available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jmbbm

Research paper

Compressive behaviour of bovine cancellous bone and bone analogous materials, microCT characterisation and FE analysis

T. Guillén[b], *Q.-H. Zhang*[a], *G. Tozzi*[a], *A. Ohrndorf*[b], *H.-J. Christ*[b], *J. Tong*[a,*]

[a] *Mechanical Behaviour of Materials Laboratory, Department of Mechanical and Design Engineering, University of Portsmouth, Portsmouth PO1 3DJ, UK*
[b] *Institut für Werkstofftechnik, University of Siegen, 57076 Siegen, Germany*

ARTICLE INFO

Article history:
Received 14 February 2011
Received in revised form
15 April 2011
Accepted 7 May 2011
Published online 13 May 2011

Keywords:
Cellular materials
Bovine trabecular bone
Metallic foams
Micro-computed tomography
(microCT)
Compression
Damage

ABSTRACT

Compressive behaviour of bovine cancellous bone and three open-cell metallic foams (AlSi7Mg (30 ppi and 45 ppi); CuSn12Ni2 (30 ppi)) has been studied using mechanical testing, micro-focus computed tomography and finite element modelling. Whilst the morphological parameters of the foams and the bone appear to be similar, the mechanical properties vary significantly between the foams and the bone. Finite element models were built from the CT images of the samples and multi-linear constitutive relations were used for modelling of the bone and the foams. The global responses of the bone and foam samples were reasonably well captured by the FE models, whilst the percentage of yielded elements as a measure of damage evolution during compression seems to be indicative of the micro-mechanical behaviour of the samples. The damage evolution and distribution patterns across the bone and the foams are broadly similar for the strain range studied, suggesting possible substitution of trabecular bones with appropriate foams for biomechanical studies.

1. Introduction

Biomechanical testing of orthopaedic implants in cadaver bones has provided valuable information on pre-clinical assessments of implant performance. However, the method is limited by the availability of cadaveric tissues. Furthermore, the reproducibility of such test results is generally poor, because of the large variation in the mechanical properties of cancellous bones due to a number of variables such as anatomic site and age. Several reviews have explored the relationship between the variables and the mechanical properties of cancellous bone (Goldstein, 1987; Linde, 1994; Keaveny and Hayes, 1993; Keaveny et al., 2001; Gibson, 2005). For this reason it is desirable to employ bone substitutes in mechanical characterisation and testing in order to remove some of the variables in cadaver tissues; and, furthermore, to simulate a range of cancellous bone properties by controlling the morphological parameters in bone analogue materials.

* *Corresponding address:* Mechanical Behaviour of Materials Laboratory, Department of Mechanical and Design Engineering, University of Portsmouth, Anglesea Road, Portsmouth PO1 3DJ, UK. Tel.: +44 9284 2326; fax: +44 9284 2351.
E-mail address: jie.tong@port.ac.uk (J. Tong).

1751-6161/$ - see front matter
doi:10.1016/j.jmbbm.2011.05.015