AN INVERSE FINITE ELEMENT ANALYSIS FOR THE DETERMINATION OF THE *IN VIVO* BIOMECHANICAL PROPERTIES OF THE BLADDER

Elisabete Silva (1), Sofia Brandão(2), Teresa Mascarenhas (3), Renato Natal (4)

1. LAETA, INEGI, Portugal; 2. Department of Radiology, Centro Hospitalar de São João-EPE, Faculty of Medicine, University of Porto, Portugal; 3. Department of Gynecology and Obstetrics, Centro Hospitalar de São João-EPE, Faculty of Medicine, University of Porto, Portugal; 4. LAETA, INEGI, Faculty of Engineering, University of Porto, Portugal

Introduction

Urinary incontinence (UI) has a prevalence of a up to 28%, with stress urinary incontinence (SUI) being the most common form [1,2], characterized by involuntary urinary leakage during physical strain, coughing or an increase in intra-abdominal pressure (IAP). SUI occurs when the intravesical pressure exceeds urethral resistance at which the urethra has the capacity to remain closed [2], and/or pelvic ligaments, are not stabilize the urethra. Assessment of bladder neck (BN) mobility in patients with SUI is essentially clinical, however, the imaging techniques such as ultrasound (US) and magnetic resonance imaging (MRI) are used as a method for evaluating this characteristic. The outcomes of radiographic images have been crucial and used as input for numerical methods.

The aim of the present study was to establish the IAP values and the *in vivo* biomechanical properties of the bladder tissue for two distinct groups (continent women and women with SUI). The numerical simulations of Valsalva maneuver were performed, applying the Ogden hyperelastic constitutive model to the bladder and also the inverse finite element analysis (FEA).

Methodology

To evaluate the presence and symptoms of UI, a sample of 11 women (n=6, Continent (control group) (CG) and n=5 with SUI (IG)) was recruited and submitted to scanning (MRI). In order to obtain the IAP and *in vivo* biomechanical properties of the bladder in the two distinct groups (CG and IG), it was adapted a 3D computational model (Fig. 1) of the female pelvic cavity [3], that corresponds a nulliparous 24 years old healthy female.

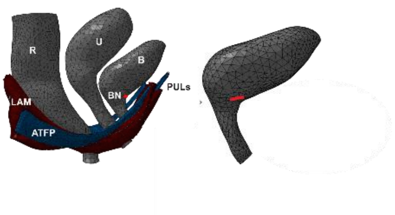

Figure 1. Computational model of the female pelvic cavity and bladder.

Results

Table 1 presents the material parameters for Ogden constitutive model, applied to the bladder tissue, obtained by inverse FEA for two groups. These parameters were obtained after adjusting the mechanical properties of support structures and IAP for the IG (5.0 MPa).

variable		*CG(n=6)*	*IG(n=5)*	*Variation(%)*
Ogden	**α_1 [MPa]**	0.180	0.202	10.89%
	μ_1 [MPa]	4.839	7.720	37.32%

Table 1. Material parameters of the bladder in women with and without SUI, and variation between the groups.

Figure 2 presents the results of the mechanical response of the uniaxial stress-stretch response for the 2 groups to compare the effect of material parameters (Table 1) obtained in this work, compared with the experimental curve.

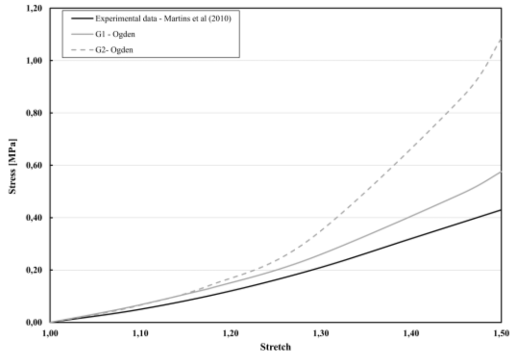

Figure 2. Uniaxial stress–stretch response for behaviour of the bladder for the Ogden constitutive model and experimental data of the literature.

Discussion

The biomechanical properties for the bladder of the Ogden constitutive model from the CG and IG have a difference of approximately 47% in stiffness, being greater for IG.

References

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3. Brandão S et al, *Journal of Biomechanical Engineering* 2017; **139**(8):1–9.

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