Experimental and Numerical Characterization of Displacement Field on Biological Tissues

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Introduction

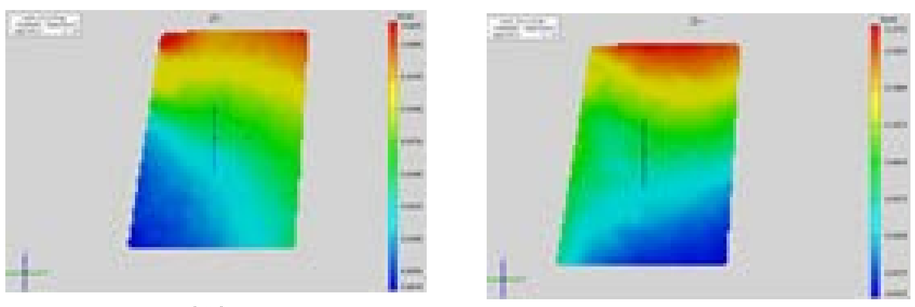
The need to understand the behavior of biological tissues, especially human tissue, has stimulated the development of experimental and numerical techniques that allow the characterization of such materials. Nowadays the use of experimental tests has been frequently replaced by the numerical simulation using finite element method, with important advantages from the standpoint of saving financial costs and time consumption.
The Digital Image Correlation (DIC) is a measurement technique which uses a mathematical correlation method to calculate the displacement on the plane surfaces of components or structures subjected to thermal or mechanical charges In this work were done two different experimental tests using the DIC to characterize hard and soft materials behavior and the respectively numerical comparison with a commercial finite elements code, Ansys®.

Results - Hard biological materials

This study intends to analyze the behavior of bovine cortical bone in the vicinity of a metal implant interface, under the action of various loads. Cortical bone is a material with a highly porous structure, which prevents the accurate measurement of deformation using conventional experimental methods, for this reason the measurements were implemented with DIC technique.

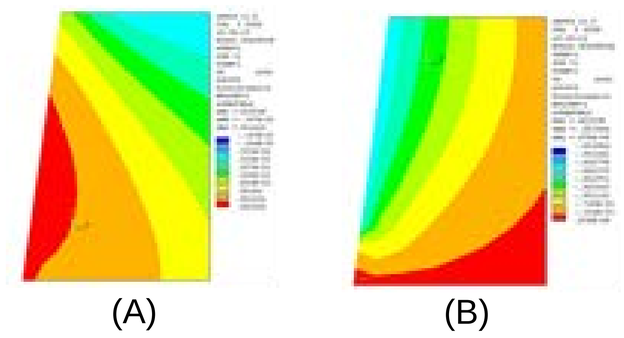
Fig. 1. Apparatus used for measuring deformations on the bone-implant interface.

The apparatus was subjected to a uniform loading applied by a universal testing machine. During the charging test were captured images in successive increments of 30 N until 1000 N. The DIC system used was the Aramis of GOM to measure with high resolution the displacement and strain fields occurred during the test. The numerical simulation of the test was performed using the finite element program Ansys®.



(A) (B)

Fig. 2. Displacement field in the directions: x (a) and y (b), for a load of 1000 N, measured with DIC.



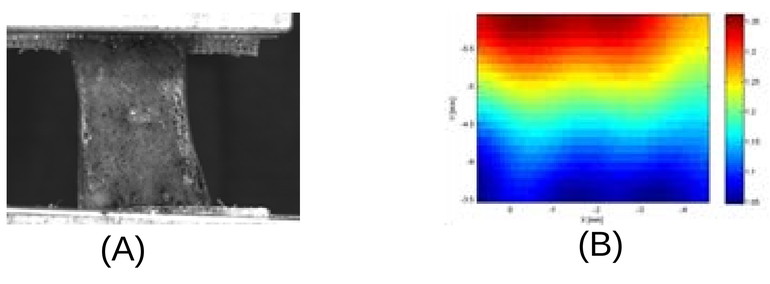
(A) (B)

Fig. 3. Displacement field in the directions: x (a) and y (b), for a load of 1000 N, determined with Ansys®.

Results - Soft biological materials

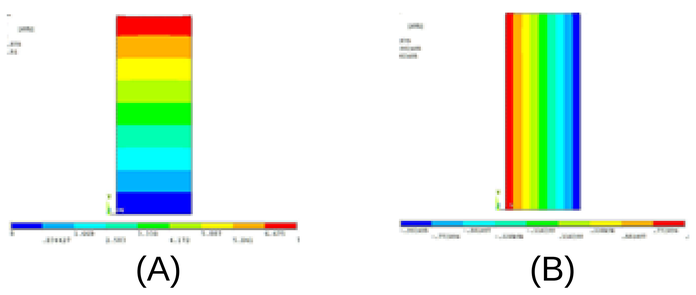
For the characterization of soft biological material was used human pelvic tissue. The tested material has hyper-elastic properties and, the deformations occurring are very high. This property brings difficulties for the use of interferometric optical techniques because could occur speckle decorrelation.

The DIC technique is an optical technique that allows the measurement of displacement and strain fields for these kinds of materials. A load of 0.25 N was applied on sample and used the DIC technique to measure the displacement field. A numerical simulation was done using the Ansys®. For this case the mathematical model implemented was the Mooney-Rivlin. The boundary conditions were: the base fixed and applying a load of 0.25 N on top.



(A) (B)

Fig. 4 Measuring the displacement field with DIC: (a) sample of tissue tested and (b) displacement field measured in the vertical direction.



(A) (B)

Fig. 3. Displacement field in the directions: x (a) and y (b), for a load of 0.25 N, determined with Ansys®.

Conclusions

The technique of Digital Image Correlation proved to be well adapted to the measurement of displacement fields on biological tissues. The numerical simulations show that it is possible to use them as an alternative to experimental tests; however the numerical algorithms for biological materials must be improved.

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