Finite element modeling comparing biomechanical efficacy of sacrocolpopexy with and without supra-cervical hysterectomy for pelvic organ prolapse

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Abstract

Introduction and hypothesis: Laparoscopic sacrocolpopexy (LSC) is nowadays one of the most common surgery performed forpelvic organ prolapse. Hysterectomy can be associated with this procedure but few data exist about its utility. We aim to compare the biomechanical efficacy of sacrocolpopexy with and without supra-cervical hysterectomy for pelvic organ prolapse using 3D finite element modeling so as to test the hypothesis that hysterectomy could improve stress and strain on pelvic organs and on apical supporting ligaments.

Materials and methods: Magnetic resonance (MR) pre- and post-operative images of two patients having respectively LSC with and without supra-cervical hysterectomy were used. 3D models of pelvic organs, cardinal and uterosacral ligaments were constructed with Slicer® software. Then, the 3D model was transformed into a geometric mesh model using Rhinoceros® software before creating a solid model using SolidWorks® software. The biomechanics study was performed by the finite element method after importing the model into ANSYS® software and using tissue linear elastic behavioural characteristics from the literature. Pelvic organs were exposed to an intra-abdominal pressure of 0.20 MPa to simulate a Valsalva maneuver at 45° to the axial plane. The Levator plate was assumed as a fixed support.

Results: Finite element modeling simulation showed that equivalent stress increased on pelvic organs after both LSC with (4.92 MPa before versus 6.81 MPa after surgery) and without supracervical hysterectomy (8.84 MPa before versus 30.34 MPa after surgery) (Table 1). However, equivalent strain on pelvic organs decreased after LSC with supracervical hysterectomy (0.12 before versus 0.08 after surgery) but increased in case of uterine preservation (0.19 before versus 0.67 after surgery). Stress and strain on the left and right cardinal ligaments decreased after both types of surgery. Whereas stress and strain also decreased for the right uterosacral ligament, both values increased for the left uterosacral ligament following LSC with and without supra-cervical hysterectomy.

Conclusion: LSC without supra-cervical hysterectomy witnessed an increase in strain on pelvic organs. An asymmetrical distribution of stress and strain is observed on apical supporting ligaments with an increase in post-operative stress and strain on the left uterosacral ligament. This result arises because the mesh is placed on the right. These biomechanical theoretical results could explain some cases of recurrence and pain after LSC.

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Preprint submitted to European Journal of Obstetrics & Gynecology and Reproductive Biology