Review Article | Basic and Mechanism Sciences

Pubourethral and uterosacral male analogues suggest parallel male/female pelvic anatomy and symptom pathogenesis

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Abstract: The thesis that functional/dysfunctional male/female pelvic floor anatomy are parallel, originated from two studies: a successful retropubic perineal male sling for post-prostatectomy stress urinary incontinence (SUI) and discovery of a male uterosacral ligament (USL) analogue, we named "prostatosacral ligament" (PSL). In 25 out of the studied 27 males (92.6%), it starts on both sides of the median sulcus of the prostate the ligament passes lateral to the rectum being fused with the lateral margin of the mesorectum before leaving it as it thins out to be attached posteriorly similar to the USL. The ultrasound data during straining in men and women showed the same three oppositely acting muscle vectors contracting around analogous ligaments, puboprostatic ligament (PPL) (male), and pubourethral ligament (PUL) (female). Further parallels were pubovesical ligaments (PVLs) and arc of Gilvernet as part of the continence and micturition mechanisms. Impressive evidence for parallel anatomy came from the successful cure of 22 males with post-prostatectomy SUI using a perineal retropubic tissue fixation system (TFS) minisling applied to the PPL using a similar methodology to that used in the female for PUL midurethral sling repair for cure of SUI. Laparoscopic evidence confirmed the prostate as a male analogue of the cervix, and PSLs as analogues of USLs: PSL origin from the prostate attached laterally to the mesorectum and inserted into the sacrum. Histologically, PSLs had identical features with USLs: collagen, elastin, smooth muscle, blood vessels and nerves. Virtually identical symptoms for "chronic prostatitis" (CP) and "posterior fornix syndrome" (PFS), such as chronic pelvic pain, overactive bladder (OAB), abnormal emptying, gave birth to the hypothesis, of a common pathogenesis for "CP" and "PFS", USL (or PSL) laxity. If this could be proven by "simulated operations", "CP", at least in theory, may be potentially correctible by PSL repair.

Keywords: Prostatosacral ligament (PSL); posterior fornix syndrome (PFS); chronic prostatitis (CP); tissue fixation system (TFS); retropubic male sling

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Introduction

The key points of the article are summarized in the video abstract (Video S1).

The thesis for parallel male/female pelvic anatomy rests on cure of post-prostatectomy stress urinary incontinence (SUI) by retropubic minisling repair of the puboprostatic ligament (PPL) (1) and the discovery of a uterosacral male analogue during laparoscopic surgery for rectal carcinoma (2).

The hypothesis which led to the male retropubic sling operation (1) was the question, "Does post-prostatectomy SUI have the same pathogenesis as SUI in the female, i.e., a weak or damaged PPL?".

Important follow-up questions were:

(I) Does the male have the same three reflex directional forces acting around the PPL on straining, as in the female?

(II) Does the PPL have the same anchoring role for pelvic muscle contraction as does the pubourethral ligament (PUL) in the female?

(III) Does digital support of PPL, via a rectal examination, control urine loss on coughing like vaginal PUL support in the female?

(IV) Would the same minisling methodology which the authors (1) used for cure of SUI in the female, also cure post-prostatectomy incontinence in the male?

The aim of this work is to test the hypothesis of parallel anatomy.

Highlight box

Key findings

- A puboprostatic ligament (PPL) restoration by retropubic minisling cured stress urinary incontinence, as does pubourethral ligament repair in the female. The prostatosacral ligament (PSL) is analogous to the uterosacral ligament.

What is known, and what is new?

- Little is known about pathogenesis of male incontinence and "chronic prostatitis" (CP).
- The role of three reflex pelvic muscle movements and PPLs in male continence.

What is the implication, and what should change now?

- PPL should be preserved during radical prostatectomy.
- Preserve PPL during prostatectomy. Explore the role of PSL in "CP".

Evidence for parallel anatomy

The evidence for parallel anatomy is detailed below.

Transperineal ultrasound

Transperineal ultrasound examinations were performed to confirm reflex directional closure vectors around the PPL. Though the patient had SUI, the same three directional forces seen during closure in the female (*Figure 1*), were present in the male: backward/downward movements of the proximal urethra, forwards and upwards in the distal urethra (*Figure 2*).

Digital support for the PPL

Digital support for the PPL rectally by pressing an index finger against the posterior wall of the symphysis controlled urine loss on coughing. Control of SUI by mechanical support of a weak PPL is similar in concept to mechanical control of PUL in the female (*Figure 1* and Video S2).

Parallel backward/downward movements on straining

The downward/backward vector forces which open the bladder neck in a woman with SUI (*Figure 1*, middle frame) is known to contract down against the uterosacral ligament (USL) (3). The identical downward/backward vector forces noted during straining in *Figure 2*, also require a firm superior anchoring point. We believe this to be the PS ligament, the male USL analogue (2).

Cadaveric testing of a male midurethral sling

A tissue fixation system (TFS) minisling inserted perineally as in the method described for females treated with the TFS minisling, was found to penetrate the PPL (*Figure 3*).

The pubovesical ligament (PVL)

PVL attaches to the arc of Gilvernet to anchor the anterior wall of the bladder during straining and micturition in both males and females (*Figures 4,5*). The role of PVL and arc, in both male and female, is to prevent collapse of the anterior

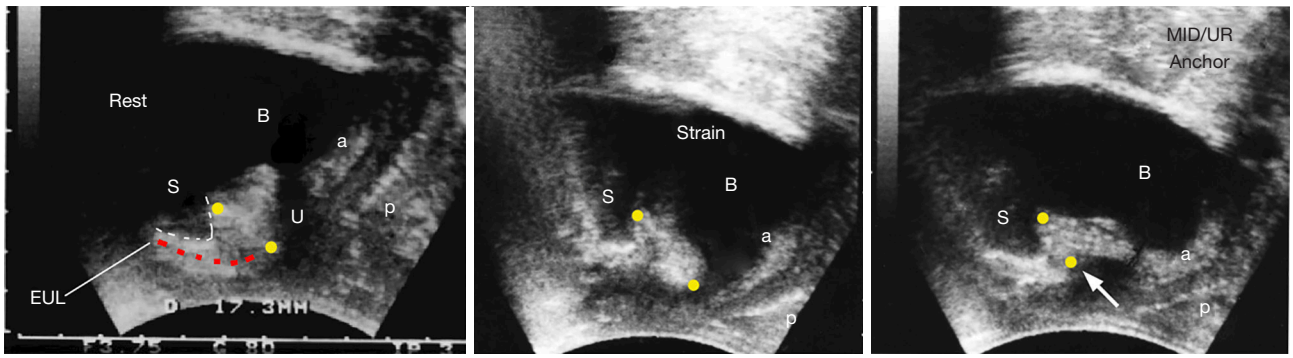

Figure 1 Transperineal ultrasound of a woman with SUI. Transperineal ultrasound of a woman with SUI. At rest (left frame). During straining (middle frame), PUL (small yellow circles) is stretched downwards; the a&p are stretched backward and downwards; the bladder neck and distal urethra are opened, and urine is lost. A hemostat (right frame white arrow) supports the PUL at the midurethra so that it does not extend as in the middle frame (yellow circles). Bladder neck and distal urethral closure are restored; a&p are firmly tensioned backwards/downwards. This is the action known to close the bladder neck. The distal urethra has been entirely closed. The two yellow circles mark the length of PUL extending from behind the lower border of the symphysis to the midurethra; red broken lines in the left frame mark the anterior wall of the distal urethra, which, in the right frame, appears to have been closed tightly from behind by the same forwards force as in *Figure 2*. White broken line, lower border of pubic symphysis. Reused from Petros P. The female pelvic floor function, dysfunction and management according to the Integral Theory. 3rd ed. Heidelberg: Springer Berlin; 2010. With permission from Peter Petros; retains ownership of the copyright. EUL, external urethral ligament; S, symphysis; B, bladder; U, urethra; a, anterior wall of the vagina; p, posterior wall of the vagina; MID, midurethral anchor; UR, urethra; SUI, stress urinary incontinence; PUL, pubourethral ligament; a&p, anterior and posterior walls of the vagina.

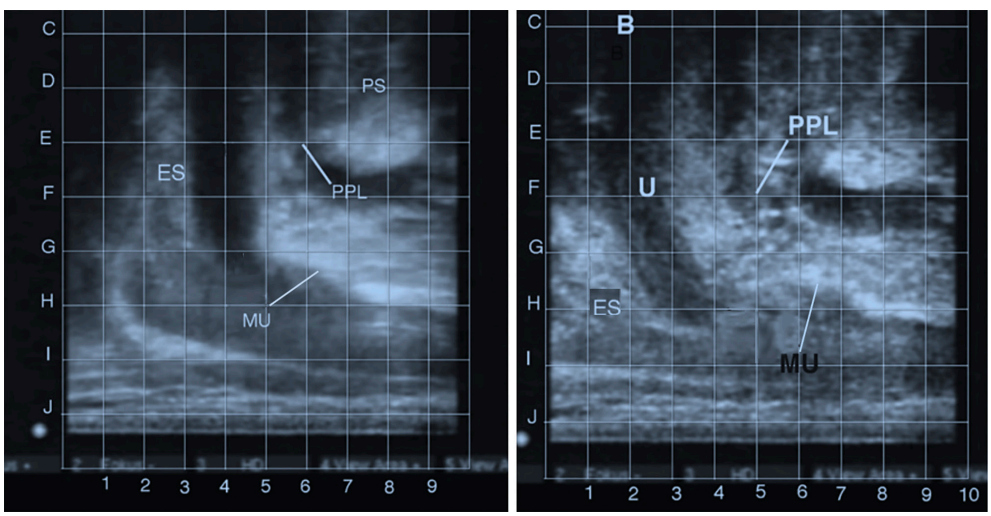

Figure 2 Transperineal ultrasound of a male with SUI. Transperineal ultrasound of a male with SUI. Three reflex muscle forces, backward, downward, and forward stretch the proximal male urethra backwards/downwards and the distal (MU) forwards & upwards, as in the female. Left figure (at rest). The lower level of proximal urethra ES is at G4. MU runs between G4 and H7. PPL is at E6. Right figure (during straining). Three reflex muscle forces, backward, downward, and forward stretch the proximal male urethra backwards/downwards and the distal (MU) forwards and upwards. ES has been pulled backwards and downwards. The lower level of ES is just below H 2.5. PPL has stretched considerably backward, from E6 to G5, almost double, indicating weakness; MU has moved very considerably upwards relative to the lower end of ES, indicating a forward force applied from behind, as seen in the distal urethra in the female. Reused from (1). Copyright 2022, with permission from Karger. ES, external sphincter; PS, pubic symphysis; PPL, puboprostatic ligament; MU, membranous urethra; B, bladder; U, urethra; SUI, stress urinary incontinence.

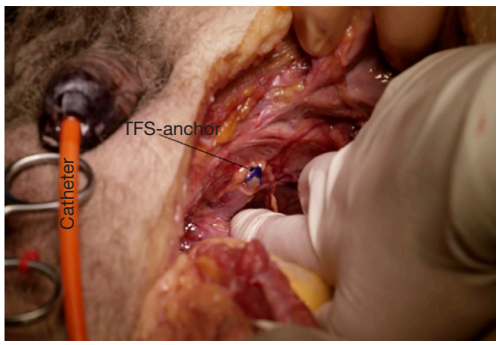

Figure 3 Blind positioning of the TFS anchor in the PPL. When the TFS was inserted into the male cadaver using the exact technique used in the female, the anchor exited in the position of the PPL. Reused from (1). Copyright 2022, with permission from Karger. TFS, tissue fixation system; PPL, puboprostatic ligament.

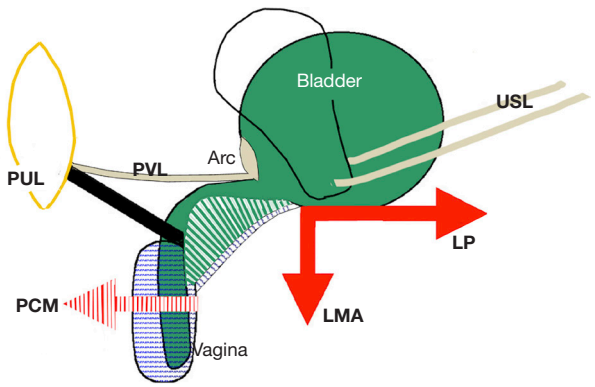

Figure 4 Role of the PVL and arc of Gilvernet in urethral closure and opening in the female. The PUL inserts into the midurethra and the vagina. Urethral closure: on effort, the PCM contracts forward against PUL to stiffen the posterior wall of the distal vagina; LP pulls back against the PUL to stiffen PVL and the proximal urethra; LMA pulls down against the USL to rotate the bladder around the arc to close (kink) the urethra at the bladder neck. Urethral opening: (micturition). PCM relaxes; LP/LMA open out the posterior urethral wall; detrusor contracts to empty. PVL contracts against the arc to prevent the anterior bladder wall prolapsing down. The PVL has the same origin as PUL; it inserts into a thickening of the anterior bladder wall called the "arc". Published with permission from Peter Petros: Personal Collection; retains ownership of copyright. PUL, pubourethral ligament; PVL, pubovesical ligament; USL, uterosacral ligament; PCM, pubococcygeus muscle; LMA, conjoint longitudinal muscle of the anus; LP, levator plate.

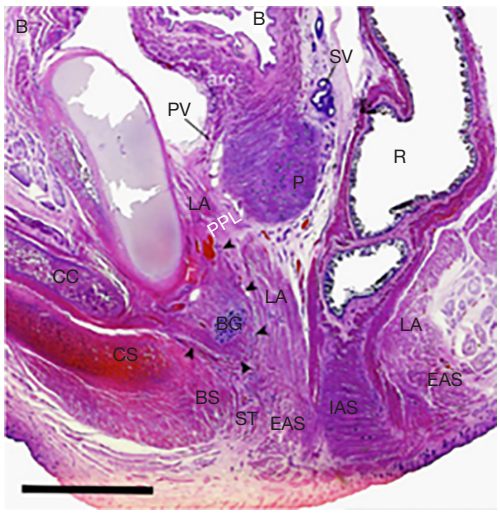

Figure 5 Anatomy of a fetal male, parasagittal section. Caudal portion of the external urethral sphincter (arrowheads). Reused from (1). Copyright 2022, with permission from Karger. By permission Professor Jose Gilvernet. B, bladder; SV, seminal vesicle; arc, precervical arc of Gilvernet; PV, pubovesical ligament; R, rectum; P, prostate; LA, levator ani; PPL, puboprostatic ligament; CC, corpus cavernosum; BG, bulbourethral gland; CS, penile bulb; EAS, external anal sphincter; BS, bulbospongiosus muscle; IAS, internal anal sphincter; ST, superficial transverse perinei.

bladder wall when the backward/downward rotating forces act to close the bladder neck or open it for micturition. The three directional movements act around PPL (*Figure 4*) as they do around PUL (*Figure 2*).

Surgical validation of PUL/PPL parallel anatomy

A key validation of the parallel anatomical hypothesis was the successful surgical treatment of 22 males with post-prostatectomy stress incontinence by TFS minisling of the PPL (1) (*Tables 1,2*). A 7-mm TFS sling was inserted between the bladder neck and perineal membrane to reinforce the PPL (*Figure 3*), which gave high success rates, when reviewed at 9 months post-operatively (1) (*Tables 1,2*). The mean pre-operative urine (pad) loss was 3.8 pads at 9 months; the mean post-operative loss was 0.7 pads; 13/22 (59.1%) patients were 100% improved; 7/22 (31.8%) improved >50% but <100%; 2/22 (9.1%) improved ≤50%.

Table 1 TFS minisling results at 9 months review

Patient	Name (initials)	Pre (pad)	Post (pad)	Difference	Improvement (%)
1	SM	1	0	1	100.0
2	CR	1	0	1	100.0
3	DB	2	0	2	100.0
4	BW	6	2	4	66.7
5	PM	6	2	4	66.7
6	WB	4	1	3	75.0
7	CP	4	0	4	100.0
8	BL	4	0	4	100.0
9	HL	4	0	4	100.0
10	WD	4	1	3	75.0
11	SP	4	2	2	50.0
12	SK	4	0	4	100.0
13	KR	4	0	4	100.0
14	RM	4	0	4	100.0
15	WM	3	0	3	100.0
16	EH	3	1	2	66.7
17	BB	3	1	2	66.7
18	HP	3	0	3	100.0
19	PW	3	0	3	100.0
20	LW	3	0	3	100.0
21	AS	7	2	5	71.4
22	CS	6	3	3	50.0
Mean		3.8	0.7	3.1	–
Median		4.0	0.0	3.0	–

Reused from (1). Copyright 2022, with permission from Karger. TFS, tissue fixation system; pre, pre-operative; post, post-operative.

Table 2 Improvement results at 9 months review

Improvement	N	%
100%	13	59.1
>50% but <100%	7	31.8
≤50%	2	9.1

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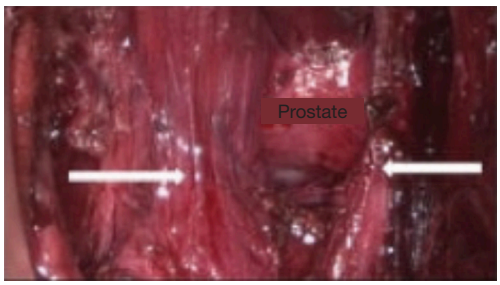

Figure 6 Intraoperative image of the PSL. White arrows, prostatosacral ligaments. Reused from (2). Copyright 2019, with permission from *Pelviperineology*. PSL, prostatosacral ligament.

Discovery of a USL male analogue

The discovery of a USL male analogue was a consequence of the necessity to find a structure for the downward/backward vectors, demonstrated in *Figure 2*, to contract against. It was hypothesized that there had to be a male USL analogue. Professor Farag, described his discovery of a male USL analogue during laparoscopic surgery for rectal carcinoma as follows (2): "In the present work, we describe a new ligament in the male which has the same anatomical pathway as in the female anatomy. The male prostatosacral (PS) ligament has its origin from the back of the prostate where it passes posteriorly on both sides of the rectum before gaining its posterior attachment. The group included 27 males and 19 females, age range 31–72 years, mean 34 years. In 25 out of the 27 patients studied (92.6%), the prostatosacral ligament (PSL) originated on both sides of the median sulcus of the prostate (*Figure 6*) (2). In the remaining 2 male patients (7.4%), it originated from the conjoined ischio-pubic ramus without obvious attachment to the prostate. In all 27 male patients, and in all the female patients, the ligament passes lateral to the rectum being fused with the lateral margin of the mesorectum before leaving it as it thins out to be attached.".

Parallel backward/downward straining movements require firm posterior ligament anchoring

The downward/backward vector forces which open the bladder neck in a woman with SUI (*Figure 1*, middle frame) is known to contract down against the USL (3). The

Table 3 Comparison of CP and PFS symptoms (2)

CP	PFS
Pain constant or variable	Pain constant or variable
Frequency	Frequency
Urgency	Urgency
Nocturia	Nocturia
Perineal pain	Perineal pain
Pain in testicles/scrotum	Pain in vagina/vulva
Pain ejaculating	Dyspareunia
	Low abdominal pain

CP, chronic prostatitis; PFS, posterior fornix syndrome.

identical downward/backward vector forces noted during straining in *Figure 2*, also require a firm superior anchoring point. We believe this to be the PS ligament, the male USL analogue (2), posteriorly, similar to the USL.

PSL anatomy and histology

The PSL is not, to our knowledge, described elsewhere in the literature. Nevertheless, PSL anatomy (*Figure 6*) was analogous to USL in the female. The histology is very similar to that of the female USL: collagen, elastin, smooth muscle, abundant blood vessels and nerves. Professor Farag also identified male pelvic visceral plexuses in an analogous position to those of the female.

Is chronic prostatitis (CP) a male analogue of the posterior fornix syndrome (PFS)?

The discovery of a male USL analogue (2) raised the question, "Is the posterior fornix syndrome a parallel condition with "chronic prostatitis?" (2). The "CP" syndrome is characterized by pelvic pain, voiding symptoms, and additional phenotypic signs that are still poorly defined (4).

Table 3 indicates that the symptoms of CP are very similar to those of PFS, with pain the predominant symptom (4). Our hypothesis is that the prostate is the analogue of the cervix, and that the male USL analogue discovered (2), has similar dysfunctions in the female as detailed in *Table 3*. Our hypothesis of parallel s for CP and PFS predicts that other posterior zone symptoms, such as obstructive defecation and fecal incontinence, would also be present in some CP patients.

Conclusions

Other than for the pelvic organs, male and female anatomy are virtually identical. Genetic and hormonal influences have changed the morphology and function of the pelvic organs. We have presented evidence that the functional anatomy of the bladder and some ligaments are similar, if not parallel. The symptom similarities in *Table 3* are suggestive that CP could be a male phenotype of the PFS. However, for now, this part of parallel male/female dysfunction remains only a hypothesis which needs to be objectively tested.

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Footnote

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-23-1888/coif). The series "Integral Theory Paradigm" was commissioned by the International Society for Pelviperineology without any funding or sponsorship. P.P. serves as an unpaid editorial board member of *Annals of Translational Medicine* from October 2022 to September 2024. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All clinical

procedures described in this study were performed in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patients for the publication of this article and accompanying images. Human participation in the video was by patient permission on the basis it was deidentified.

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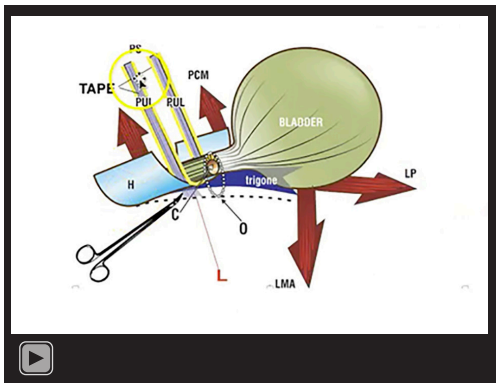
Supplementary



Video S1 Video abstract.

Video S2 Mechanical support of the pubourethral ligament immediately behind the symphysis controls urine loss on coughing. By permission Professor Paolo Palma.

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