Original article

Quantification of Levator Ani (LA) Hiatus enlargement and pelvic organs impingement on Valsalva maneuver in parous and nulliparous women with obstructed defecation syndrome (ODS): a biomechanical perspective

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Abstract: Aim: to standardize a method for axial MR multislice image acquisition of female levator ani hiatus on straining in the steady state. *Subjects and Method*: The clinical and imaging series of 41 symptomatic women with evacuation dysfunction, aged 22-56 yrs. (mean 43± 4.1 yrs, median, 43 yrs.) referred for static and dynamic MR imaging between July 2013-June 2014, were reviewed. Of them, 13 were nulliparous (mean age 37±2 yr), the remaining 28 were parous by either vaginal delivery (15, mean age 46±8 yr), cesarean section (8, mean age 46±3 yr), or both (5, mean age 45±5 yr). MR Imaging (Philips, Achieva, 1.5 T, horizontally oriented, the Netherland) was obtained at rest, on evacuation of acoustic gel and during Valsalva maneuver in the steady state using axial, sagittal and coronal sections. Image analysis in the midsagittal plane included (1) quantification of pelvic organs position relative to the hymen plane (mm above [-], or below [+]); and (2) measurement of levator hiatus area (cm^2) at rest and on straining in the axial plane from three key images passing through the midsymphysis (level I); tangent to the inferior border of the symphysis (level II); and at the point of the maximal anterior rectal wall bulging (level III), respectively. Characterization of levator ani muscle defects, included presence of thinning, discontinuity and/or focal increase in the MR signal intensity compared to that of the obturator internus muscle. Classification of ODS at MRI into five degrees was used as described in a previous report. Statistics included, among others, the correlation coefficient between hiatus area at rest and on maximal straining in search for potential prediction of hiatus enlargement under the effect of abdominal pressure. *Results:* At rest, considerable overlap occurred in the average values of levator hiatus areas of parous and nulliparous groups (range 17.1±1.4 cm^2 to 19.6±3.5 cm^2, $p > 0.005$) as opposed to the significant increase (range 108-134%) in all groups seen on Valsalva; however, despite mild difference between parous and nulliparous, a surprising overlap between subjects with vaginal and cesarean delivery (43.1±14.9 cm^2 vs 44.2±9.1 cm^2, p ns) was noted; in addition, values at rest did not correlate with those on Valsalva (Pearson's correlation coefficient, Y = 0.37 + 19.27, R^2=0.14), indicating that in no case was it possible to predict the actual hiatus enlargement on the basis of resting values. Finally, regardless of parity or not (8/10 nulliparous; 5/8 with cesarean delivery; and 6/15 with vaginal delivery) the levator hiatus ballooning and organs impingement involved mainly the posterior compartment and were most frequently associated with difficulty in rectal emptying and trapping of contrast; interestingly, focal anatomical defects affecting both the muscular and fascial component was seen more frequently in women who delivered vaginally compared to nulliparous and cesarean groups (10/15 [66.6%] vs 2/13 [15.3%] and 1/8 [12.5%], respectively). *Conclusions*: Regardless of parity, delivery history and the onset of symptoms, the existence of difficult evacuation in women makes it unpredictable to establish the actual levator ani hiatus deformity and pelvic organ impingement under the effect of abdominal vector forces until using static and dynamic pelvic MRI.

Keywords: Fast MR pelvic imaging; Childbirth-related defects of pelvic floor; Biomechanics of levator hiatus; Evacuation dysfunctions; Pelvic organ prolapse.

INTRODUCTION

Quantification of the pelvic descent process with use of fast MR imaging having value in surgical planning and post-surgical follow-up, was described for the first time by Yang *et al*. in 1991.[1] From that time on, several studies followed until Lienemann *et al*.[2] published their study on the MR imaging of dynamic rectal evacuation using sonographic gel as contrast, an examination subsequently called MR-defecography. Despite the potential disadvantage of its less physiologic nature when compared to conventional X-ray defecography (the patient is usually examined supine), the examination has rapidly gained widespread acceptance throughout the world mainly due to the lack of ionizing radiation and its multiplanar evaluation of all pelvic contents including muscles, fascia, ligaments and fat recesses. Besides depicting in exquisite detail the emptying function of bladder and rectum in a cine-loop presentation, a distinct advantage of MR over other currently available imaging modalities, such as ultrasonography and X-ray contrast studies, lies in the fact that the grading of pelvic organs descent has also become possible relative to consistent anatomic landmarks using the HMO classification system, as described by Comiter *et al*. in 1999.[3] In particular, the "H-line", which measures the distance from the pubis to the posterior margin of the anorectal junction on sagittal MR images, was rapidly adopted almost invariably in most current studies as it closely reflects the change of the maximum anteroposterior diameter of the levator hiatus either at rest, on straining or during evacuation. On the other hand, with the exception of the papers by Tunn *et al*.,[4] only limited attention has been given to the measurement of hiatus width as seen on axial MR images,[5-7] which were considered not particularly helpful by Yang because the anatomic plane shifts during pelvic strain, or even scarcely reproducible by Hoyte[8] in case of minimal slice tilt angle during image acquisition. The first aim of the present paper was to describe a strategy for standardizing the strain effort during MRI scan in a more proficient way than that described by Tumbarello *et al*.;[9] secondly, a systematic comparative analysis between axial MR images taken at rest and on straining is described, which can be used in perspective to explore important biomechanical properties of biological systems, such as friction, adhesion, wear-resistance, and load producing reciprocal sliding motion until damage or failure occur.

SUBJECTS AND METHODS

Patients

The medical records and imaging series of 41 symptomatic women with evacuation dysfunction and obstructive defecation syndrome (ODS), aged 22-56 years, mean 43± 4.1 yrs, median 43 years, referred to our diagnostic center between July 2013 and June 2014 for static and dynamic MR imaging, were reviewed by both phone interview and retrieval of original pictures. Of them, 13 were nulliparous (mean age 37±2 years), the remaining 28 were parous by either vaginal delivery (15, mean age 46±8 years), cesarean section (8, mean age 46±3 years), or both (5, mean age 45±5 years). Symptoms of ODS, defined as difficulty in expulsion, straining at stool for more than 25% of the time, prolonged toilet time, hard feces and need for self digitation, were diagnosed by the referring physician on the basis of medical history and clinical examination. At interview (AV and NM), women were asked to provide information on their delivery data, if any, (including mean gestation at delivery, induction of labour, episiotomy, mean birth weight, shoulder dystocia, median duration of 2nd stage, perineal tear, repair technique, time interval to recovery of daily activity) and current symptoms or impact of MR examination on subsequent treatment.

Imaging Technique

All MR imaging studies were performed (PV) on a 1.5 T scanner (Philips; Achieva Sinergy model, SENSE XL TORSO coil, The Netherland) in the supine position. Following rectal filling with up to 300 mL of acoustic gel, the dynamic fast images were immediately obtained with a *singleslice*-technique in the midsagittal plane using the balance fast field echo (BBFE) pulse sequence (TR,2.7 msec; TE, 1.3 msec; 45° flip angle; 30-mm-thick section; FOV, 300 mm; 256x256 matrix and two averages; 1 im/0.768 sec over 43 seconds) during evacuation of the contrast. Then, the dynamic sequence was repeated with use of the same parameters in the midcoronal plane passing through the ano-rectal axis for better evidence of any abnormalitiy. Thereafter, given the shift of anatomic planes during pelvic strain, a different strategy was chosen for the dynamic acquisition in the axial plane, as follows: images were obtained during Valsalva maneuver in a steady state with use of a*multislice* technique (TR, 4.1msec; TE, 1.4 msec; flip angle, 45°; 10-mm-thick section; 256x 256 matrix and two averages; FOV, 300 mm; 2.7 sec/slice over 13 seconds) taking the pubic bone as reference at the following three different contiguous levels: (a) through the midsymphysis (level I); (b) tangent to the inferior border of the symphysis (level II); and (c) at the point of the maximal anterior rectal wall bulging (level III), respectively (Figure 1). Sections were taken horizontally, perpendicular to the long axis of the body with no need for adjusting the angle of acquisition. The specific instruction for pelvic strain was the following: “take a deep inspiration so as to maintain enough air inside the chest for 15 seconds; now bend down to produce your maximal pelvic strain, starting now and holding that position without interrupting the maneuver until told to breath and relax”. To ensure both maximal voluntary effort and collection of any rectal content without discomfort o embarrassment, patients were placed on a waterproof pad with their underclothing removed and were asked to void at least 1 hour prior to imaging, so as to have the bladder on-

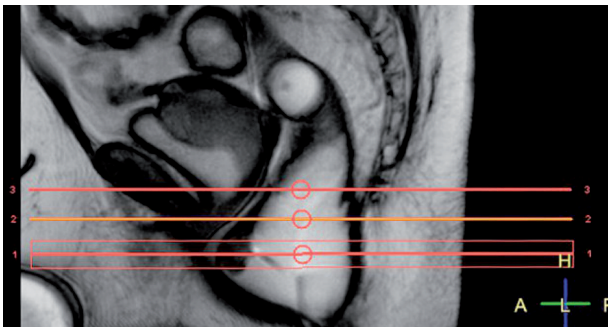

Figure 1. – (A) Positioning of three contiguous, horizontal 10-mm- thick- sections relative to the symphysis pubis and to the deepest position of pelvic organs for standard MR image acquisition in the axial plane of the levator hiatus on straining: section n° 3 = level of midsymphysis; section n° 2 = level of arcuate ligament; section n° 1 = level of the most prominent bulging of anterior rectal wall. (B) Levator hiatus enlargement under the effect of straining in a steady state. A = area; numbers are square mm.

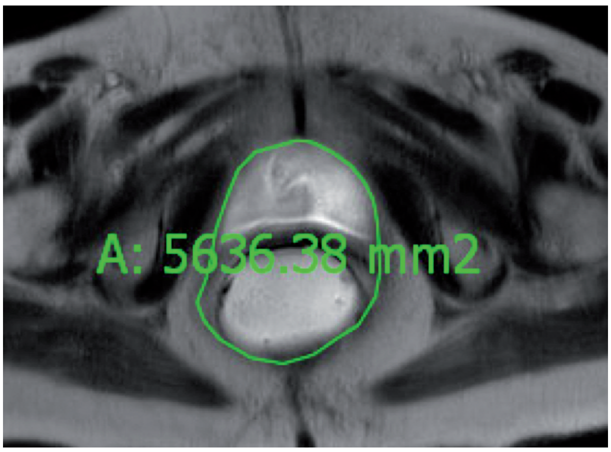

Figure 1. – (B).

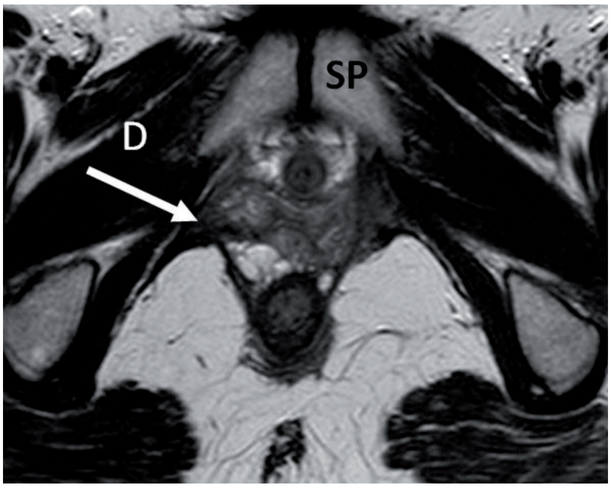

Figure 2. – Axial T2-weighted view at rest of the levator hiatus for imaging of urethra, vaginal and paravaginal supports, and anal canal. SP = symphysis pubis; D = defect of pubococcygeus muscle and posterior paravaginal attachment (arrow).

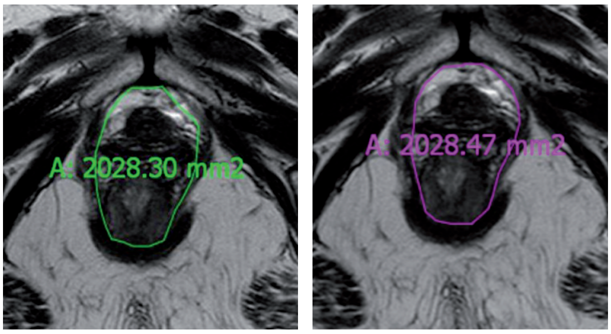

Figure 3. – First (A - green) and second (B - pink) measurement of the hiatus area with the manual contour tracking technique from section n° 2 demonstrate good reproducibility (test and retest correlation coefficient, r = 0.94).

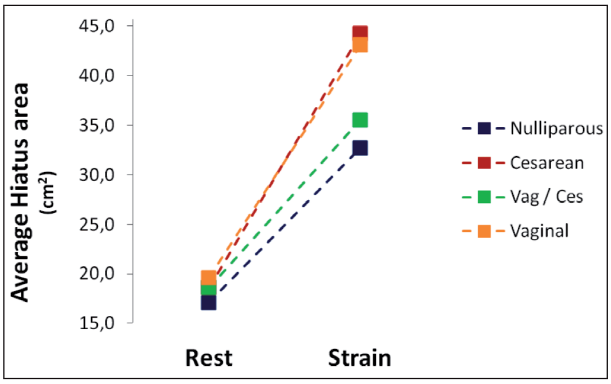

Figure 4. – Data showing results of levator hiatus area measurement in parous and nulliparous women with evacuation dysfunction. Average values of different groups are seen to overlap at rest and can be better distinguished on maximal straining with the exception of women who delivered vaginally and by cesarean section.

ly half full. After the dynamic series, routine resting axial, sagittal and coronal turbo spin-echo (TSE) T2-weighted 4-mm-thick sections (TR, 4630 msec; TE,90 msec; flip angle, 90°; thickness, 4 mm, 444/310 matrix and four averages; FOV, 350 mm, acq. time, 3.37 min; total images, 25) were also obtained to define anatomy, exclude other pelvic disease and determine residue of contrast, if any, inside the rectal ampulla. Occasionally, axial proton density (PD) was also obtained for better depiction of ligaments and fascial supporting structures.

Image Analysis

On sagittal MR images, the hymen plane is consistently and precisely identified by drawing a horizontal line tangent to the most inferior border of the symphysis pubis and extending backward to join the external urethral orifice and vaginal introitus. That line, as described in a previous paper,[10] was used as a reference and preferred to both the pubococcygeal line (PCL), defined as a line extending from the inferior border of the pubic bone to the last sacrococcygeal joint, or the midpubic line (MPL) defined as a line drawn through the longitudinal axis of the pubic bone, because independent of pelvic bone tilting and credited with widespread acceptance among clinicians and researchers when defining the position of pelvic organs.[11,12] Quantitative description of the anatomic position of bladder, cervix and rectum relative to the reference line is calculated at the point of their maximal descent during emptying of rectal contrast by measuring the vertical distance from the line to the most dependent margin of the (a) bladder base; (b) cervix or vaginal cuff in posthysterectomy patients; and (c) anorectal joint. Values are expressed as millimeters above (negative number) or millimeters below (positive number) the hymen. On axial images, the area of the levator hiatus was calculated at rest and on straining using a manual contour tracking technique from the pubic bone to the posterior rectal wall and between the medial margin of the right and left levator ani (LA) muscle. For evaluation of the LA integrity, the signal intensity was compared to that of the obturator internus (OI) muscle on the T2-weighted and PD sequences and described as being the same, higher or lower; also, the thickness and continuity of the LA muscle fibers were noted and any thinning or defect in both the pubococcygeus and iliococcygeus muscles was recorded. Alteration in normal H-shaped vaginal configuration with or without lateral shift was interpreted as evidence of focal defect of the endopelvic fascia (Figure 2). Quantification of ODS at MR with a 1-5 point scale was done according to

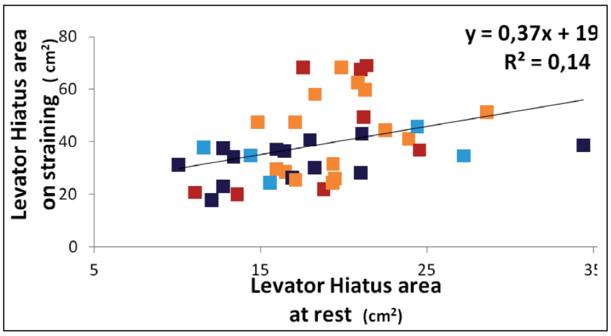

Figure 5. – Graph showing lack of correlation (Pearson coefficient y, 0.37; r^2, 0.14) between resting and maximal straining values of the levator hiatus area, regardless of the patient group.

established diagnostic criteria described in a previous report.[13] Measurements were made on line using an internal scale. Distances were expressed in mm, angles in degrees and areas in square cm. Values were given as mean ± SD, and were compared by absolute differences and percentage variations.

Statistical analysis

Simple statistics of mean, median, standard deviation (SD) and range were calculated (PF) for all measurements, and the data were compared between groups. Differences between means of various parameters at rest and on straining were analyzed by the paired Student t-test. In order to assess the reliability of the technique when measuring the hiatus area, in 12 subjects measurements were made on two consecutive reading sessions (Figure 3) and the intraobserver reproducibility of repeated measurement was calculated by the intraclass correlation coefficient. In addition, to evaluate the relationship among the various parameters and whether or not the area at rest could enable prediction of the maximal strain, Pearson's correlation coefficient was calculated. Differences were considered statistically significant at a probability value of $p < 0.05$. Data are reported as mean ± standard deviation (SD). Calculations were performed with SPSS/PC + software.

RESULTS

All patients gave vocal consent to the phone interview and cooperated actively with the two interviewers to fill in the questionnaire investigating the aspect of their delivery data, and acceptance of MR examination. In particular, it emerged that the MR examination was well tolerated by all patients who were always capable to perform the Valsalva maneuver during image acquisition according to the instructions of the examiner after proper coaching at the moment of the preliminary interview (average time, 5 minutes). On emptying, in 3 out of 41 cases, no more than a weak stream of contrast was obtained and in 2 no expulsion at all occurred, despite repeated attempts. More particularly, while a complete expulsion was seen in 7/41 (17.07%) subjects, a residue of 2/3 the total amount injected was observed in 16/41 (39.02%); 1/2 in 14/41 (34.14%); and < 1/3 in 4/41(9.75%). Nevertheless, even in case of failed contrast emptying ,it was always possible to properly measure the maximum downward displacement of bladder, cervix and rectal floor so as to allow taking their deepest visible position as a measure and grading of the prolapsed pelvic organ. Overall, the position of various organs relative to the hymen plane on straining varied significantly in singular cases as follows: the bladder base ranged from –30.40 mm (above) to +26.90 mm (below); the cervix or vaginal vault from – 72.60mm to + 43.30 mm and the rectal floor from –

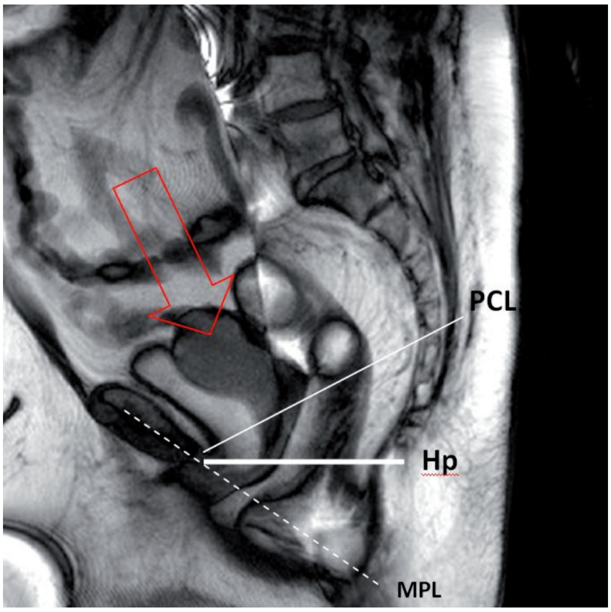

Figure 6. – The downward displacement of pelvic organs under the effect of vector forces (large arrow) from above is quantitated differently depending on the reference line in use. PCL = pubococcygeal line; MPL = midpubic line; Hp = Hymen plane.

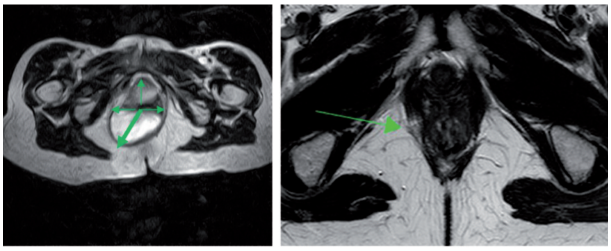

Figure 7. – (A) Asymmetric ballooning of levator hiatus on Valsalva reflecting the different capacity of its peripheral boundaries to counteract the radial forces from inside the abdomen in a similar way (arrows of different length). (B) A fibrofatty focal defect (arrow) was found in the right pubococcygeal muscle on the corresponding axial T2-weighted static sequence.

Table 1. Clinical and MR Imaging data in the patient population (n° 41)

Note* including abnormal presentation, prolonged second-stage labor, operative vaginal delivery, fetal macrosomia; ** either muscular, fascial or both. *** According to Piloni *et al* [13]

	Item	Group				
		Nulliparous	Cesarean	Vaginal	Vag/Cesar	*P*
clinical	N° subjects	13	8	15	5	< 0.005
	Age (yr)					
	average	37± 2	46± 3	46± 8	45± 5	< 0.005
	median	38	48	49	43	
	range	22-47	36-55	29-56	40-52	
	Parity (n)					
	average	/	1.5 ± 0.8	1.7 ± 0.4	2.6 ± 0.6	< 0.005
	median		1.0	2.0	2.0	
	range		1-3	1-3	2-5	
	Adverse Obstetric Factors *	/	/	10	4	ns
MR imaging	Defect **	2	1	10	2	< 0.005
	ODS degree ***					
	1st	3	1	1	1	ns
	2nd	2	1	1	/	ns
	3rd	2	3	5	4	< 0.005
	4th	3	2	8	2	< 0.005
	5th	2	/	/	/	
	PO Impingement					
	anterior	2	1	6	1	
	middle	4	2	7	1	ns
	posterior	8	5	6	1	
	Hiatus area *resting* (cm^2)					
	average	17.1±1.4	18.6±2.6	19.6±3.5	18.6±6.8	ns
	median	16.4	19.9	19.3	15.5	
	range	10-34.4	11-24.5	14.8-28.6	11.6-27.2	
	Hiatus area *straining* (cm^2)					
	average	32.7±3.7	44.2± 9.1	43.1±14.9	35.5±7.6	< 0.005
	median	34.3	43.1	44.5	34.9	
	range	17.9-43.1	20.0-69.0	24.4-68.4	24.5-45.8	
	% increase	104	134	122	108	

43.30 mm to + 55.0 mm. While the average hiatus area at rest was 18.3± 5 cm^2 with only minimal differences among groups, that on straining was 39.11± 14.6 cm^2 (percentage increase, 117%), allowing better discrimination with the exception of a surprising overlap between women who delivered vaginally and by cesarean section (Figure 4). The mean difference between two intrasession measurements of the levator hiatus area showed only minimal variation (see Figure 3) and high intraobserver reproducibility rate (intraclass correlation coefficient r, 0.94); on the other hand, the Pearson correlation coefficient between resting and maximal straining values of levator hiatus areas was only 0.37, r^2=0.14 (Figure 5), indicating lack of substantial correlation between the two variables. In addition, the presence of ODS, irrespective of severity, annulled the effect of any difference in hiatus size between groups. A complete summary of the clinical and imaging data in the patient population is shown in Table 1.

DISCUSSION

Although the boundaries of the levator ani hiatus are easily palpable on pelvic examination, determining its size with a ruler to the nearest 0.5 cm and producing the area of an oval, as it is commonly assessed by the gynecologist, remains an approximate method indeed. In his classic paper,[14] DeLancey demonstrated that the urogenital size is larger in women with prolapse than in those with normal support, even though such difference may persist in some women after surgical repair, thus indicating that an enlarged hiatus does not necessarily reflect *per se* the presence of prolapse. Current opinions and evidence by the literature suggest that changes in the closure mechanism of the levator hiatus are most frequently associated with defective connective tissue support occurring with or without damage of the muscular component.[15-17] The advent of fast MR imaging in the early 90s has radically changed the approach of modern medicine to the assessment and treatment of pelvic pathologic conditions. Also it was no longer necessary to administer hypotonic drugs or ask patients to maintain a light respiration during image acquisition, so as to avoid substantial degradation of image quality from either gut peristaltic activity or abdominal wall movement. Besides better depiction and characterization of various pathologic processes including endometriosis, primary and metastatic malignancy, and infectious diseases of the lower urinary tract, genital system and distal gut, it soon became possible to extend the use of MR imaging to the assessment of functional disorders of pelvic floor as well. More specifically, technical advances registered in the field of image acquisition up to 16 times faster than with the standard Spin echo (SE) pulse sequence were followed by concurrent quicker image reconstruction, ultimately leading to the development of a "real-time" visualization and cinematic display of imaging series obtained during bladder and rectal emptying. In addition, MRI seems ideally suited to depict the pelvic floor anatomy in its entirety, including the extensive fibro-elastic network which is thought to play a major role in obtaining "the suspension" of pelvic organs within the pelvis. That structure is consistently and clearly seen on routine images, starting just below the skin and penetrating fat recesses, muscles and organs, which are interconnected with each other by means of fascia and ligaments and are anchored to the bony pelvis, giving also support to the kinetic activity of multiple muscular chains. Currently, despite great debate and lack of uniformity still existing among authors regarding the optimal technique and diagnostic criteria to be adopted, the only recognized drawback of the examination seems to be the potential disadvantage of its less physiological nature: the examination is usually performed with the patient supine instead of sitting on a commode, due to the horizontal configuration of most conventional MR scanner in use. It can be argued however that, despite an identical position assumed by the patient, performing the Valsalva maneuver during the physical examination is less reliable and difficult to be replicated by examiners. Conversely, a unique advantage of MRI relies on its ability to depict the expulsion of rectal contrast and repeat it until obtaining the maximum potential descent of pelvic organs, thus providing objective grading of prolapse with superior accuracy when compared to the physical examination. Not by chance, until recently the interest of most authors has been focused almost exclusively on the analysis and quantification of (a) the upward-downward displacement of pelvic organs under the effect of the squeeze/strain maneuvers; and (b) the progressive emptying of the bladder and rectal ampulla. Special consideration is deserved to explain the rationale behind our choice of the hymeneal plane as reference for prolapse quantification, the reasons being: first of all, it remains the only universally accepted reference system allowing efficient and precise communication between clinicians and radiologists; secondly, despite the bulk of papers published on this issue, definite agreement among researchers is still lacking and a number of reference lines have been proposed, each with its pros and cons, and with high risk to overestimate or underestimate of the extent of organs descent when using PCL or MPL, respectively. In any case, to obtain the depiction of downward displacement, the radiologist utilizes the so-called "single slice, multiple maneuver technique" which consists of stimulating the same midsagittal or midcoronal body section properly chosen from the region of interest during the rest-strain-emptying cycle at a rate of 1 image/every 0.786 seconds. By adjusting the speed of image review in a cine-loop replay, information are obtained with regard to the motile activity of distal gut and lower urinary tract, i.e. the *cinematic function*. On the other hand, the same fast imaging technique can be applied to depict the pelvis in the axial plane, as shown in the present study, during continuous, maximum Valsalva maneuver in the steady state, so as to develop what we called a " multislice, single maneuver technique". In practice, after selecting three different 10 mm-thick body sections relative to the symphysis pubis, the straining series were compared with those at rest by the same anatomic landmarks, allowing detection of (a) the geometrical deformity and enlargement of the levator hiatus; and (b) the impingement of various organs by compartment. The adoption of the method of the three horizontal axes relative to fixed and consistent anatomic landmarks was chosen by us for two reasons. Firstly, to minimize the systematic error generated by the measurement performed using a flat plane in a complex, 3D structure such as that of pelvic floor muscles and hiatus. Secondly, due to the impact of even minimal slice tilt angles on measurement reproducibility, to avoid the need for adjusting arbitrarily the angle of acquisition from a plane axial to the body to a plane parallel to the direction of the puborectalis muscle (also called the plane of minimal hiatal dimensions). Although we admit that the best technique on how to measure the levator hiatus with axial MRI sequences is still a matter of great debate, this strategy proved worth in obtaining satisfactory reproducibility from repeated measurements of hiatus area in our patient population. Besides this, the most striking results of the present study seem to be (1) the overlap in resting hiatus size at MR imaging between nulliparous and parous women, regardless of the fact that the latter group delivered vaginally or by cesarean section; (2) the lack of correlation between resting and straining values, indicating that, contrary to what has been described by Dietz *et al*.[18] the levator area at rest seemed to predict descent on Valsalva, in no case could the actual hiatus enlargement be predicted on the basis of either the physical examination alone or delivery history, especially when symptoms of evacuation disorders and ODS are present; and (3) the geometrical deformity of hiatus boundaries and organs impingement on it closely reflect the action of a vector quantity from above, i.e the force of abdominal pressure (Figure 6), that tends to produce an acceleration of various structures in the direction of its application against the resistance of hard (like bone) and soft tissues (like skin, tendon, muscle and fat). Under this perspective, a new kind of information can be generated from the analysis of axial MR images applied to the study of the mechanical principles of living organisms, i.e. the *biomechanics,* particularly their movement and structure. Conceptually, it can be assumed that pelvic organs and supporting structures are subjected to complex phenomena such as intermittent repetitive load and reciprocal sliding motion, which involve important properties of biological systems including lubrication (layered interposition material), adhesion (attraction force), friction (interlock between surfaces), wear (degradation) and potential failure. All the above is part of the so called "Tribology", a new interdisciplinary field of research combining methods and knowledge of physics, chemistry, mechanics and biology.[19-21] According to the scientific principles of contact mechanics, the geometrical deformations of hard tissues are hardly visible and should be analyzed with the theory of linear elasticity; conversely, soft tissue usually undergoes large deformations and, as such, their analysis relies on the finite strain theory and computer simulation, making magnetic resonance imaging an ideal tool which helps in understanding the equilibrium between active and binding forces (Figure 7) affecting structures subjected to reciprocal slide motion within the pelvis. Future studies will tell us if trends observed here will continue.

CONCLUSIONS

A variety of factors are responsible for the enlargement of levator hiatus in women under the effect of increased intra-abdominal pressure, including mainly the defective connective supports and focal damages in the muscular components. Although vaginal delivery is the strongest established risk factor, the presence of ODS adds a note of complexity to the issue, making it difficult to recognize an index having discriminatory effect between parous and nulliparous women. Nevertheless, any geometrical deformity seen at MR imaging affecting the pelvic organs muscles, fascia, tendons, ligaments and fat on straining, has a potential biomechanical significance attached to it and should be taken in consideration. Overall, a comprehensive understanding of complex phenomena occurring when two biological systems interact with each other can only be achieved through the cross-fertilization of ideas from different disciplines and the systematic flow of information among research groups.

DISCLOSURE STATEMENTS

The authors declare no conflicts of interest and the patients informed consent was obtained.

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Multidisciplinary UroGyneProcto Editorial Comment

To improve the integration among the three segments of the pelvic floor, some of the articles published in *Pelviperineology* are commented on by **Urologists, Gynecologists, Proctologists/Colo Rectal Surgeons** or **other Specialists**, with their critical opinion and a teaching purpose. Differences, similarities and possible relationships between the data presented and what is known in the three fields of competence are stressed, or the absence of any analogy is indicated. The discussion is not a peer review, it concerns concepts, ideas, theories, not the methodology of the presentation.

Gyneco... MRI imaging of the pelvic floor is still an emerging science. This is article by Professor Piloni has several levels of interpretation. Firstly, Professor Piloni continues his pioneering quest to lay down reproducible landmarks. This is a difficult but important quest. Difficult, as shown by his findings of overlap in resting hiatus size at MR imaging between nulliparous and parous women, regardless of the fact that the latter group delivered vaginally or by cesarean section and the lack of correlation between resting and straining values. Important, because the MRI findings can be used to confirm or invalidate theories of organ function. MRI was a key tool in the confirmation of an external striated muscle open ing mechanism for defecation (1). Piloni et al have shown definitively that the area of the levator hiatus at rest cannot predict descent on Valsalva manoeuvre. I agree with his comment that changes in the closure mechanism of the levator hiatus are most frequently associated with defective connective tissue support. I do not agree with the comment *“the geometrical deformity of hiatus boundaries and organs impingement on it closely reflect the action of a vector quantity from above, i.e the force of abdominal pressure*”. This comment implies causation by pressure. Our considered view based on video xray, EMG and mathematical models is that intrabdominal pressure is secondary. Since 100 years, it has been known that the abdominal pressure is secondary to contraction for the anterior abdominal wall which contracts reciprocally with the pelvic floor diaphragm (2,3). The anterior abdominal wall and pelvic floor embryologically derive from the same myotomes, Power (4), giving an anatomical basis for the observations by Paramore (1908) and Sturmdorf (1919) of simultaneous reciprocal contractions of this group of muscles. On the basis of the above, it is suggested that the observed increase in abdominal pressure is due to the simultaneous reciprocal contraction of the abdominal muscles in response to the pelvic floor contraction and vice versa. We have demonstrated in a mathematical model with regard to micturition, that a pressure 100 times greater than that recorded would be required to overcome the inherent closure forces of the urethra and adjoining tissues. A practical validation is that paraplegics cannot micturate spontaneously because the external striated muscles cannot open the urethra (or anus). This mathematical model is a confirmation of Professor Piloni's vision, that MRI will be a key tool in future biomechanical studies of the pelvic floor. To this we would add flow mechanics, tissue and bioengineering (6-8). Important in this new direction will be the knowledge that the pelvic floor is complex, non-linear and exponentially determined, with complex reflex feedback mechanisms controlling every aspect of function (9). It is also important to realize that 'obstructive micturition' and 'obstructive defecation' are not caused by anatomical obstruction. It is a functional obstruction, caused by inability of external striated muscle vectors to open out the outflow tubes of the urethra and anus.

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Procto... Based on a static and dynamic MRI study particularly evaluating the levator ani hiatus enlargement, the Author stresses the impossibility of predicting the onset of obstructed defecation in patients either nulliparous or undergoing a caesarean or vaginal delivery. The topic sounds quite intriguing for the proctologist and the colorectal surgeon as these findings suggest an opportunity for a detailed clinical study concerning the differences in the occurrence of female obstructed defecation in relation to method of birth, and subsequently possible imaging predictors to such a kind of unsatisfactory defecation. In the short term obstructive symptoms don't seem so directly related to trauma from childbirth. Other variables should be considered as the timing of symptoms and their variability, the coexistence of pelvic floor dyssynergia, abnormal rectal sensitivity, onset of a low rectocele or of a posterior colpocele, or finally other types of constipation. A morphological abnormality as documented by the imaging of a rectocele, or internal mucosal prolapse or of an intussusception should not be absolute indications for surgery. Only a careful clinical and instrumental evaluation may suggest the therapeutic strategy more suited to the individual case, pondering the cost benefits of a medical- rehabilitation treatment vs surgery, and, a most important item, planning a long term follow up.

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Autore's replay. The comment to the paper by dr Ferraro demonstrates how distant entities information and communication are. Information is no more than a means for sending and receiving news and messages. On the other hand, communication implies the exchange of thoughts. In simple terms, information can be regarded as *what I say*, while communication is *what is understood* as result of what I said. Nevertheless, in the course of my professional life, I was rarely witness before of such a complete upsetting of an (original) message of mine. Consequently, It seems worth spending few more words in the hope to better clarify the central message of the paper, as follows: firstly, the lack of correlation between resting and straining levator hiatus values at MR imaging and the consequent inability to predict its size do not necessarily indicate the superiority of physical examination over imaging. Rather, it simply means that in no case the actual hiatus enlargement can be assessed **until performing** such a study; secondly, and most important, the advent of obstructed defecation syndrome (and not the impossibility to predict its onset) can nullify any discriminatory capacity between parous and nulliparous women when calculating the hiatus enlargement on straining. This, in turn, suggests the need for better characterization of the biomechanical properties of living tissues in the pelvis.