A HYBRID METHOD TO CHARACTERIZE THE MECHANICAL BEHAVIOUR OF BIOLOGICAL HYPER-ELASTIC TISSUES

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Introduction

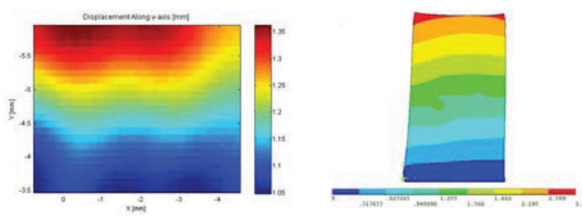
The increase of interest in the study of human biological tissues led to the characterization of certain biological materials which have a hyper-elastic mechanical behaviour [Afonso, 2008 and Martins, 2006]. Traditionally are used experimental tests to characterize such materials, however, these have been replaced by numerical simulations using finite element codes, with advantages from the point of view of saving time and financial costs. The optical experimental field methods have the advantage, such as the assessment of displacement fields without contact with high resolution, using ordinary white light or laser illumination. Both techniques, experimental and numerical, have limitations in the characterization of hyper-elastic biological tissues. The numerical simulation has different constitutive models, but none of them could characterize completely these materials. In the other hand, most of the optical techniques have a high sensibility which is not adequate for hyper-elastic behaviours. Only the digital image correlation (DIC) has the sensibility range that could allow the measurement of such large displacements. However, the strain fields are computed by the differentiation of displacement fields and this technique could amplify the image noise, in this case the quality of strain fields are not adequate. To overcome these limitations the authors of this work have developed a hybrid method which uses the displacement field obtained with DIC applied in the nodes of a finite element model.

Methods

In the experimental test was used tissue of human vaginal pelvic floor. The tissue preparation had two phases; firstly it was cut in rectangular shape and after applied a random speckle with toner in one of the sample faces. Was done a tensile test with the tissue samples, where the sample face with speckle stayed in front of the CCD DIC system (Aramis). The DIC system saved 150 images for each test in a sequence of one image per second.
The finite element code Ansys® was applied for the numerical simulation. In previous work [Ribeiro, 2011] showed that the Ogden phenomenological model had demonstrated a good approximation to characterize the behaviour of these materials. Such as for this work was chosen that model. In each node of the numerical model were applied two orthogonal displacements settled by DIC and were applied a vertical displacement in the top border and the under border was fixed.

Results

The figures 1 and 2 show the results obtained with hybrid method and experimentally by DIC



(a) (b)

Figure 1: Displacement field in y direction: (a) DIC; (b) hybrid method.

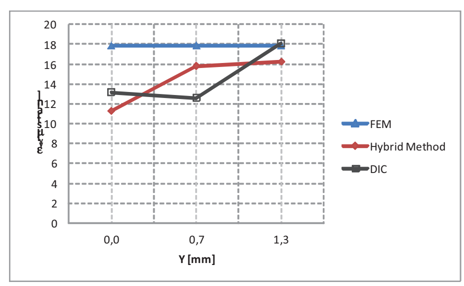


Figure 2: Strain variation along of vertical direction in the sample centre for FEM, hybrid method and DIC.

Conclusions

The hybrid method developed in this work demonstrated that could be a valid alternative to the traditional finite element methods (FEM). The proposed method describes with good accuracy the mechanical behaviour of hyper-elastic biologic tissues.

References

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[Ribeiro, 2011] Ribeiro et al, CIBEM 2011, in conference proceedings, 2011.