POST DOC OFFER

ACOUSTOFLUIDICS IN THE MICRO-ENVIRONMENT OF BONE CELLS: ASSESSMENT OF MECHANICAL STIMULI

Labs	**Institut de Recherche sur les Phénomènes Hors Equilibre**, IRPHé, UMR7342, Marseille, France **Laboratoire de Mécanique et d'Acoustique**, LMA, UMR7031, Marseille, France
Duration	24 months starting from sept./oct. 2023
Skills	(bio)mechanics, acoustics
Key words	Ultrasound stimulation ; osteocyte ; microfluidics ; acoustic streaming ; micro-PIV ; experimental set-up ; Finite Element modelling
Supervisors	Cécile Baron, CR CNRS, Carine Guivier-Curien, MCF AMU - IRPHé Philippe Lasaygues, IR - LMA
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Context

Bone tissue is a complex biological tissue, capable of adapting to its mechanical environment by optimizing its structure, a process known as bone remodeling. Low Intensity ultrasound (LIUS) stimulation of bone regeneration was discovered in the 1950s and has been widely studied since. Its use in clinical routine has been authorized for a couple of decades. However, the underlying mechanotransduction mechanisms (translation of mechanical stimuli into biological response) remain poorly identified and this lack of knowledge fuels controversy, preventing the development of more efficient and optimized therapeutic tools (Padilla, 2014).

The characterization and quantification of mechanical stresses induced by ultrasound stimulation on bone cells (osteocytes) is essential to understand these mechanisms and go further in its use for the clinic. We hypothesize that the key involved mechanical stresses are fluid shear stresses (Weinbaum, 1994). Actually, *in vivo*, osteocytes are surrounded by a fluid inside the complex 3D lacuno-canalicular network embedded in the extra-cellular matrix (ECM). The LIUS interaction with the 3D-micro environment could generate hydrodynamic phenomena, such as acoustic streaming in the fluid environment of the cell allowing shear stresses levels sufficient to trigger a biological answer.

Objectives of the postdoc recruitement

Three objectives are considered to get new insights into mechanotransduction by LIUS stimulation:

- to experimentally characterize the interaction of millimeter wavelength ultrasound (corresponding to LIUS stimulation) on physiological-type flow in straight microchannels (few tens of µm) through a dedicated µ-PIV set-up available at IRPHé as a proof of concept.

- to develop a microfluidic assembly currently made with material and dimensions mimicking lacuno-canalicular network, while being suitable for acoustics and allowing optical access for measurements. This will help to identify the hydrodynamic phenomena induced depending on the LIUS parameters.

- as the micro-PIV resolution is insufficient to accurately quantify shear stresses induced, the next step will be to develop a finite element multiphysics model matching the experimental microfluidic model as a reference. This computational model could therefore be gradually complexified as far as its geometry is concerned to mimic the current 3D bone cells micro-environment.

It is worth noticing that this subject is part of a larger project in collaboration with biologists from iBV (Université de Nice) to correlate the biological response of stimulated osteocytes to identified mechanical stresses. Regular meetings are held to review progress on both sides and compare results.

Profile required

The candidate, who holds a Ph.D., must have academic knowledge and/or experience in one or more disciplinary areas related to the subject: (bio)mechanics of fluids and solids, microfluidics, acoustics. He/She must have an appetite for experimentation and ideally has skills in (micro-)PIV measurement techniques. Skills in numerical FE modelling would be a plus.

He/she will have to show synthesis, communication, rigor, and methodology to be able to invest in the various aspects of the work requested.

Environment

The successful candidate will be co-advised by C. Baron, (acoustics and (bio)mechanics) and C. Guivier-Curien (fluid mechanics, fluid/structure interaction) from the IRPHé and P. Lasaygues (acoustics experiments) from the LMA. The candidate will conduct the main experimental and computational part of her/his research at IRPHé by taking advantage of the developments made at LMA for the acoustics part.

In the context of this recruitment within the institute IMI (Institut de Mécanique et d'Ingénierie), he/she will also have to participate in teaching sequences which can take many forms: supervision of projects or trainees, participation in teaching projects or trainees, participation in teaching sequences at advanced levels (M2 and at advanced levels PhD), seminars to present his/her research activity of his/her research activity to a student audience, dissemination of scientific culture.

Funding

The postdoc will be funding by IMI (Institut de Mécanique et d'Ingénierie) from Aix-Marseille University

Bibliography

Padilla F. *et al.* 2014. Stimulation of bone repair with ultrasound: a review of the possible mechanic effects. *Ultrasonics*, vol. 54, no. 5, pp. 1125–1145. doi: 10.1016/j.ultras.2014.01.004

Weinbaum S. *et al.* 1994. A model for the excitation of osteocytes by mechanical loading-induced bone fluid shear stresses. *Journal of Biomechanics* 27(3): 339–360. doi.org/10.1016/0021-9290(94)90010-8