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Research paper

Characterization of the nonlinear behaviour and the failure of human liver capsule through inflation tests

A. Brunon[a,b,c,d,*], *K. Bruyère-Garnier*[a,b,c], *M. Coret*[a,d]

[a] *Université de Lyon, Lyon, F-69000, France*
[b] *Ifsttar, UMR_T9406, LBMC, F-69675, Bron, France*
[c] *Université Lyon 1, F-69622, Villeurbanne, France*
[d] *INSA-Lyon, LaMCoS UMR5259, F-69621, France*

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ABSTRACT

This paper aims at describing an inflation test protocol on a human liver capsule using stereo-correlation. The biaxial tension created by the inflation test is comparable to the type of loading the capsule would be subjected to during a liver compression. Confocal microscopy associated to an anti-collagen coloration reveals that the tissue is isotropic at the meso-scale. Stereo-correlation provides the strain field of the capsule during the test. It emphasizes the boundary condition effects on the strain field. The measurement of the shape of the capsule is used to determine the parameters of two hyperelastic (polynomial and exponential) homogeneous models. The ultimate first principal strain before failure is measured locally and its value is 50.5% ± 10.8%. In this protocol, the light goes throughout the sample and makes the heterogeneities of the material appear as darker grey levels on the pictures. These heterogeneities also appear on the strain fields, so we can assume that they have different material properties.

1. Introduction

Today, many road safety and vehicle regulations are based on validation tests like crash-tests. Such tests using anthropomorphic test devices do not give information about soft tissues and their behaviour under impact. Therefore, research turns towards numerical modelling to predict more precisely the occurrence of injuries on the different constituents of the human body, especially soft tissues. It is all the more necessary since various studies focused on accidentology revealed that damage to abdominal organs account for an important number of serious injuries in car accidents (Tinkoff et al., 2008; Welsh et al., 2007; Augenstein, 2000; Elhagediab and Rouhana, 1998). Liver damage in particular occurs in 38% of the injuries rated 3 to 5 in the Abdominal Injury Scale (AIS), AIS 5 resulting in a high risk of fatality.

Predicting liver injuries requires knowledge about its main constituents (vessels, parenchyma, capsule). Characterizing the constitutive laws and failure properties of these tissues is a first step in the numerical modelling of the whole organ. This study is focused on the liver capsule, which surrounds

* *Corresponding address:* Laboratoire de Biomécanique et de Mécanique des Chocs - Ifsttar, 25 Av. F. Mitterrand, Case 24, 69675 Bron Cedex, France. Tel.: +33 472437105; fax: +33 472142360.
E-mail address: aline.brunon@ifsttar.fr (A. Brunon).

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