Bone repair and ultrasound stimulation-: an insight into the interaction of LIPUS with the bone callus through a multiscale computational study.

In the 50’s, the effect of ultrasound stimulation on bone healing has been discovered. Nowadays, Low Intensity Pulsed Ultrasound Stimulation (LIPUS) is admitted to influence the mechanotransduction of bone. Nevertheless, despite a growing litterature – cell cultures, animal models, clinical studies – the underlying physical and biological mechanisms of LIPUS on bone bone healing are still misunderstood. Inspired from previous studies on the mechanotransduction induced by physiological loading, this work focuses on the effect of LIPUS on the osteocytes. These bone cells are thought to be the principal mechanosensors of bone. They are ubiquitous inside the bone matrix, immersed in the lacuno-canalicular network (LCN) filled with interstitial fluid (IF). The goal is to relate the ultrasound stimulation applied at the tissue scale, to the biological response at the cell scale. To tackle this question, two finite element models were implemented in the commercial software Comsol Multiphysics. The tissue-scale model considers an anisotropic poroelastic matrix to evaluate the IF pressure gradient induced by LIPUS into the LCN. Then, in the cell-scale model, the IF shear stress magnitude and the induced drag forces applied on osteocyte process are calculated and compared with levels of cell activation recorded in literature.