# Biomechanical Simulation of Different Prosthetic Meshes for Repairing Uterine/Vaginal Vault Prolapse

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**Abstract** – Women – often elderly and/or multiparous – may suffer from uterine/vaginal vault prolapse, which is caused by the loss of support from the apical ligaments and muscles within the bony pelvis. Risk factors are assumed to be obesity, chronic increase in intra-abdominal pressure (IAP), and also tissue damage during vaginal delivery, etc. Such problems often recover spontaneously. However, critical damages in the muscles and ligaments around the cervical ring are prone to cause significant descent of the uterus into the vaginal canal. Approximately, 50% of parous women have some degree of prolapse [1] and more than 60% of the patients are aged over 60 [2]. Prosthetic mesh implants are surgically inserted to support the function of lax (weak) apical ligaments and muscles. These implants are widely used to stabilize and support the normal anatomical position of the cervical ring by fixing it to the sacrospinous ligaments, the upper sacrum or the pelvic sidewalls. Polyvinyliden fluoride (PVDF) is the newly used polymer to construct such devices due to their minimal inflammatory reaction, reduced risk of infection, and preserved tensile strength in long range compared to other conventional meshes.

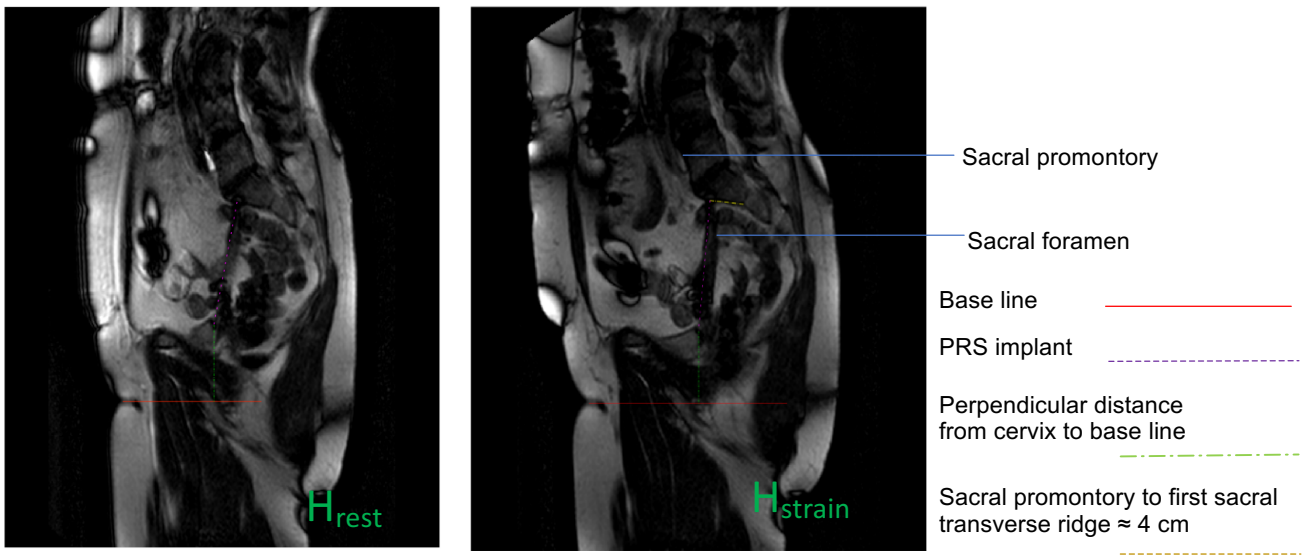


***Fig. 1*** *Female pelvic floor in rest (left) and strained (right) condition. Vertical displacement of cervical ring ($H_{rest}$ – $H_{strain}$ ) is 5 mm [Source: Dr. Ralf Anding, Bonn].*

**Materials and Methods:** Three different mesh types (DynaMesh-PRP soft, DynaMesh-PRS soft and DynaMesh-CESA) from FEG Textiltechnik GmbH, Aachen, Germany have been tested to support the function of weakened apical ligaments. These meshes are manufactured as nonlinear elastic orthotropic materials. The 3D finite element (FE) model has been reconstructed from a 70 year old female cadaver specimen, which is obtained from the human donation program of the Medical University of Vienna [3]. The soft organs, ligaments, fasciae and muscles are modelled as hyperelastic materials, using the Mooney-Rivlin class of strain energy functions. To simulate the progressive development of the PFDs, supporting tissues are successively weakened between 0% and 95% by reducing the material stiffness [4]. Frictionless contact between the organs is taken into account, which is a realistic assumption. An intra-abdominal pressure of 4 kPa is applied, which is measured during Valsalva maneuver. We then compare the efficiency of the mesh implants to minimize the dislocation of the cervical ring and examine the mesh-tissue interaction using FEM.

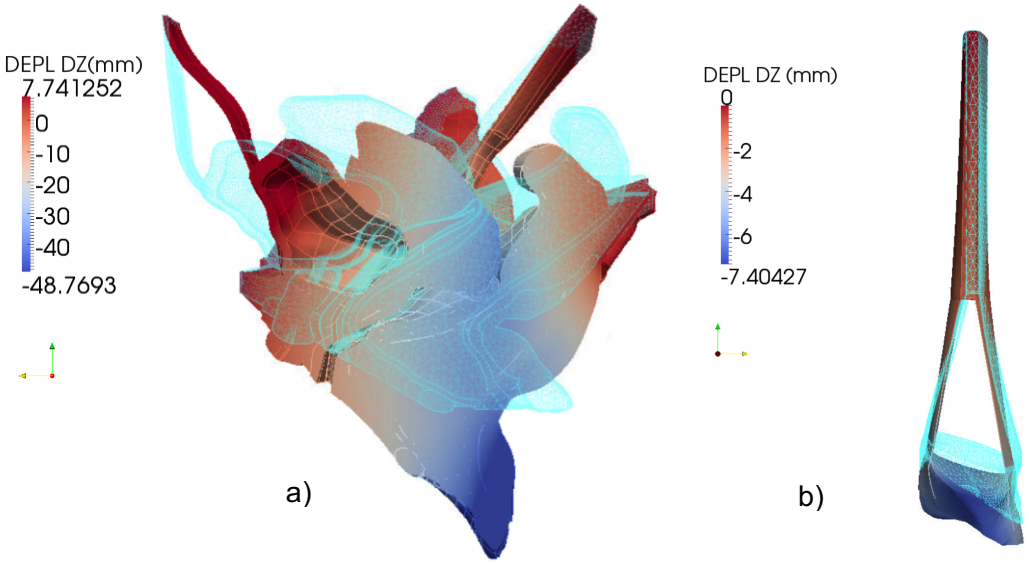


***Fig. 2*** *Distribution of deflection in a) 95% impaired pelvic floor and b) cervical ring with implant. Wireframe models are in rest position.*

**Results:** For prolapse pelvic floor, the simulated vertical dislocation of the cervical ring is around 26 mm. Comparing the rest and strained condition of pelvic floor, as shown in Fig. 1, demonstrates that the vertical movement of the cervical ring is restricted to about 5 mm. The displacement computed with FEM considering the PRS implant is about 7mm, which is close to measured MRP values. The pelvic floor response will be also analyzed with PRP and CESA implants and the results will be compared, which help decide for the better implant.

## References

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