Female pelvic floor dysfunction: progressive weakening of the support system

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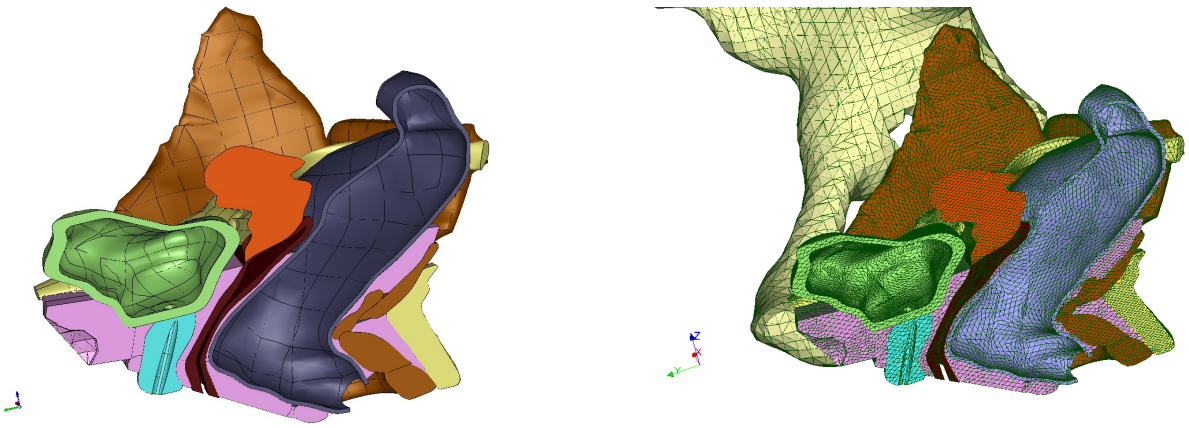
Abstract – The structure of the female pelvic floor (PF) is an inter-related system of bony pelvis, muscles, pelvic organs, fascias, ligaments, and nerves with multiple functions. Mechanically, the pelvic organ support system are of two types: (I) supporting system of the levator ani (LA) muscle, and (II) the suspension system of the endopelvic fascia condensation [1], [2]. Significant denervation injury to the pelvic musculature, depolimerization of the collagen fibrils of the soft vaginal hammock, cervical ring and ligaments during pregnancy and vaginal delivery weakens the normal functions of the pelvic floor. Pelvic organ prolapse, incontinence, sexual dysfunction are some of the dysfunctions which increases progressively with age and menopause due to weakened support system according to the Integral theory [3]. An improved 3D finite element model of the female pelvic floor as shown in Fig. 1 is constructed that: (I) considers the realistic support of the organs to the pelvic side walls, (II) employs the improvement of our previous FE model [4], [5] along with the patient based geometries, (III) incorporates the realistic anatomy and boundary conditions of the endopelvic (pubocervical and rectovaginal) fascia, and (IV) considers varying stiffness of the endopelvic fascia in the craniocaudal direction [3]. Several computations are carried out on the presented computational model with healthy and damaged supporting tissues, and comparisons are made to understand the physiopathology of the female PF disorders.

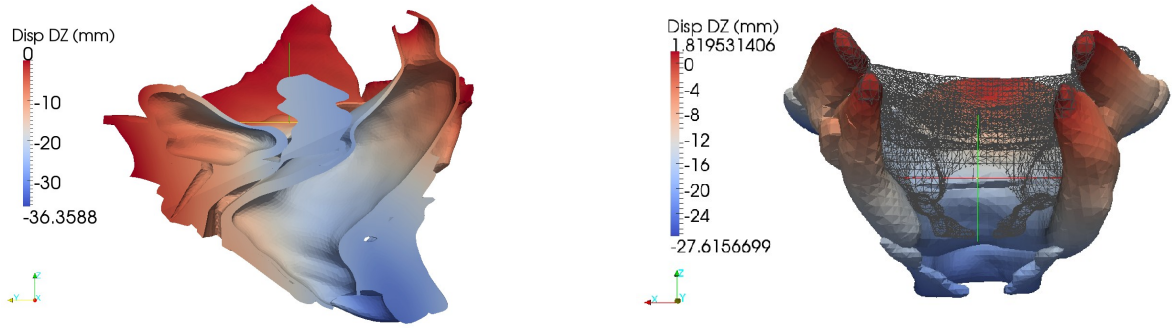


(a) (b)

Fig.1: (a) Midsagittal section of the geometry and (b) a 3D finite element model of the female PF showing the pelvic muscles (brown), fascias (pink), ligaments (yellow), bladder (green), urethra (blue), uterus (orange), vagina (wine), rectum (navy), and pelvic bone (oyster).

Results and Discussions: The finite deformation simulations for the computational model are performed with the open source FE software, *Code_Aster*. The computational results presented show the movement of the pelvic organs due to the increased intra-adbominal pressure (IAP), detrusor muscle and the levator plate contraction. The bladder (vesica) and the urethral position are measured for the healthy and structurally impaired (weakened) muscles, ligaments and fascias

to evaluate the stress urinary incontinence (UI), an involuntary urine leakage due to sudden increase in IAP. With progressive muscles and soft connective tissues impairment, the IAP and the muscle contraction forces increases the urethro-vesical angle by 4° more than the healthy case. The results are compared with the *Q-tip test*, a simple diagnostic tool to access the hypermobility of the urethro-vesical junction for stress UI. Progressively weakened pubourethral ligament at the mid-urethra and the internal urethral sphincter muscle at the bladder neck fails to close the urethra during straining, see Fig. 2. This correlation of the UVJ movement and opening of the urethra with the laxity of the pelvic supporting structures indicates the higher risk of stress UI which can be surgically treated by the prosthetic mesh implants [5].



(a) (b)

Fig.2: (a) Movement of the pelvic floor organs with impaired supporting structures: midsagittal view. (b) Displacement of the levator ani (LA) muscle. Undeformed state (gray wireframe) and displaced LA muscle (solid): anterior view [6].

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