

# Comparing urethral closure mechanisms

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The ongoing debate in “International Urogynecology Journal” about urethral closure mechanisms is important, because without a clear understanding of the anatomy of closure and stress urinary incontinence, the surgeon can never understand how corrective surgery works, or how to systematically address complications of such operations. The two dominant mechanisms which explain urethral closure rely either on Enhorning’s ‘pressure transmission theory’, or musculo-elastic closure which relies on structurally sound suspensory ligaments.

Pressure transmission hypotheses fail a simple test, “Why does the same raised intrabdominal pressure which ‘closes the urethra’ not stop micturition when the woman strains downwards?” Rather, it increases urine flow, a consequence of the relaxation of the forward closure muscle, pubococcygeus, which allows the posterior vectors levator plate/longitudinal muscle of the anus, to open out the urethra prior to micturition, while the raised pressure from straining drives the urine out faster.

**Key Words:** urethral closure ↔ Integral Theory ↔ pressure transmission theory  
↔ pubourethral ↔ midure-thral sling surgery

The recent debate about closure mechanisms for the urethra [1, 2, 3] is important, because without a clear understanding of the anatomy of closure and non-closure (SUI – stress urinary incontinence), the surgeon can never understand how corrective surgery works, or how to systematically address complications of such operations.

The two dominant mechanisms which explain urethral closure rely either on Enhorning’s “pressure transmission theory”, or musculo-elastic closure which relies on structurally sound suspensory ligaments, VIDEO1 [https://www.youtube.com/watch?v=\\_BRsrJvz0Yk](https://www.youtube.com/watch?v=_BRsrJvz0Yk)

Drs Delancey and Ashton-Miller present pressure data to support their view that a closed urethra is an important part of the continence mechanism [1]. No mechanism is given, other than a reference to Dr De Lancey’s ‘hammock hypothesis’, which relies on pressure transmission theory for urethral closure, as does Dr Bergstrom’s ‘Urethral hanging’ hypothesis [2]. The urethra is an emptying tube connecting the urine reservoir to the outside. It is closed for continence, and, importantly, opened for evacuation (Figure 1). Without these two functions, the bladder would dribble 24 hours per day. Dr Gold [3] described four

different experiments which rebut pressure transmission as a continence mechanism, but explainable by the musculoelastic closure mechanism (Figure 1, VIDEO1) as published in 1990 with 11 supporting experimental studies [4]. <https://obgyn.onlinelibrary.wiley.com/toc/16000412/1990/69/S153>

It is not sufficient for hypotheses [1, 2] to explain continence by raised intrabdominal pressure closing the urethra. They need to explain Dr Gold’s clarifying test for pressure transmission hypotheses [3], “Why does straining during micturition not close the urethra, but rather, straining increases urine flow?” This test is anatomically explained in Figure 1 and VIDEO2: <https://www.youtube.com/watch?v=eiF4G1mk6EA&feature=youtu.be> During micturition, the forward vector pubococcygeus (PCM) relaxes; this allows the two posterior vectors LP/LMA (LP – levator plate; LMA – longitudinal muscle of the anus), to open out the urethra prior to micturition [4]; straining presses on the bladder to increase urine flow.

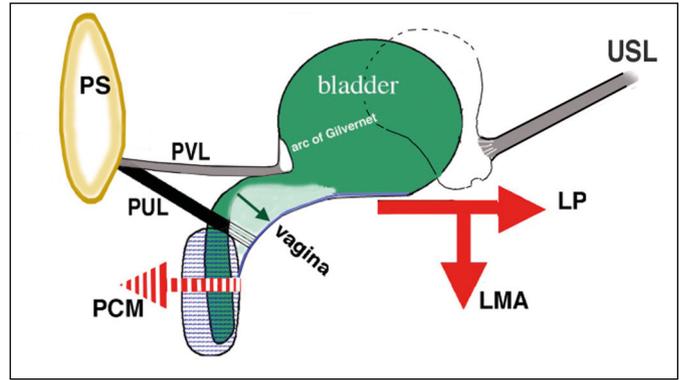
Dr Bergstrom’s prominent diagram of a fractured pubourethral ligament (PUL), PUL is not supported by 35 live anatomical dissections in each sulcus (70 PULs), made in women who were having a mi-

durethral sling for SUI [5]. Some PULs were attenuated, but no fracture was seen in any ligament [5]. Dr Delancey's hypothesis for higher MUCPs (midurethral closure pressure) in continence women as opposed to those with SUI is not supported by post-operative MUCP (data following successful midurethral sling surgery (MUS) [6]. There was no change in MUCP in 85 women, 88% cured by MUS [6]. Maximal urethral pressure (MUP) preoperatively was 37.3 cmH<sub>2</sub>O (range 5–72 cmH<sub>2</sub>O, SD ± 16.4), and post-operatively 34.5 cm (range 12–74 cmH<sub>2</sub>O, SD ± 14.9), not statistically significant [6].

Clinical confirmation of the urethral and bladder neck closure mechanism Figure 1 [6].

The MUS operations [6], were performed through two parallel incisions from bladder neck to external meatus. Quoting [6], "The local anesthetic methodology permits direct observation of the closure mechanisms. There was a vast, often uncontrollable, increase in urine loss during coughing, immediately after making the paravaginal incisions. Gentle pressure on the tape generally controlled urine loss immediately (bladder neck closure mechanism as did tightening of the suburethral vaginal hammock (distal urethral closure mechanism)" [4]. These direct observations of continence cannot be explained by [1] or [2].

How a MUS controls SUI. A weak pubourethral ligament (PUL) cannot support the urethra or vagina into which it inserts [6] (Figure 1). A sling below urethra in the position of PUL prevents the posterior muscle vectors LP/LMA (Figure 1), from stretching open the posterior urethra during effort in women with SUI, 'with the same geometry as micturition' (Figure 1). The importance of collagenopoietic slings to repair weak ligaments was demonstrated by Shkarupa et al., who



**Figure 1.** Reflex urethral closure and opening. Three directional forces (arrows) stretch vagina and urethra in opposite directions around PUL (pubourethral ligament) to close urethra distally and at bladder neck (see VIDEO1). Micturition, PCM relaxes (broken lines); LP/LMA pull vagina and posterior urethral wall backwards/downwards to open out ('funnel') urethra, exponentially reducing resistance to flow. Detrusor contracts to empty. See VIDEO2.

PCM – pubococcygeus muscle; LP – levator plate; LMA – conjoint longitudinal muscle of the anus; PVL – pubovesical ligament; USL – uterosacral ligament

explained poor results of native ligament repair by collagen breakdown in ligaments after the menopause [7], further elaborated by two editorials [8, 9]. A further question arises, what to do in countries where mesh kits have been banned, even for SUI? It is still within the province of the surgeon to use a 'tension-free' artisan tape for an individual patient. The technique was well described by Pinango-Luna et al. [10].

#### CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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