Development of a Personalized Computational Model to Simulate Pelvic Organ Prolapse

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ABSTRACT

Pelvic organ prolapse (POP) is a complex condition resulting from defects in the supporting structures of the vagina [1]. POP affects 25-41% of middle-aged and elderly women [1] and is estimated that from 2010 to 2050, the total number of women undergoing surgery for POP will increase by 48.2% [2], with a re-operation rate of 30% [3].

Until now, the treatment of POP includes non-surgical and surgical management. Although surgical management of POP is currently adopted, non-surgical treatments such as pelvic floor muscle training, pessaries, or both can be useful in symptomatic improvement as well as weight loss in case of obesity [4]. Nevertheless, most of these treatments are not helpful for women with severe prolapse; therefore, surgical therapy is more appropriate in these cases, using vaginal meshes. However, the use of mesh may induce post-operative complications as recognized by the International Society Continence (ICS) and International Urogynecological Association (IUGA). The main post-operative complications identified by both societies, include infections, erosion of the mesh through the vagina or mesh contraction, voiding symptoms and sexual dysfunction, directly related to the insertion of prostheses (meshes, implants and tapes).

Main goal of this work is the development of a personalized computational model that can be used to devise more accurate strategies for diagnosis, and preventive and therapeutic interventions, namely the implantation of biodegradable vaginal implants for the POP reconstruction. For this purpose, subject specific micromodels of pelvic floor muscles (PFM) properties from inverse finite element analysis (FEA) [5] were integrated with macromodelling of the pelvic structures. The inverse FEA is an optimization scheme, involving the Powell´s algorithm and the finite element method (FEM). This methodology showed that the PFM of prolapsed women are stiffer than that of asymptomatic women, being the difference approximately 28%. Additionally, the inverse FEA can be an important tool to map the subject specific intra-abdominal pressure (IAP).

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