Original article

A critical review of TFS ligament repair. Part 3: The role of ligaments in the control of bladder, bowel and pain symptoms

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Background. Fundamental to the understanding of abnormal bladder, bowel and pain symptoms is the understanding of normal control mechanisms. Essentially, pelvic symptoms can mainly be attributed to dysfunctions of organ closure (incontinence), evacuation (emptying), control of the micturition and defecation reflexes, and pelvic pain. *Aim*. To explain the role of intact ligaments and vagina in the control of these normal functions. *Methods*. Seven key anatomical points are identified by the Integral Theory for normal pelvic function. Each of these is critically analysed with reference to Parts 1& 2. The urethra and anus function as emptying tubes for evacuation of the bladder and rectum. They are opened and closed by 3 directional muscle forces contracting or relaxing in concert against anterior (PUL, pubourethral) and posterior (CL/USL cardinal/uterosacral) suspensory ligaments. *Conclusions*. These 7 basic anatomical points prepare the groundwork for Part 4, how two main ligament groups are associated with the generation of pain and major symptoms of bladder and bowel dysfunction, pubourethral ligaments anteriorly and cardinal/uterosacral ligaments posteriorly.

Keywords: TFS; Urge incontinence; nocturia; chronic pelvic pain; fecal incontinence; obstructive defecation; abnormal emptying.

INTRODUCTION

This is the third of four related papers seeking to critically analyze the TFS ligament repair system and the Integral Theory System on which it is based. The first two articles have been previously published[1,2].

The Integral Theory[3], states that: *"Pelvic organ prolapse, bladder and bowel dysfunction and some types of pelvic pain, mainly derive, for different reasons, from laxity in the vagina or its supporting ligaments, a result of altered collagen/elastin."*

The Integral Theory System or Integral System is a self-contained entirely anatomical system of female pelvic floor management. A comprehensive account can be found in the textbook *"The Female Pelvic Floor. Function, Dysfunction and Management according to the Integral Theory"*, 3rd Edition, 2010, Petros PEP, Springer, Heidelberg.

Understanding the role of ligaments in the normal mechanisms is fundamental to understanding pain, bladder and bowel dysfunctions and how to fix them. Based on the anatomy detailed in Part 1 and historical observations following repair of damaged ligaments in Part 2, it is possible to state that there are 7 key anatomical points which are important for normal function of the pelvic floor. As regards dysfunction, the key to understanding symptom cure is that laxity (mainly) in the pubourethral and cardinal/uterosacral ligaments weakens the muscle forces contracting against them. In up to 30% of women, this laxity may set off a cascade of bladder, bowel and pain symptoms.

Anatomical point 1. The urethra and anus function as emptying tubes for evacuation of the bladder and rectum[3], fig. 1.

Anatomical point 2. These evacuation tubes are opened and closed by 3-directional muscle forces acting in concert against anterior (PUL) and posterior (CL/USL) suspensory ligaments[3-6], fig. 1.

How the 3 directional forces close bladder neck: with reference to fig. 1, LP (Levator Plate) inserts into the posterior rectal wall. It pulls the rectum, vagina and bladder base backwards via their attachments to each other (which include the vesicovaginal ligament 'VVL'). Downward contraction of the conjoint longitudinal muscle of the anus (LMA), pulls down the anterior lip of LP, rectum, vagina and bladder base. This action rotates the bladder base around the PUL and with contraction of the PCM distal to the PUL acts to 'kink' the bladder neck. See also figs 2 & 3.

How the 3 directional forces open out the urethral tube, fig1: PCM (pubococcygeus) relaxes to relieve the forward tension on the urethra. LP pulls the bladder base backwards; LMA pulls the bladder base downwards to open the outflow tract.

How the 3 directional forces close the anal tube, fig. 1: LP contracts backwards. LMA pulls down the anterior lip of LP to rotate the rectum around a contracted PRM (puborectalis muscle) to create the anorectal angle and closure. See also fig. 5.

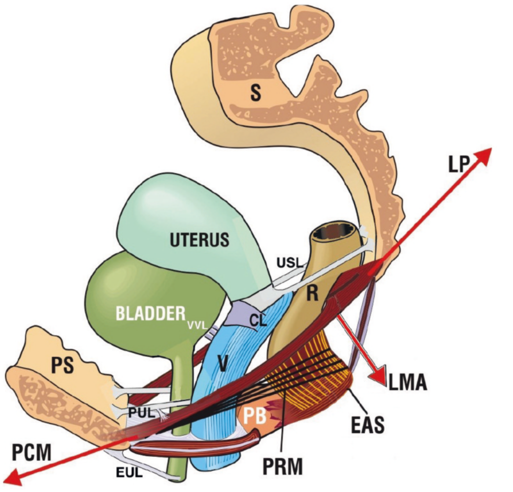

Figure 1. – Directional muscle forces and their relationship to ligaments. 3D Sagittal view, standing.
Forward contraction pubococcygeus muscle (PCM); puborectalis muscle (PRM).
Backward/downward contraction levator plate (LP); conjoint longitudinal muscle of the anus (LMA). PCM, LP contract against PUL; LP/LMA contract against CL/USL. PRM does not contract against any ligaments, only against pubic symphysis (PS); S=sacrum; V=vagina; CL=cardinal ligament; USL=uterosacral ligament; EAS=external anal sphincter; R=rectum.

(*Active opening by an external striated muscle force (LP/LMA), figure 3, exponentially decreases the internal frictional resistance to flow, inversely by the 4th power of radius change (Poiseuille's Law), enabling a much lower expulsion pressure by the detrusor[7, 8]).

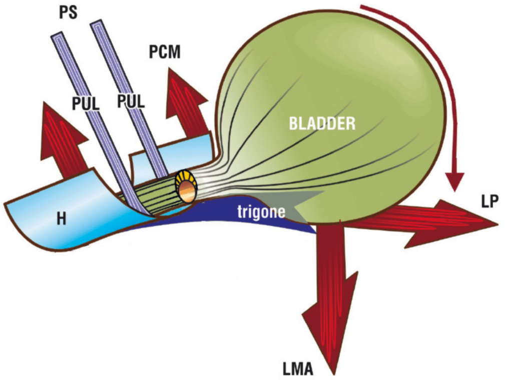

Figure 2. – Bladder neck closure mechanism. This is the main closure mechanism for urinary continence. LP contracts against PUL to stretch the trigone backwards; LMA contracts against USL to pull the trigone downwards. This action rotates the bladder neck around PUL to effect 'bladder neck' closure. The distal urethral closure is achieved by PCM pulling the distal vagina 'H' forwards to close the distal urethra. This action mainly seals the urethra.

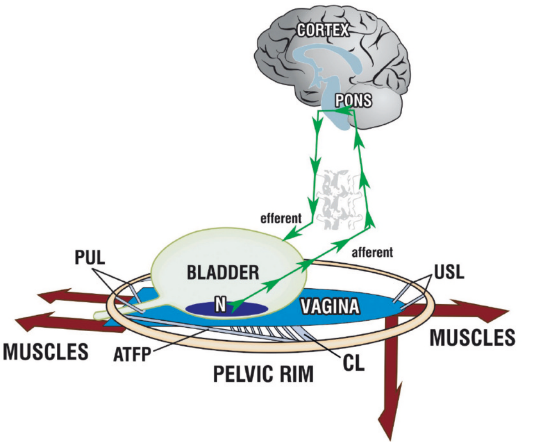

Figure 4. – Peripheral control of urgency, normal woman. Schematic 3D view. The 3 muscle forces stretch the vagina bilaterally against the suspensory ligaments* to support the stretch receptors 'N', preventing activation of the micturition reflex (small green arrows). Like a trampoline, any loose spring (ligament) may invalidate vaginal stretching, so 'N' fires off at a low bladder volume (urgency).
* mainly PUL, CL, USL.

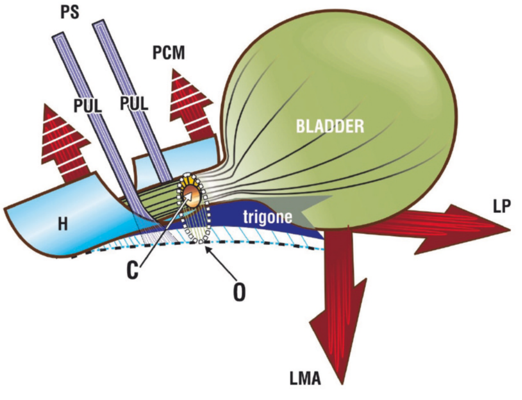

Figure 3. – Micturition, the mechanical dimension. PCM relaxes (broken lines). Initially, the LP stretches the vaginal hammock (H) and trigone backwards; next, the LMA stretches vagina and trigone downwards to open the urethra from "C" (closed) to "O" (open). External opening of the urethra vastly reduces the frictional resistance to urine flow. Arrows = muscle forces. LMA contracts against USL's. (see also fig 1).

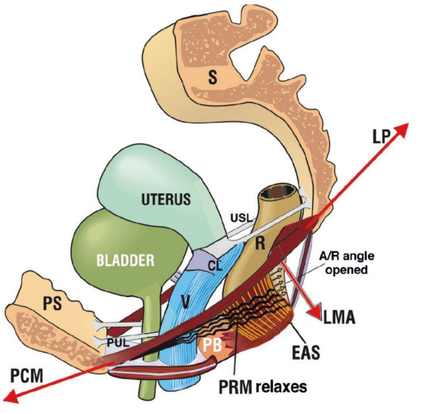

Figure 5. – Anorectal closure and defecation standing, sagittal view.
Anorectal closure Puborectalis muscle (PRM) contracts forwards; LP stretches the posterior rectal wall backwards; LMA rotates the rectal wall downwards around the contracted PRM to create the anorectal angle and closure.
Defecation Puborectalis muscle (PRM) relaxes (wavy lines). This allows the posterior vectors LP/LMA to stretch open the posterior wall of the anorectum, opening out the anorectal angle (small arrows posterior to R). PCM stabilizes the anterior rectal wall, preventing it from prolapsing inwards. Active opening exponentially decreases the internal frictional resistance, inversely by the 3rd power of radius change. The rectum contracts and empties.

How the 3 directional forces open the anal tube, fig. 1: PRM relaxes; LP pulls rectal wall backwards as the LMA pulls it downwards to open the posterior aspect of the outflow tract. The PCM also pulls forward opening out the anterior wall of the anus/rectum. See also fig. 5.

Anatomical point 3. Bladder closure (continence), fig. 2. On effort, a closure reflex activates the fast-twitch striated muscle fibres to close the urethral tube at the distal urethra and bladder neck. Both mechanisms require a competent PUL[3-6]. Mechanically closing the urethral tube exponentially increases the internal frictional resistance to flow (continence), inversely by the 4^{th} power of radius change (Poiseuille's Law)[7,8].

Anatomical point 4. Micturition, mechanical dimension, fig. 3. As the bladder fills, the micturition reflex is activated: PCM relaxes (broken lines); the backward muscles, LP and LMA contract to mechanically open out the urethra; the smooth muscle of the detrusor contracts (spasms) to evacuate the urine[5,6]. This mechanism requires a competent USL (see fig. 1). A loose USL reduces the LP/LMA opening force, so the detrusor has to contract against a higher urethral resistance*. The patient perceives this as 'obstruction' to flow. There is indeed an obstruction, but it is frictional, not mechanical.

Anatomical point 5. Micturition control, the neurological dimension[5-10], fig. 4. The micturition reflex is activated by stretch receptors within the bladder wall, 'N'. 'N' sends afferent impulses to the cortex which are interpreted as urge symptoms. If it is inconvenient to empty, the feedback system activates slow-twitch stretching of the vagina to support the bladder base stretch receptors: all 3 muscles, (large arrows) contract to support 'N', reducing the afferent (urge) signals.

Anatomical point 6. Defecation and anal continence[11-13]. The mechanics of anorectal continence and defecation, fig 5, are very similar to those of the bladder. During defecation, the forward muscle vector, the puborectalis relaxes; the backward LP/LMA muscle vectors open out the posterior rectal wall an-

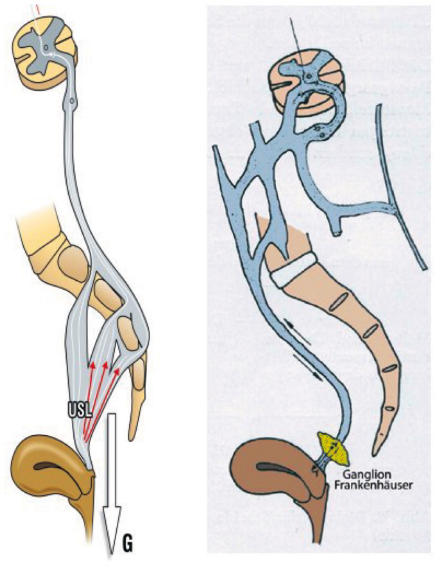

Figure 6. – Origin of chronic pelvic pain
Left figure S2-4 distribution, parasympathetic nerve pathway. If the uterosacral ligaments (red arrows) cannot provide adequate anatomical support for the nerves (thin white lines) the force of gravity (G) may stretch them, causing referred pain in the distribution of S2-4: vulva, perineum, vagina, paraurethral, low sacral, perhaps even interstitial cystitis pain.
Right figure with T12-L1 distribution, sympathetic nerve pathway, Ganglion of Frankenhauser. If the uterosacral ligaments cannot provide adequate anatomical support for the nerve plexus, anything which stretches the nerves, for example, gravity, may cause referred pain in the nerve distribution T12-L1, groin, low abdomen, abdominal, contact dyspareunia.

gle; the PCM opens out the anterior rectal wall and the rectum contracts to expel faeces. The defecation reflex is activated by stretch receptors within the rectal wall. Like the bladder, control of the reflex is reliant on adequate bilateral stretching by PCM & LP/LMA (large arrows, fig. 5).

Anatomical point 7. Origin and prevention of chronic pelvic pain. The are two types of chronic pelvic pain distributions, the sacral plexus (S2-4), fig. 6 and the sympathetic plexus of Frankenhauser (T11-12-L1)[14-17]. These derive from the inability of the uterosacral ligaments to support the nerve plexuses.

CONCLUSIONS

These 7 basic anatomical points prepare the groundwork for Part 4, how two main ligament groups are associated with the generation of pain and major symptoms of bladder and bowel dysfunction, pubourethral ligaments anteriorly and cardinal/uterosacral, perineal body ligaments posteriorly.

CONFLICTS

There are no financial conflicts.

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