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MODELLING OF BODY PARTS CONSISTING OF BONES AS WELL AS SOFT TISSUE: -AN EXPERIMENTAL AND FINITE ELEMENT STUDY

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INTRODUCTION

PREDICTION OF BONE FRACTURE under impact requires knowledge of constitutive properties of materials involved and information on the dynamic property of tissues is essential for the development of FE based models. Bone tensile and compressive properties are available in literature. The dynamic properties of soft tissues are more difficult to characterise because they are viscoelastic and hyperelastic, [1,2,3]**.** In this paper we have investigated the feasibility of modelling the fracture of body segments that consist of bones as well as soft tissues and to estimate the viscoelastic properties of the soft tissues from experiments conducted.

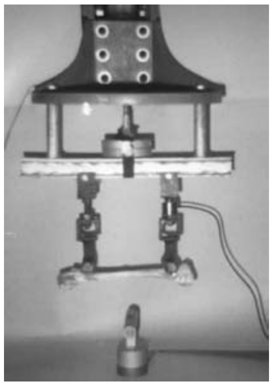

Figure 1 Experimental Setup

EXPERIMENTS

THE UPPER REAR LEG of a goat cadaver was impacted with a 2.4 kg cylindrical impactor at speeds of about 3m/sec under three point bending conditions and the impactor force recorded. The setup is shown in Figure 1. The impact was severe enough to fracture the specimen. In the next stage, a similar specimen was stripped off muscles and skin and impacted and the impact history recorded.

Impact tests were conducted on goat rear leg to obtain impact force history. The specimens fractured on impact. Tests were conducted on six specimens. The impact tests showed that the peak loads were identical for limbs with and without soft tissue. The duration of the load was larger for limbs with soft tissues, indicating greater energy absorption in impact.

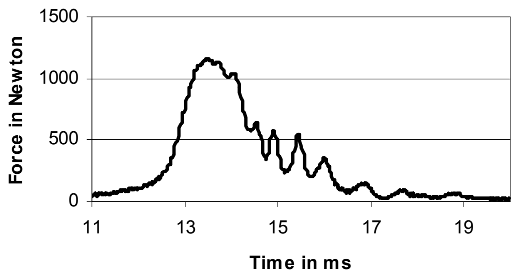

Figure 2 Force history for flesh and bone

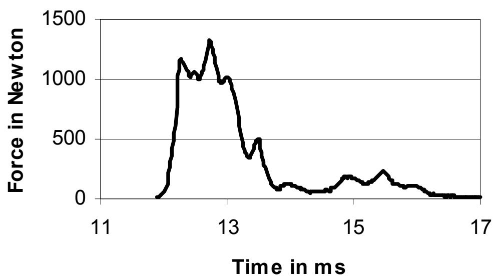

Fig. 3 Force history for impact on bone

FINITE ELEMENT SIMULATIONS

GEOMETRY MEASUREMENTS of the specimen were used to create FE mesh of the specimen. The mesh is shown in Figure 4 and Figure 5 below. Starting with material properties available in literature, the ultimate strength of the bone was modified to match the recorded impact history. Matching experiments with FE simulations identified that bone material has a plastic strain zone that is about twice the elastic strain zone. Young's Modulus, density, Poisson's ratio and ultimate breaking strain for the bone material was identified.

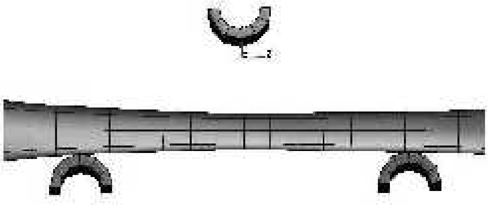

Figure 4 FE model of bone impact

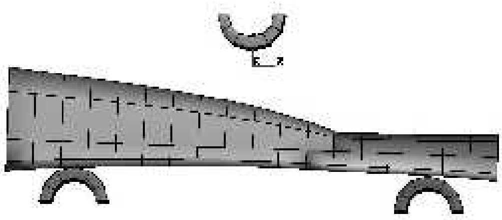

Figure 5 FE model of bone and flesh impact

The soft tissues are known to conform to viscoelastic models. For them, other than Young's Modulus, density, Poisson's ratio, the bulk modulus, long time shear modulus, the short time shear modulus, and decay constant was identified.

Parameters	Bone	Flesh
Young's modulus E (N/m^2)	2×10^{10}	6×10^4
Density ρ (Kg/m^3)	2000	1000
Poisson's ratio ν	0.3	0.4
Ultimate breaking strain, ε_{ul}	0.023	
Bulk modulus K (N/m^2)		0.1×10^6
Long time shear modulus (N/m^2)		2300
Short time shear modulus (N/m^2)		2.14×10^4
Decay Constant (/sec)		100

CONCLUSIONS

It was determined that FE models can be established for bones as well as soft tissues that reproduce the load history under whole limb impacts that lead to fracture of the specimen. The impact properties of bones as well as soft tissues for goat cadaver data have been obtained by matching FE simulation results with experimental impact data. The peak loads as well as impact duration is reproduced in simulation.

The objective has been to establish the procedure for deducing the impact properties of soft tissues. The limitation of this study was that the impact fractured the specimen. A model validated for a range of impact magnitude and corresponding validation needs to be established. It is planned that, similar tests will be conducted for human tissues subsequently.

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