PhD position at LMI (MAGBONE project)

Coupling between a static magnetic field and bone remodeling, role of magnetic particles

Laboratory	Laboratoire de Mécanique et ses Interfaces ENSTA-Paris
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Background	Master mécanique,

The MAGBONE Project

Since 2016, our team has been developing a new surgical device: the magnetically activated mandibular distractor [1, 2, 3]. This implantable device uses the interaction between two permanent magnets. Due to the configuration of the surgery, the internal magnet, integrated into the implant, remains close to a fracture line throughout the procedure (4 to 5 months). The magnetic field produced could therefore have a direct influence on the bone remodeling process.

The objective of the project is to quantify the influence of a static magnetic field on bone cells (osteoclasts and osteoblasts) and on the bone produced (organotypic cultures). First, we will carry out cell cultures under static magnetic fields with different configurations. In particular, this will involve exploring the influence of the intensity, orientation and gradient of the magnetic field. The magnetic structures integrated into the cultures will be produced using 3D printing for optimum control of the configuration. From these systems, we will then characterize the effect of the magnetic field on the differentiation and function of osteoblasts and osteoclasts.

Then, we will explore the effect of the magnetic field on bone growth in an organotypic model using calvaria and femurs of newborn mice. The microstructure will be imaged and the mechanical properties will be characterized through various traction, bending, indentation and compression tests.

PhD description

If the influence of the magnetic field on the bone seems obvious at short distance, it seems to diminish quickly. Furthermore, as the mechanism of interaction between the field and the remodeling medium is not yet understood, it seems important to seek to extend the influence of the magnetic field over greater distances. The objective of the proposed thesis is to explore the possibility of adding magnetic particles to the biological environment in order to increase the region interacting with the magnetic field.

Initially, the doctoral student will use a 3D printing machine using Electrowriting technology newly acquired in the laboratory for the production of a scaffold for cell proliferation. In parallel, the objective will be to add magnetic particles to a 2D cellular medium in order to characterize the interaction between the field and bone cells. Finally, the objective will be to mix the two approaches to optimize the coupling between the magnetic field and the remodeling zone.

Candidate profile

The profile sought is that of a materials or structures mechanic with a very good knowledge of biological materials, or a biologist with an interest in the mechanics of materials. As experimental aspects are important to the project, the candidate will need to demonstrate a good interest in setting up such tests. The candidate will be part of the LMI's life mechanics team and will have to work in collaboration with the biologists and surgeons involved in the project. An excellent ability to work in a multidisciplinary team is important.

Location
The host site is the Mechanics and its Interfaces Laboratory (LMI) of ENSTA-Paris, located in Palaiseau on the Ecole Polytechnique campus. This site will host the design of the magnetic systems and the mechanical tests. Cell cultures will be carried out in the BIOSCAR U1132 research unit at the Lariboisière hospital (Paris 10ème).

Application
Interested candidates should contact J. Boisson (jean.boisson@ensta-paris.fr) and send a CV and covering letter.

References
[1] Boisson et al, Feasibility of magnetic activation of a maxillofacial distraction osteogenesis, design of a new device, J Craniomaxillofac Surg, 2016
[2] Strozyk et al, Distracteur à plaques et ensemble d'un tel distracteur à plaques et d'un outil d'activation, PCT/EP2016/080481 2015
[3] Kadlub et al, Mandibular magnetic distractor: preclinical validation, Br J Oral Maxillofac Surg, 2022