



# Master Thesis: Refreshing Articular Cartilage Defects by Laser Ablation -Parameter Optimization and Validation

**Context:** Cartilage damage in the knee joint can be caused by aging or repetitive actions. It can be treated by surgically removing the damaged cartilage tissue and filling the generated defect with a precisely shaped, healthy cartilage graft [1]. Nowadays, removing the defected cartilage is done manually using surgical curettes or scalpels. This approach is simple and quick, but only provides limited cutting accuracy. Moreover, removing defected cartilage exactly down to subchondral bone is not possible by hand. However, regenerative grafts will only reintegrate and survive if placed in the correct layer without leaving defective cartilage behind. Thus, we are developing a system (a) leveraging robotic positioning and laser light for precise, controlled, and contactless tissue ablation [2, 3].

**Task description:** As of now, we have used Nd:YAG and Er:YAG lasers to ablate pathologic and live articular cartilage samples (**b**), with promising results regarding cell viability in live samples. However, laser parameters such as pulse frequency and energy need to be optimized towards higher cutting efficiency, all while ensuring that cells close to the cut are not being mechanically damaged or carbonized. Your task will be to prepare a setup to test various parameter sets for different lasers, to optimize them for articular cartilage ablation, and to validate them by ablating live cartilage samples and performing histological analyses to check for cell damages.



(a) The developed tissue preparation system with (1) robotic stage, (2) biological sample, (3) ablation laser, (4) camera, and (5) graphical user interface.



(b) Cartilage ablated with Nd:YAG laser (2 min, 2 Hz, 105.5 mJ).

## Work packages:

- Review the relevant literature on laser ablation of soft tissue, in particular articular cartilage.
- Define an experimental protocol for your study and prepare the laser ablation setup.
- Compare various parameter sets for different lasers on pathologic cartilage samples.
- Ablate live cartilage samples using your optimal parameters and validate with histological analyses.

## **Benefits:**

- Gain practical experience with optical setups for biomedical applications.
- Learn to work with lasers for biological tissue ablation.
- Apply histological analyses and gain experience with interpreting their results.
- Work in a highly interdisciplinary team of laser physicists, robot engineers, and biologists.

## **Requirements:**

- Solid background in biomedical engineering, physics, or a closely related field.
- Basic knowledge of optics and biology.
- Prior experience in working with optical setups is a plus, but not strictly required.

### **References:**

- M. Mumme et al. "Nasal chondrocyte-based engineered autologous cartilage tissue for repair of articular cartilage defects: an observational first-in-human trial." The Lancet, 388(10055), pp. 1985-1994, Oct. 2016. doi.org/10.1016/S0140-6736(16)31658-0 2
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- [3] L. Beltrán Bernal et al. "Laser in Bone Surgery." In: S. Stübinger et al. (eds), Lasers in Oral and Maxillofacial Surgery, pp. 99-109, Springer, Cham, Mar. 2020. doi.org/10.1007/978-3-030-29604-9\_9 Z

Student: TBD Earliest start: January 2022 Duration: 6 months

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Supervision:

Dr. Ferda Canbaz (ferda.canbaz@unibas.ch $\boxdot$ ) Cédric Duverney

**Professors:** Prof. Dr. Georg Rauter Prof. Dr. Andrea Barbero