Experimental Characterization of Pressure Wave Generation and Propagation in Biological Tissues

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INTRODUCTION: This work develops a measurement technique for pressure waves in soft tissues. It aims at characterizing, understanding and modeling the generation and propagation of pressure waves in soft tissues, with a view towards medical applications for the treatment of various tissue pathologies.

METHODS AND RESULTS: First, Hopkinson bar techniques[1] have been adapted to measure the waves emitted by an impact generator, transmitted through the material and reflected at the interfaces. Simulation with an explicit FEM software reproduce the measured data well.

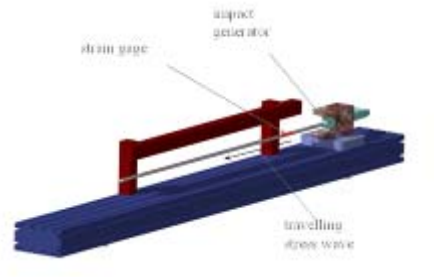

Fig. 1: Schematic of Hopkinson pressure bar and stress records at one location along the bar

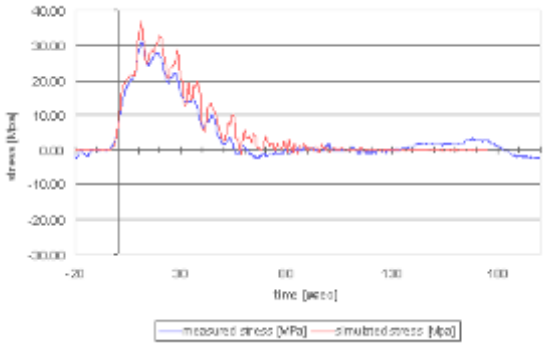

Fig. 2: measured and simulated record for an impact speed of 15m/sec

Secondly, flexible PVDF gages have been calibrated for measurement of wave propagation in soft tissues. Although PVDF gages have acoustic impedance similar to soft tissues, they act nevertheless as foreign inclusion and perturb the measurements. FEM simulation using a non linear hyper-elastic Ogden model (1) to represent soft tissues can predict the behavior of wave propagation in biological material.

$$\phi = (2\mu/\alpha^2)(\lambda_1^{\alpha}+\lambda_2^{\alpha}+\lambda_3^{\alpha}) \quad (1)$$

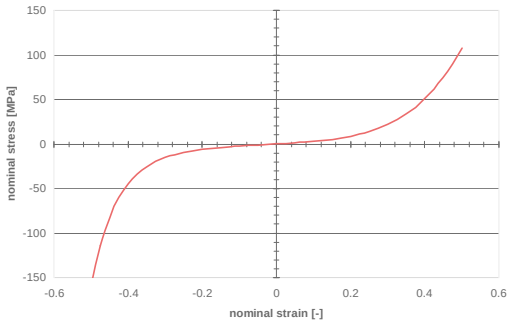

Fig. 4: Ogden model for an incompressible, isotropic, hyper-elastic solid and nominal stress-strain response

Comparison of results of simulations with and without the gage inclusion provides a method to evaluate the measured signals and extract reliable pressure data. Results are applied to the design of biomedical devices for the Extracorporeal Shock Wave Therapy (ESWT).

DISCUSSION & CONCLUSIONS: Adapted Hopkinson bar technique coupled with FEM simulation can predict pressure wave emitted, transmitted and reflected at the interfaces of an impact generator. PVDF flexible gages are a potential technique for measuring wave propagation in soft tissues and non linear hyper-elastic Ogden model is a good candidate for FEM simulation of wave propagation in these tissues. This work contributes to improve the scientific knowledge of the healing effect of shockwaves for different pathologies by providing a well characterized mechanical wave input in the treated tissues.

REFERENCES: [1] H. Kolsky (1963) *Stress waves in solids*, New York, Dover publications, Inc.