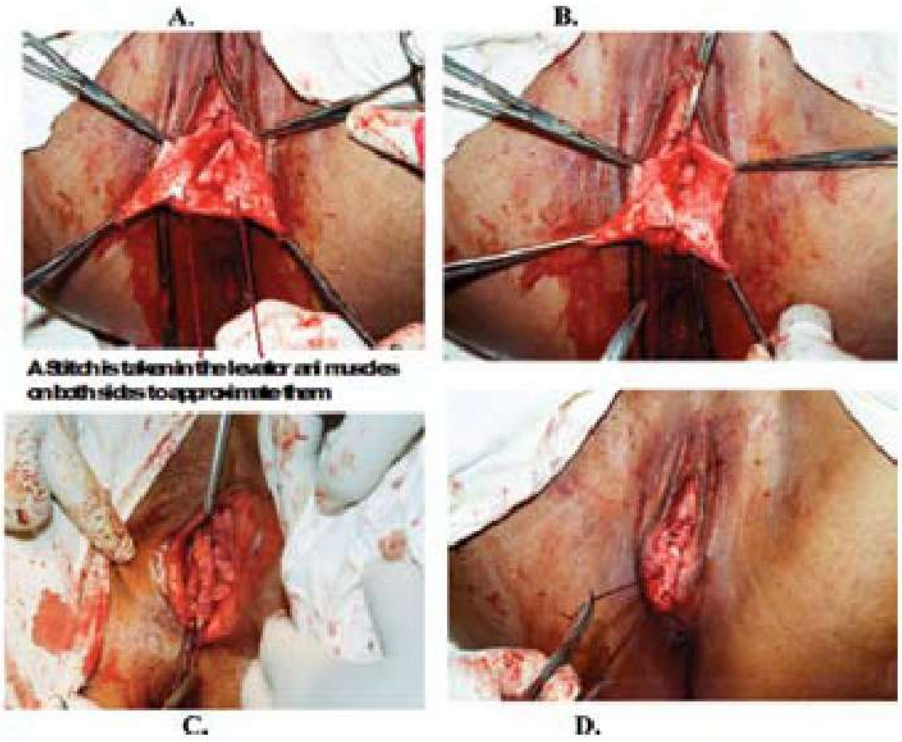

Figure 15

The vaginal flaps are overlapped by " dragging" sutures bringing the right flap beneath the left one then suturing the left flap as far laterally as possible. The two levator ani muscles sutures are then tied and the perineum repaired.

DISCUSSION

High urethral pressure (Pura) which is much higher than vesical pressure (Pves) is the cause of urinary continence (figures 1 & 4). The main causes of high Pura are:

1- The tough constituent of the IUS that have abundant collagen, which creates the high wall tension necessary for keeping high urethral pressure (Pura).
2- The acquired high alpha-sympathetic tone at the IUS that keep it closed all the time.

Drop of one or both factors leads to leak of urine. This drop in Pura happens:

1- Physiologically when we voluntary inhibit the high alpha-sympathetic tone at the IUS that leads to opening the urethra and voiding occurs.
2- Pathologically because of rupture, atrophy and degeneration of the collagen sheet of the IUS. The weak IUS will not stand against sudden rise of abdominal pressure as on cough, sneezing, jumping, coitus, or sometimes getting up.

Childbirth trauma causes rupture of the collagen layer of the IUS leading to its weakness. Drop in estrogen level causes atrophy of the pelvic collagen and subsequent weakness. Chronic and or repeated genito-urinary infections cause degeneration of the collagen of the IUS and of the vagina that lead to it's weakens causing SUI and vaginal prolapse, figure 13. 3DUS and MRI we can see the rupture in the IUS clearly. The level of the rupture along the cylinder of the IUS and its extent will determine the type of SUI (DO, genuine SUI or mixed type of incontinence) and the morphological shape of the urethra seen on imaging. If the rupture affects mainly the upper part of the IUS, detrusor over activity (DO) ensues, and funneling of the bladder neck with loss of urethra-vesical angle is seen on imaging. When the main damage is in the lower part of the IUS, it will lead to genuine SUI, and a "flask-shape" appearance is seen on imaging. If the damage affects the entire length of the IUS, then mixed type of urinary incontinence is the result, and a collapsed, apparent short urethra with irregular walls is seen on imaging figures 5 & 7.

Normally, the anal canal is empty and closed with intact IAS, and strong intact EAS. Figure 11.

In patients with FI the IAS is torn and the anal canal is wide and open, as is seen by imaging with 3DUS figures 11 & 12.The EAS can be assessed clinically, in addition to imaging with 3DUS. Many studies have shown that on ultrasound, fecal incontinence is strongly associated with anal sphincter defects; patients most often have a combined external and internal sphincter defect, or an EAS defect alone; isolated IAS defects are rare 9, 17. We believe that isolated IAS defects are much more prevalent than recorded, and it is a major cause of FI.

The vagina is standing up due to its own strong collagen sheet, which gives it strength and stout upright position. Childbirth trauma injuries its collagen sheet leading to flabby, redundant vaginal wall which collapse, prolapse. The injury affects, more the transverse diameter leading to patulous vagina. Clinically we can prove this as well, in nulliparous women the vagina is H-shape, which changes with parity to transverse slit.
There had been trials to evaluate the role of 3DUS in urinary continence and surgical treatment of SUI; 9, 10 & 11.

3DUS has been used in the assessment of patients with urinary incontinence by imaging the urethral morphology and measuring the urethra and its sphincter. 3DUS imaging had shown that women with SUI have urethral sphincters that are shorter, thinner, and smaller in volume 8. There had been debate about the urinary continence mechanism, whether it is related to an extrinsic mechanism such as a sling that is located under the urethra that is pulled upward and compresses the urethra during pelvic floor contraction, 9. Alternatively, whether it is related to an intrinsic mechanism such as striated sphincter that contracts down on the urethral lumen when the pelvic muscles contract 20. With use of 3DUS there was a trial to elucidate the urethral continence mechanism 10 &11. With use of a transrectal transducer, the morphology of the urethra was recorded and the urethral diameters, sphincter, and smooth muscle lengths as well as their thickness and volumes were measured. Those investigators found that urethral diameters and sphincter thickness were smaller during pelvic floor contraction compared with pelvic floor relaxation. In addition, total urethral and sphincter volumes are smaller during contraction compared with relaxation. The smooth muscle complex of the urethra did not change in thickness or volume during contraction periods compared with relaxation periods. Those investigators concluded that the urethral continence mechanism was extrinsic and occurs because of external compression by paraurethral tissues rather than intrinsic contraction of the urethral sphincter 10 &11.

Conclusions

We demonstrated that urinary continence depends on high urethral pressure (Pura). Intact and strong collagen sheet of the IUS creates the high wall tension necessary to have high urethral pressure. In addition the acquired behavior gained by learning and training in early childhood of keeping high alpha-sympathetic tone at the IUS confirm its closure all the time and add to the high urethral pressure.

Again, strong and intact collagen of the IAS, in addition to maintaining high alpha-sympathetic tone at the IAS is extremely important factor of preventing FI. Pelvic collagen is the most important factor of maintaining the shape, state, position and functions of the pelvic organs. It is hormone dependent and loss of steroid hormones causes its atrophy and weakness. Childbirth trauma is the main cause of its injury and weakness. Cumulative effects of injury, hormone deficiency plus degenerations from chronic or repeated infections lead to its weakness and pelvic organs dysfunction.

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