Nanoscale mechanical analysis of the ligament-to-bone interface

The musculoskeletal system comprises of highly specialized interfaces often prone to injuries, with a typical example being the rupture of the cruciate ligaments in the knee [1]. Current treatments fail at restoring the original structure-function relationship and, hence, the pristine anchoring competence of the interface. A prerequisite to improve the regeneration of soft-tissue-to-bone interface is the detailed knowledge of the local mechanical behavior of the tissue to be treated. Previous studies have highlighted the highly complex and controlled composition and spatial organization across the multi-tissue insertion site; however, much less is known about the corresponding local variations in mechanical properties (see figure).

The main goal of this Master Thesis is to develop a suitable framework for the nanoscale mechanical characterization of the ligament-to-bone interface using the unique combination of nanoindentation [2] and fluorescence microscopy. The specific workflow includes: i) sample preparation (e.g., embedding, cutting and polishing), ii) selection of fluorescent dyes to target the different tissues across the interface and iii) tuning the experimental nanomechanical testing procedure (e.g., tip geometry, loading function, oscillation frequency and indentation depth). The main outcome of the Thesis will be an optimize protocol for the mechanical characterization of ligament-to-bone interface by nano indentation.

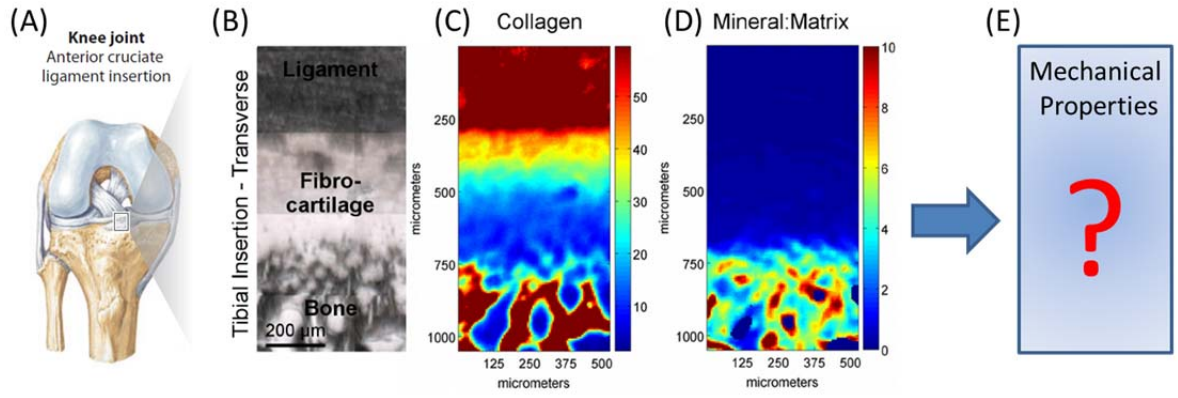

Figure: A) Anterior cruciate ligament (ACL) insertion site at the knee joint. (B) Light microscopy image of a decalcified ACL insertion and corresponding distributions of (C) collagen and (D) mineral measured with spectroscopic imaging. The resulting mechanical properties (E) are, to date, not well characterized.

MAIN TASKS

- Review the relevant literature on bone-ligament interface
- Sample preparation and selection of proper fluorescent dyes (samples will come from small animals already sacrificed and will be prepared in collaboration with students of the Faculty of Veterinary Medicine, Ulg)
- Perform image-guided nanoindentation testing
- Write a detailed report and prepare a presentation of the work performed

PRACTICAL INFORMATION

- Project type: 90% experimental, 10% data analysis
- Project location: Department of Aerospace and Mechanical Engineering; Building B52/3
- Project supervisor: Prof. Davide Ruffoni
- Required background: no previous knowledge but creativity and curiosity

REFERENCES

1. Lu, H.H. and S. Thomopoulos, *Functional Attachment of Soft Tissues to Bone: Development, Healing, and Tissue Engineering.* Annual Review of Biomedical Engineering, Vol 15, 2013. **15**: p. 201-226.
2. Ebenstein, D.M. and L.A. Pruitt, *Nanoindentation of biological materials.* Nano Today, 2006. **1**(3): p. 26-33.

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