IV Reunión del Capítulo Español de la Sociedad Europea de Biomecánica (ESB)
20 - 21 de noviembre 2014, Valencia

A continuum damage model characterization based on the soft tissue mesostructure

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Introduction

Material properties of soft tissues are highly conditioned by the hierarchical structure of this kind of composites. These collagen-based tissues present a complex framework of fibres, fibrils, tropocollagen molecules and amino-acids [3]. As the structural mechanisms that control the degradation of soft tissues are related with the behaviour of its fundamental constituents, the relationship between the molecular and intermolecular properties and the tissue behaviour needs to be studied [2].

Materials and methods

In this work a relationship is derived between the mechanical and geometrical properties of the fibril constituents and the soft tissue material parameters at macroscopic scale. A Hodge-Petruska bidimensional model [1] has been used to describe the fibrils as staggered arrays of tropocollagen molecules (see Fig. 1).

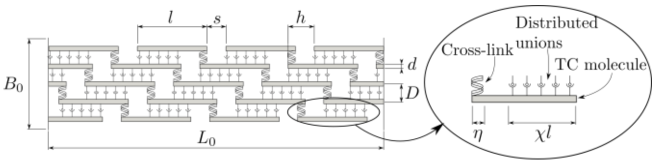

Fig. 1: 2-D Hodge-Petruska model

After a mechanical characterisation of each of the fibril components, two fibril failures modes have been defined related with two planes of weakness (see Fig. 2).

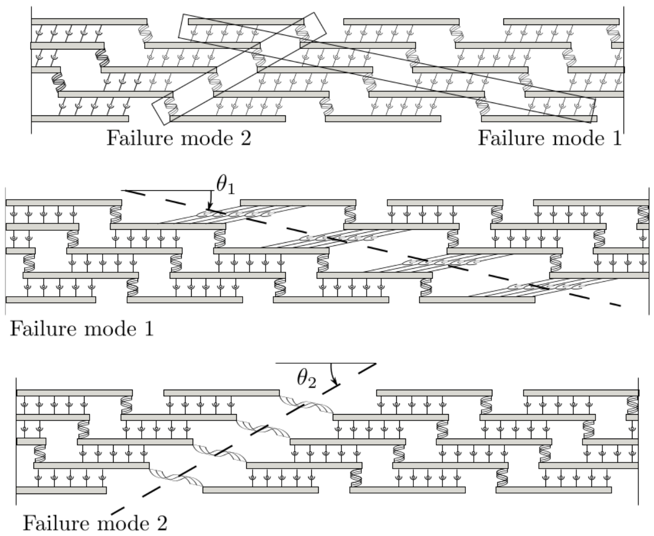

Fig. 2: Fibril planes of weakness

Macroscopic mechanical parameters of the fibre at tissue level are obtained by using a homogenisation approach. Finally, numerical fitting of material parameters of an exponential-type law for the fibres is performed.

Results and discussion

Numerical analysis at fibril and fibre levels have been made to examine the capabilities of the model. Only the study of how the cohesive force of the cross-links affects the yield strength of the fibril is presented in this abstract (see Fig. 3). We see an increase in the yield strength with increasing the bearing capacity of the cross-links, until the strength of the cross-links is so large that failure occurs along the distributed unions in the overlapped length.

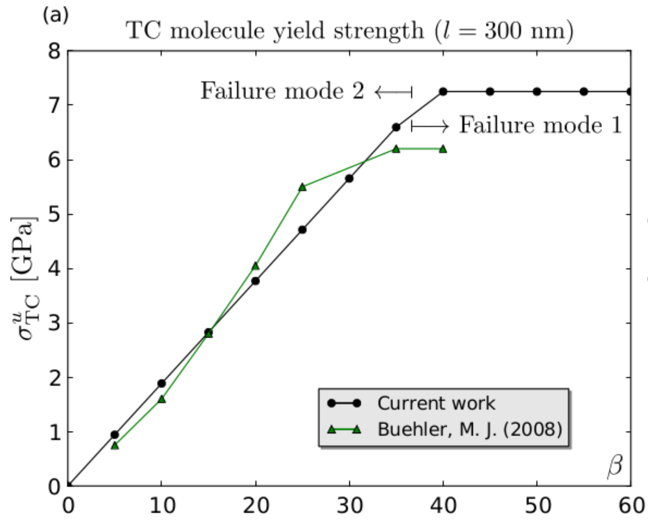

Fig. 3: TC molecule yield strength as a function of cross-link strength

Conclusion

We have obtained meso-structurally based definitions for the elastic parameters defining the effective strain energy function, and for the inelastic parameters defining the ingredients of the damage model (density per unit area of total dissipated energy and yield strength).

Acknowledgements

Financial support from the Spanish Ministry of Science and Technology, through Grant DPI 2011-27609 is gratefully acknowledged.

References

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