

Proposal for a M2 internship (spring 2025) and a PhD thesis starting in October 2025

Characterization of the mechanism of periosteal adhesion to bone, implications for bone remodeling

Laboratoire de Mécanique et ses Interfaces, ENSTA

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Context

The periosteum is a soft tissue that covers all the bones in the body. It nourishes the cortical bone, protects it from fractures, and transmits forces from tendons and ligaments. Located at the interface between bone and soft tissue, the periosteum transmits mechanical stimuli between these two environments, thereby influencing bone cell differentiation, remodeling, and healing. However, the role of periosteal adhesion in transmitting these stimuli remains poorly understood.

According to the literature, the adhesion of the periosteum to bone is ensured by transcortical collagen fibers known as Sharpey's fibers, which anchor it to the bone. However, research on this topic remains limited, and no direct observations have yet confirmed the functional role of these fibers during periosteal detachment.

Following a thesis defense scheduled for fall 2025, our team—comprising researchers from ENSTA and Necker Hospital—partially characterized the adhesion properties of porcine mandibular periosteum. Using a peeling experiment, we quantified the adhesion energy and found it to vary significantly depending on the measurement location. This study also suggests that periosteal adhesion properties play a critical role in osteogenic distraction, a surgical technique used to lengthen bone.

The work conducted to date has characterized the macroscopic properties of porcine mandibular periosteal adhesion, but only at a specific peeling speed and angle. However, the microscopic mechanisms underlying this adhesion remain unexplored.

Description of the subject

The objective of this internship—and subsequent thesis—is to thoroughly characterize the adhesion properties of the periosteum and to achieve a deeper understanding of the underlying mechanisms, particularly at the microstructural level. This will be accomplished through biomechanical experiments, primarily instrumented peeling tests to detach the periosteum from the bone.

During the internship, the student will further investigate the adhesion properties of the periosteum by conducting experiments at various peeling speeds. To assess whether adhesion occurs through discrete fibers, the effect of adhesive area size will also be explored using samples of different dimensions and aspect ratios.

In the subsequent thesis phase, the student will develop an advanced peeling device that integrates multiple motors. This device will enable precise control of the peeling angle—a critical parameter in this mechanical system—and enhance the accuracy of peeling front advancement. Additionally, this experimental development will include setting up a system to visualize the dynamics of the peeling front, using synchronized cameras paired with real-time peeling force measurements.



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Candidate profile

The ideal candidate will be a student with a high level of training in physics, mechanics, or biomechanics. A good knowledge of biological materials would be an advantage, but is by no means a prerequisite. The candidate must demonstrate an interest in setting up instrumented experimental devices, as these aspects are important to the project. The candidate will join the LMI's living mechanics team and will work in collaboration with researchers from Paris-Saclay University and surgeons from Necker Hospital involved in the project. The ability to work in a multidisciplinary team is therefore also essential.

Location

The internship and thesis will take place at the Laboratoire de Mécanique et ses Interfaces (LMI) at ENSTA in Palaiseau. This laboratory is one of three research units, along with LadHyX and LMS, that make up the Mechanics Cluster on the École Polytechnique campus.

Application

Interested candidates should contact J. Boisson (jean.boisson@ensta.fr) and send a resume and cover letter.

