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CORRESPONDENCE

An anatomical basis for mesh complications and prevention thereof

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Dear Sir,

We would like to comment on the treatment rationale of pelvic organ prolapse and discuss specific issues concerning the role of mesh usage emerging from recent publications in your journal [1, 2]. Pelvic ligaments support AQ1 organs. Unlike the vagina, ligaments do not stretch significantly with function, (Fig. 1). Breaking strain for ligaments is 300 mg/mm^2 and for vagina 60 mg/mm^2, indicating ligaments provide primary support while vagina is not primarily structural. A recent RCT (Prospect Study [3] comparing level 2 native tissue repair against level 2 vaginal mesh, proved the vagina was not structural: both AQ2 methods had >80% failure at 6 months. This reinforces our view that ligament reinforcement, not vaginal repair, is the key to successful prolapse surgery.

Figure 1 demonstrates that an elastic vagina is critical for the correct transmission of muscle forces by directional vectors (arrows). All the maneuvers b–d require significant vaginal elasticity. Anything which alters vaginal elasticity, for example scarring, mesh, excess bladder neck elevation, excess vaginal stretching by sacrocolpopexy (SCP), may alter one or more of the 4 functions. Implanted mesh elicits fibrosis and scarring. We believe that the success of the midurethral sling compared to relative failure of mesh sheets is due to two factors, ligament reinforcement and maintenance of vaginal elasticity. The midurethral sling tape works by precisely reinforcing the pubourethral ligaments, with no effect on vaginal elasticity. In contrast, mesh sheets placed behind vagina do not reinforce any ligaments, are much larger in volume and significantly affect elasticity, sometimes critically.

Many of the complications related to pelvic meshes can be explained by loss of vaginal elasticity. Pelvic tissues are innervated by visceral nerves that are sensitive to stretching which may cause pain. Implanted mesh creates inflammation, collagen 3, morphing to collagen 1 which then contracts. Sufficient compression (stretching) of visceral nerves may cause pain. We have found pelvic pain following mesh implantation is almost invariably due to tight mesh (relieved by surgically reducing tension); dyspareunia by penis stretching an inelastic vagina; difficult micturition or defecation after SCP by excess mesh tightness preventing the downward vectors (arrows) which open urethra (Fig. 1d) or anus. Erosion (tape surfacing) is the least problematic complication. Most cases resolve when the extruded segment is trimmed.

Sufficient elasticity is needed in the vagina for normal urethral closure (yellow circle), by the opposite vectors, Fig. 1b. Vaginal scarring from mesh sheets may tether the stronger posterior forces to overcome the weaker anterior forces (arrows), so that the urethra is forcibly pulled open as in micturition (Fig. 1d). The classic symptom is massive and uninhibited urine loss on getting out of bed in the morning 'Tethered Vagina Syndrome'. A skin graft in the vagina is required to restore elasticity and function [4]. *This is an important as yet unrecognized complication of mesh sheet implantation.*

In conclusion, the vagina is not primarily a structural organ. Vaginal elasticity is essential for normal function and must be preserved in pelvic floor surgery. Elasticity may be compromised by the use of mesh sheets in close contact with the vaginal wall. Efforts to repair pelvic organ

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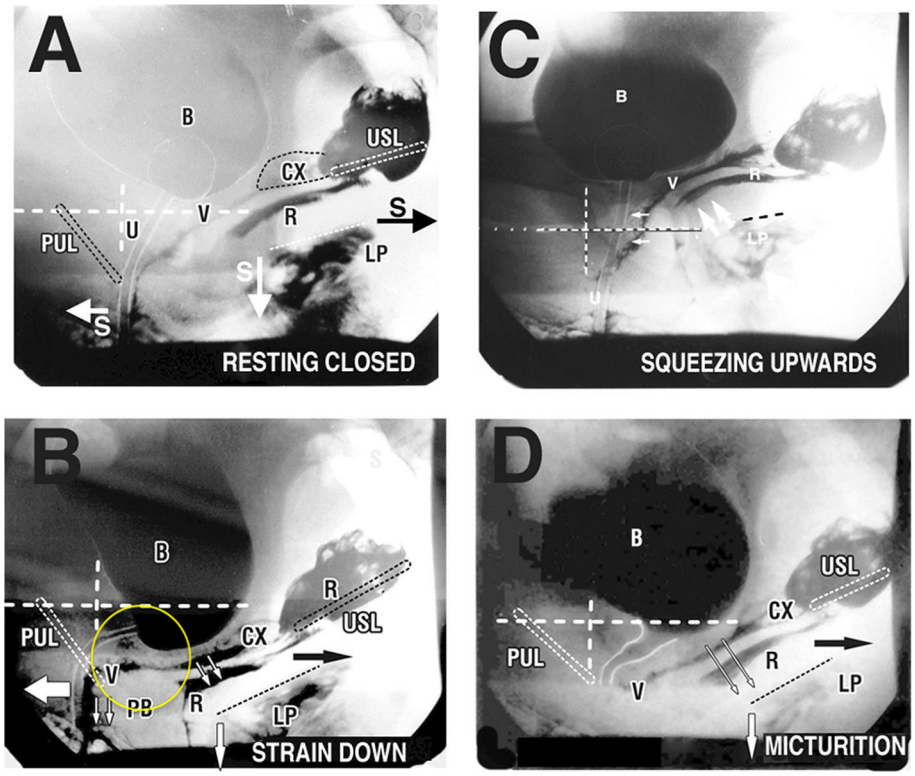

Fig. 1 An elastic vagina is critical for the correct transmission of muscle forces by directional vectors (*arrows*). Note the change of shape of the vagina 'V' and the positions of bladder 'B', rectum 'R', levator plate 'LP' relative to the vertical and horizontal bony co-ordinates (*white broken lines*) during the different maneuvers (**b**–**d**). **a** *Resting closed position* 'S' denotes slow twitch muscle contraction of the 3 directional striated muscle forces, forwards, backwards, downwards (*arrows*) which contract against pubourethral ligament (PUL) anteriorly and uterosacral ligament (USL) posteriorly. *CX* cervix, *U* urethra. **b** *Straining down position* Fast twitch directional vector forces stretch the vagina in opposite directions, forwards, backwards, downwards against PUL and USL, to close the distal and proximal urethra. Adequate elasticity is required in the bladder neck area of vagina 'Zone of Critical Elasticity' (*circle*) so as to allow the opposite muscle forces which stretch the vaginal membrane to operate independently of each other. *PB* perineal body. **c** *Squeezing upward* (Kegel movement). This action is activated by voluntary contraction of the puborectalis muscle (*twin white arrows*). All the organs are pulled upwards and forwards. This action interrupts defecation and micturition. Adequate vaginal elasticity is required to allow this action. **d** *Micturition* The forward vector in Fig. 1b relaxes. The backward vectors stretch the vagina backwards and downwards against USL to open out the posterior urethral wall. Adequate elasticity is required in the vagina to facilitate this action. An overtight SCP or rectopexy mesh will prevent the downward vectors; urethra and anus cannot be adequately opened; the patient presents with obstructive defecation or micturition

prolapse should be directed at reinforcing the 5 main AQ3 ligaments of the pelvis as this seems sufficient to cure 3rd and 4th degree uterine, anterior and posterior vaginal wall prolapse [5].

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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