Biomechanical models of the lower urinary tract as ancillary tests to urodynamic studies

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ABSTRACT

Urinary incontinence (UI) affects more than 200 million people worldwide, harming their emotional, psychological and social life [1]. Urodynamic study has been a crucial tool to assess the functioning of the lower urinary tract, being useful in diagnosis, in monitoring the progress of a disease, and in evaluating objectively the results of a therapy. This urological examination uses a catheter to fill the bladder while pressure is measured, dynamically assessing the behaviour and functioning of the bladder in the filling and voiding phases, and also evaluating the function of the urinary sphincter. Computational modelling emerges as a tool capable of deepening knowledge about the coordinated performance of the bladder and urethra during micturition cycle. Whereas, if progress is to be made in the neuromuscular field, a grasp of the purely mechanical behaviour is essential.

The goal of this work was to create a biocomputational model of the lower urinary tract and to identify and compare the mechanical changes that lead to a diagnosed UI. A 3D model of the bladder and urethra, based on magnetic resonance imaging data of a nulliparous female without pelvic floor dysfunction complaints was used. To characterize the bladder tissue behaviour, experimental tests from the literature were reproduced using different constitutive models [2]. A thorough focus on the mechanical properties to characterize its typical mechanical behaviour (large deformations with slight pressure variations) was taken. Then, computational analysis with fluid-structure interaction was performed, simulating the bladder’s filling. Lastly, to calibrate the computational model, experimental data from urodynamic was used.

The conducted simulations regarding the bladder’s filling suggested that both stress urinary incontinence and overactive bladder patients exhibit a stiffer bladder’s wall. More complex constitutive model should be used to characterize muscle contractions which are crucial to represent data from urodynamics.

REFERENCES
