NUMERICAL ANALYSIS OF THE BIOMECHANICAL PARAMETERS IN A SPECIFIC PATIENT KNEE CARTILAGE

[1] António Completo, [1]Joana Pereira, [1]António Ramos, [1]Carlos Relvas and [1]José Simões
[1]Mechanical Engineering Department, University of Aveiro, Portugal
completo@ua.pt

SUMMARY
The self-regeneration capacity of articular cartilage is limited, due to its avascular and aneural nature. Each year, the number of performed arthroscopies is 1 500 000 in the USA and 350 000 in the EU. Total joint arthroplasty is a surgical solution to restore the mechanical function of the articulating surfaces, but metal is a poor substitute for healthy biological tissues and the long-term outcome for young patients is still controversial. The mechanobiology of articular cartilage has been extensively studied since the early 90s. Initially, the mechanical response of explant and intact articular cartilage against static and/or dynamic loading was investigated. The results of these studies provided a good understanding of the native tissue response under extreme and/or physiological conditions. However, many of these studies given a limited insight into the intrinsic mechanical stimuli developed in the natural cartilage under physiological load conditions. This study, quantify the intrinsic mechanical stimuli developed on in-vivo tibiofemoral cartilage through a specific patient model during stance phase of gait. The von Mises stress in knee cartilage during the stance phase of gait can be an important parameter for the advance of cartilage tissue engineering.

INTRODUCTION
Osteoarthritis, the erosion of articulating joints, currently affects more than 200 million people worldwide. The limitations of current therapies and promising results obtained from tissue engineering research are the driving forces behind regenerative concepts for degenerated and traumatic joints. The mechanobiology of articular cartilage has been extensively studied since the early 90s. Initially, the mechanical response of explant (Smith et al., 2004) and intact (Boococok et al., 2009) articular cartilage against static and/or dynamic loading was investigated. The results of these studies provided a good understanding of the native tissue response under extreme and/or physiological conditions. However, many of these studies given a limited insight into the intrinsic mechanical stimuli developed in the natural cartilage under physiological load conditions. This study, quantify the intrinsic mechanical stimuli developed on in-vivo tibiofemoral cartilage through a specific patient model during stance phase of gait

METHODS
One male subjet was used for the development of specimen-specific knee finite element model. Femoral and tibial bone models were generated from CT using the semi-automated segmentation tools available in ScanIP (Simpleware Ltd). Based on the distribution of HU, the bone material properties were obtained through the apparent density. The cartilage layers (femur and tibia) were reconstructed from the CT and MR data through semi-automated segmentation tools and then meshed using poro-elastic 20 node brick elements with linear pore pressure and quadratic displacement. The loading patterns applied to these specimen-specific tibiofemoral models were take of a reference in-vivo experimental data. Based on this data, was replicated the contact location between femur and tibia at the sagittal and coronal planes and then imposed the tibiofemoral contact deformation. The von Mises stress was evaluated at 0%, 30%, 60% and 90% of stance phase.

RESULTS AND DISCUSSION
The von Mises stress gradients for each step of the stance phase at the medial compartment are presented in figure 1..

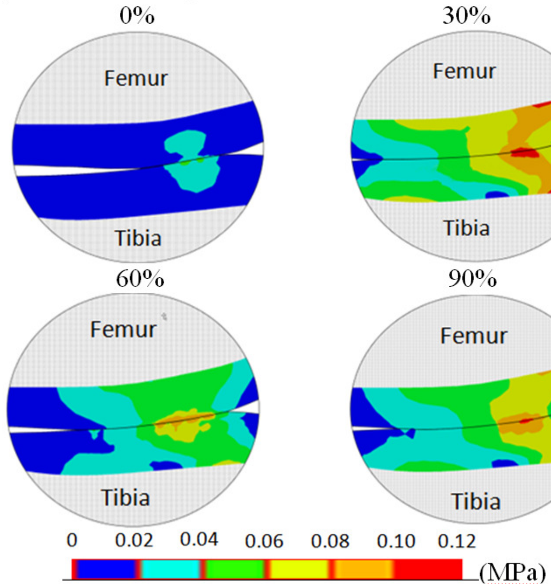

Figure 1: von Mises stress gradients in tibiofemoral cartilage.

CONCLUSIONS

The von Mises stress magnitude and pattern during the stance phase of gait can be important to define ranges of mechanical stimuli for cartilage tissue engineering.

ACKNOWLEDGEMENTS

COMPETE program through the projects PTDC/EME-PME/103578/2008, PTDC/EME- PME /111305/2009 and PTDC/EME TME/113039/2009.

REFERENCES

1. Smith RL et al, Clin Orthop Relat R S427: S89–95, 2004
2. Boocock M et al, Osteoarthr Cartilage 17(7): 883–890., 2009