Original article

MR anatomy of the endopelvic fascia and ligaments in males

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Abstract: *Aim* To describe the characteristics of the connective supporting system at MR imaging and its clinical impact. *Materials and Methods* The imaging series of three hundred and fifty four consecutive men submitted to pelvic MRI between April 2012 and November 2019, were systematically reviewed for evidence of any linear hypointense structure consistent with the connective system as seen on the axial, sagittal and coronal planes using the T 2-weighted pulse sequence. *Results* In the anterior compartment, the fundiform ligament, the puboprostatic ligaments and the suspensory penis ligaments were recognized most frequently (100 %, 87.5 % and 70 %, respectively); in the middle compartment, the neurovascular bundle contained in the posterior triangular prostatic corner, the peritoneal reflection running over the bladder and suspending the seminal vesicles and the Denonvilliers fascia were see in 55.9 %, 42.6 % and 40.9 % of cases. Besides all, the typical H-shaped morphology of the sacro recto vescicolo genito pubic fascia characterized the endopelvic fascia of the posterior compartment in up to 77.9% of cases, closely resembling the features of the sacro uterine ligaments. *Conclusions* As it occurred in the case of female patients, MRI proves to be the imaging modality of choice to depict the anatomy of the connective tissue. This have a potential impact on the early detection of pathological processes (tumor staging and recurrence, abscess location and spread) as well as on the pathophysiology of functional disorders.

Keywords: Endopelvic fascia; Male pelvis; Magnetic Resonance Imaging; Mesorectal fascia; Denonvilliers fascia; Sacro recto vesico genito pubic fascia

INTRODUCTION

Over the past 20 years, numerous contributions have been published concerning the tudy of the endopelvic fascia in the female population, both from an anatomical and imaging point of view[1-5]. On the contrary, those were scarce for the same structure in males and limited to the interest in the anatomy involved in total mesorectal excision surgery after rectal tumor removal[6-8], prostatic cancer staging and periprostatic tissues following radical prostatectomy[9-13], or the retropubic space after inguinal hernioplasty[14].

In an attempt to fill the void, we hereby report our experience concerning the anatomical features of the endopelvic fascia, as seen on magnetic resonance imaging, in a wide range of male patients referred to our diagnostic unit for a number of pathologies other than those mentioned above[15]. All this, in the supposition that their fascial system was intact or, at most, was affected by minor changes only. Over time, however, the need for taking care of even minimal abnormality/variant during the reporting phase, has lead us to gradually change our view of male pelvic fascia and ligaments until the point of considering their relevant possible role also in the development of functional disorders, sexual dysfunctions and chronic pelvic pain syndromes. As such, the goal of the paper is two-fold, as follows: firstly, to fill the existing gap of knowledge which is still present in the medical literature with regard to the characterization of the pelvic connective structures as a whole; secondly, to stimulate readers interpreting pelvic floor pathologies and dysfunctions in males under the new perspective of the anatomical defects of the connective tissues that sustain them.

MATERIALS AND METHODS

The pelvic MR imaging series of three-hundred and fifty-four consecutive men (mean age 53.2±6.1 yr, range 16-83 yr) referred to our unit between March 2012 and November 2019 were systematically reviewed. Reasons for the examination included voiding dysfunctions, obstructed defecation syndrome and rectal prolapse, ano-perianal fistula disease, sexual dysfunctions, and chronic pelvic pain. All MR imaging examinations were developed on a 1.5-T, horizontally oriented, whole-body system (Philips, Multiva model, The Netherland) using a TORSO XL SENSE four-element, flexible wraparound surface coil. No bowel preparation or intravenous antispasmodic agents were used. However, patients were encouraged to empty their rectal ampulla early in the morning of the examination date by a spontaneous bowel movement and were asked to void their bladder in the toilette room just before imaging. Regardless of the presenting symptoms, which led us to tailor the MR imaging protocol to the singular case, a fast localizer scout scan (TFE T1 pulse sequence, TR 8 ms, TE 5 ms, FA° 25, thickness 15.0 mm, number of images 5-to-11) was acquired first which served to mark the boundaries of the region of interest (ROI); then, sagittal, axial and coronal T2-weighted turbo spin-echo (TSE) acquisitions of the pelvis were performed in all cases with the following technical settings: TR, range 3649–4656 ms; TE, 100 ms; flip angle, 90°; section thickness, 4 mm; intersection gap, 4 mm; reconstruction matrix, 576 and 3-4 averages; echo train length, 16; FOV, 280-350 mm; acq.time, 3:00- 3:44 min; total number of images, 35. The field of view extended from the testes (bottom level) to the upper margin of the iliac crest (upper level) and from the sacrococcygeal spine (backward) to the anterior margin of the abdominal wall (forward) so as to include all relevant anatomy (fat recesses and connective supporting structures, prostate gland and seminal vesicles, distal gut and the urinary bladder, testes and the fixed portion of penis). Image analysis of each scan plane was focused, besides all, on evidence of any linear, low- intensity-signal condensation of the connective tissue consistent with one of the pelvic supporting structures, as reported by previous articles[16-21] or by Atlas and Text-book of Human Anatomy. With regard to the subdivision of pelvic spaces into compartments[22, 23], owing to the partial overlap of bladder base with the prostate and the more complex topographical anatomy of male pelvis, the classic subdivision adopted in the females was revised, as follows: the anterior compartment included the external genitalia and the retropubic space, taking the anterior aspect of prostate as its backmost boundary; the middle compartment comprised the entire prostate and the seminal vesicles, while the posterior compartment extended back from here to the sacrococcygeal spine (Fig. 1) . The frequency with which the various anatomical components of the endopelvic fascia could be consistently recognized as distinctive structures in the three compartments was recorded. Although beyond the scope of the current study, the analysis of images included also routine linear measurements (list of tool bar options, putting the cursor on "Annotation Toos" and selecting "ruler") of (1) the vertical distance (mm) of bladder neck, prostate base, seminal vesicles and rectal floor from a reference line drawn horizontally tangent to the inferior border of the symphysis pubis; and (2) the levator hiatal anterior/posterior and transverse diameters (mm); and area (cm^2).

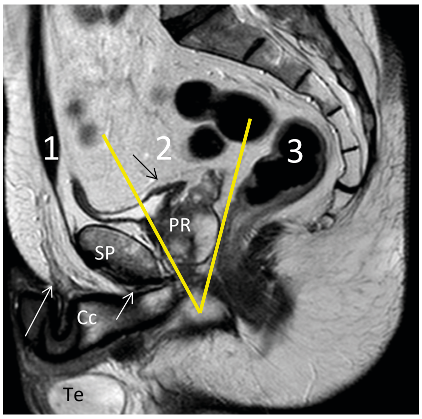

Figure 1- Midsagittal T 2-w TSE MR image of the male pelvis for subdivision into three compartments by two planes (yellow lines) tangent the anterior and posterior aspect of the prostate, respectively: 1= anterior; 2= middle; 3= posterior; SP = symphysis pubis; Cc = corpus cavernosum; Te = testis; thin black arrow= supra bladder peritoneal reflection; long white arrow= fundiform ligament; short white arrow = suspensory ligament of penis.

RESULTS

Anterior Compartment

On median and paramedian sagittal MR sections, the fundiform ligament of penis was the most frequently identifiable connective structure (100% of cases) among those located superficially inside the anterior compartment. It appears as a hypointense fibroelastic sheat which originates from the linea alba of the lower abdominal wall 5 cm above the symphysis pubis and is seen to fade into fan branches when reaching the dorsal aspect of penis (Fig. 2); thereafter it splits in two bundles that adhere to the penis fascia and merge on its ventral surface to join the scrotal septum. More deeply and back to it, the suspensory ligament of penis is also visible (70%) as a short, robust 2-mm thick, quadrangular shaped structure of low-signal-intensity which attaches the dorsal aspect of penis to the lower border of pubic bone. Inside the abdominal cavity, on the axial MR images, the retropubic, subvesical preprostatic space (Retzius space) was occupied in 87.5 % of cases by an intricate latticework system of linear structures (see Fig.1) showing low-intensity signal which are thought to represent the combination of the puboprostatic/pubovesical ligaments, the anterior urethral connective support, the dorsal vein of penis and some smooth muscle fibers, as part of the detrusor apron.

Less frequently (31 and 16.6 % of cases, respectively), thanks to the background of the hyperintense prevesical adipose tissue, just behind the posterior aponeurosis of the rectum abdominis muscle, the median and lateral umbilicovesical ligaments are seen (Fig. 3) as a long, tapering hypointense structure which arises from the apex of the antero-superior bladder wall, In favourable conditions, i.e. adequate amount of intraabdominal fat, no crowded or overlapping bowel loops, and empty bladder, the thin linear hypointense image of the visceral peritoneal reflection could be depicted in up to 42.6 % of cases. It is seen to arise from the posterior transveralis fascia and course parallel over the superior bladder wall continuing back and holding in suspension the apex of seminal vesicles (see Fig. 1).

Middle Compartment

The outer layer of the prostate gland tissue was seen to assume a continuous contour appearance (mimicking a true capsule) of low- signal- intensity, consistent with the so called prostatic fascia. Posterolaterally, depending on where the contour meets the neurovascular bundle, a triangular space of hyperintense signal intensity (fat) containing thin hypointense structures (nerves and vessels) was visible in 55.9 % of cases. At the point of contact with the posterior surface of the seminal vesicles, the peritoneal reflection fuses with the endopelvic fascia and the fibromuscular stroma of the prostate to give origin to the Denonvilliers fascia which appears as low-intensity-signal linear reinforcement of the posterior prostate contour (Fig. 4).

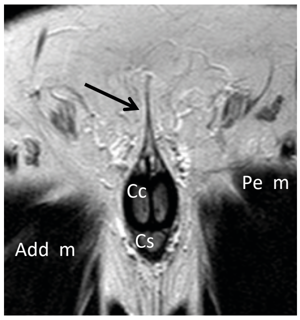

Figure 2- Coronal T 2-w TSE MR image taken at the level of the anterior abdominal wall with arrow pointing at the fundiform ligament: Add m = adductor muscles; Pe = pectineus muscle; ; Cc = corpus cavernosum; Cs = corpus spongiosum

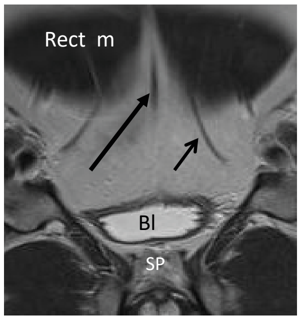

Figure 3 Coronal T2-w TSE MR image taken behind the symphysis pubis (SP), at the level of the rectum abdominis muscle (Rect m) showing the median (long arrow) and the lateral umbilico vesical ligaments (short arrow).

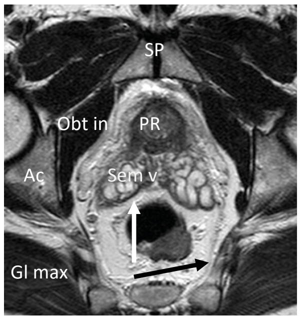

Figure 4- Axial oblique T 2–w MR image taken at the level of the acetabulum (Ac) showing the Denonvilliers fascia (white arrow)) as a reinforcement of the hypointense posterior margin of the seminal vesicles (Sem ves). SP= symphysis pubis; Gl max = gluteus maximus muscle; Obt in = obturator internus muscle.

Posterior Compartment

The three rectal wall layers of different signal intensity reported in the literature (the inner low-intensity mucosa, the intermediate high-intensity submucosa, and the outer low-intensity circular and longitudinal muscle separated by the high-intensity myenteric plexus) were visualized only rarely, probably due to inadequate rectal cleansing and/or residual fecal material. Similarly, short linear or undulated low-signal condensations arising from the outer margin of the rectal wall at the 12, 6, 3 and 9 o clock position, could only occasionally (22.8 %) be observed which were

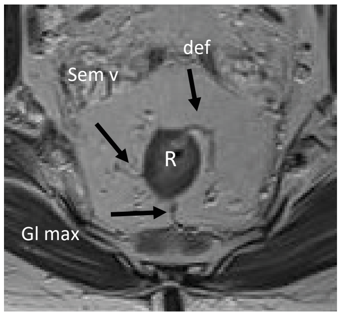

Figure 5 Axial T 2-w MR image of the posterior and lateral rectal ligaments (arrows) which are seen in contrast to the hyperintense perirectal fat. R= rectum; Gl max = gluteus maximus muscle; Sem ves = seminal vesicles; Def = deferent ducts.

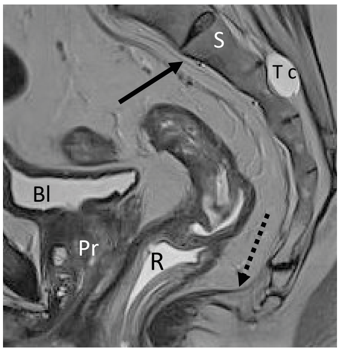

Figure 6 Midsagittal T2-w MR image of the posterior compartment for evidence of the presacral space: note the presacral fascia (blak arrow) and the Waldeyers fascia (dotted arrow). Bl = bladder; Pr = prostate; R = rectal ampulla after evacuation of contrast (acoustic gel); S= sacrum; Tc = Tarlov cyst.

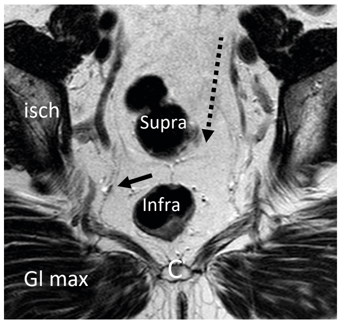

Figure 8 Coronal T 2-w MR image taken at the level of the "H-shaped" morphology of the endopelvic fascia (short arrow) joining the peritoneal reflection (long dotted arrow) which separates the supra from the infra mesocolic rectum

interpreted as the anterior, posterior or lateral rectal ligaments, respectively (Fig. 5). Conversely, the high-intensity perirectal fat surrounded by the low-signal-intensity of the mesorectal fascia were consistently seen in the vast majority of cases (up to 96%). In the prerectal space, the thin linear condensation of the peritoneal reflection, after suspending the apex of the seminal vesicles, is distinctly seen to continue dorsally and pass over the anterior aspect of the rectal ampulla dividing the supra from the infra mesorectal portion of distal gut. The sagittal MR images are also most suited to depict the retrorectal space (Fig. 6), which contains the presacral fascia (71.7%), the Waldeyer fascia (80%) and the mesorectal fascia (between 81.9 and 96 %). A new feature in over 77% of cases was the evidence of two bilateral and symmetrical low-signal- intensity linear condensations (Fig. 7 and 8) which are slightly concave toward the internal side of pelvic cavity and are seen to arise from the anterior aspect of the sacral spine. They course laterally to the mesorectal fascia in a symmetric fashion and connect the anterior aspect of the sacral spine on both sides to the posterior margin of the seminal vesicles, mimicking the shape of the female utero sacral ligaments. From here, they continue forward along the inner surface of the pelvic side wall and fuse with the prostatic fascia being sometimes continuous also with the Denonvilliers fascia to form a "H-shaped" configuration and were interpreted as the so called "sacro-recto-vescico-genito-pubic fascia". A complete summary of the results of MR imaging studies relative to the visualization of the pelvic connective support system in males is presented in Table 1.

DISCUSSION

As expected, MRI has proved more effective than any other imaging diagnostic tool for depicting the connective tissues and ligaments of male pelvis, as it occurred in the case of women. This, thanks to its superior contrast resolution and multiplanar capabilities which make MRI unique to visualize even minimal anatomical detail and variant. The routinary utilization of sagittal, coronal and axial planes combined with high-resolution, T2-w pulse sequences gave us a complete and detailed spatial representation of the male pelvic anatomy, quite similar to that obtained in the female population. More precisely, the depiction of ligaments and fascia as low-signal-intensity linear structures has become consistently feasible and easily identifiable, according to their anatomical position. In particular, it's worth noting how useful has been tilting the scan plane, taking the long axis of the anal canal as reference, for revealing unknown features of the connective support system. Not by chance, the two most important innovations highlighted by this study, never reported earlier to our knowledge, concern the dense lattice network of connective structures seen in the retropubic space and the bilateral, symmetric linear hypointense condensations of the sacro-recto-vesico-genito-pubic fasciae which connect the sacrococcygeal spine to the pubic bone. Such structures in turn, seem to act as a sort of scaffold which securely anchor the internal organs to the pelvic side wall. In addition, in the posterior compartment the single most striking observation has been the arcuate linear hypointense stripe arising from the posterior aspect of the seminal vesicles which closely resemble the feature of the female uterosacral ligaments.

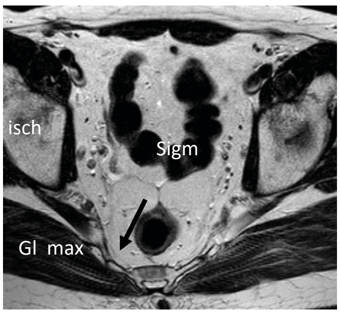

Figure 7 Axial T 2-w MR image taken at the level of the ischiatic bone showing the typical appearance of the sacro recto-vesico genito pubic fascia (arrow). Gl max = gluteus maximus muscle; Isch = ischiatic bone; Sigm = sigmoid colon.

Table 1 Proportion of visualized connective structures at MRI of male pelvis by compartment and scan plane (n° = 354)

Comp	Observed structure	Scan Plane					
		Sagittal		Axial		Coronal	
		N°	%	N°	%	N°	%
Anterior	Fundiform ligs	354	100			354	100
	Suspensory penis ligs	240	70			112	31.6
	Umbilico vesical ligs						
	Median	110	31			156	44
	Lateral					58	16.3
	Puboprostatic ligs	310	87.5	299	84.4		
	Peritoneal reflection (supra vesical)	195	55			99	27.9
Middle	Peritoneal reflection			96 27.1			
	Denonvilliers fascia	145	40.9	115	32.4	98	27.6
	Neurovascular bundle			198	55.9	117	33
	Peritoneal reflection (seminal vesicles)	151	42.6			120	33.8
Posterior	SRVGP fascia			250	70.6	276	77.9
	Rectal ligs			81	22.8	64	18.07
	Mesorectal fascia	290	81.9	310	87.5	340	96
	Presacral fascia	254	71.7	170	48		
	Waldeyer fascia	284	80.2				

Note SRVGP = Sacro recto vesico genito pubic fascia; Comp= Compartment

Now turning the attention of readers to the issue of the potential clinical impact of the study, there is no doubt that having such an effective imaging tool as MRI to depict the anatomy in vivo, may be used to improve the diagnosis and localization of relevant pathological processes, including tumor spread and recurrence, and complex fistula-in-ano disease. Aside from this, the depiction in exquisite details of the connective support system, is also promising for a new interpretation of the functional disorders of pelvic floor in males, whose reports are increasingly frequent in the clinical practice and deserve more attention.
Further progress can be anticipated in the future from studies comparing the results of imaging tools with those of techniques for the analysis of anatomical samples so as to add better certainty to the diagnosis of pathological entities still in search for definition.

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DISCLOSURE STATEMENTS

There was no conflict of interest on the publication of the study.

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