University of Basel
Department of Biomedical Engineering

BIROMED-Lab
Medical Robotics and Mechatronics

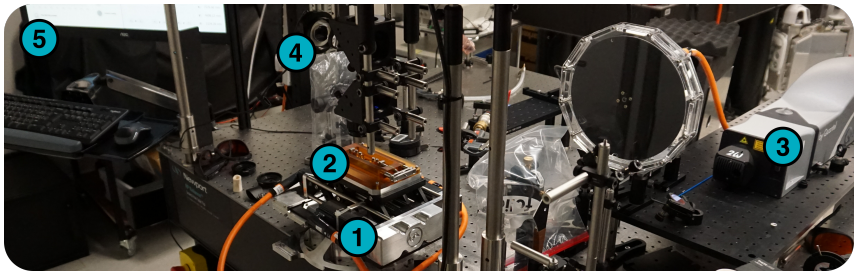
BLOG
Smart Laser Osteotome

Departement Biomedizin Basel

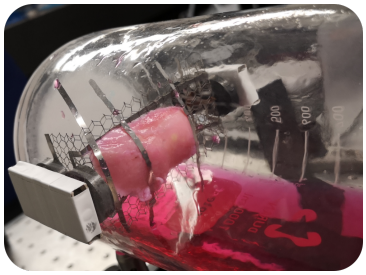
Master Thesis:
Design, Implementation, and Evaluation of a Sterile Workflow for Robot-Assisted Laser Ablation of Cartilage Tissue

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: A workflow and container (**b**) for sterile laser ablation of tissue has been designed and validated [2]. However, several limitations related to sample handling and fixation, ease of use, and robustness have been identified in the current design. Your task will be to design and manufacture a new sterile ablation container addressing these issues, to adapt the overall sterile ablation workflow towards higher intuitiveness and usability especially for novice users, and to validate your design in a sterile laser ablation experiment.



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



(b) A cartilage sample fixed in the current sterile ablation container.

Work packages:

- Review the relevant literature on sterile laser ablation of soft tissue.
- Detail requirements for sterile workflow and container based on application and insights from past experiments.
- Define an optimized sterile ablation workflow.
- Design and manufacture your new sterile ablation container.
- Perform laser ablation of live cartilage tissue with your workflow and validate process sterility.

Benefits:

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

Requirements:

- Solid background in biomedical or mechanical engineering or a closely related field.
- Basic knowledge of mechanics, materials, and physics.
- Prior experience with mechanical design is a plus, but not strictly required.

References:

[1] 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] C. Duverney et al. "Sterile Tissue Ablation Using Laser Light - System Design, Experimental Validation, and Outlook on Clinical Applicability." *J. Med. Devices*, 15(1), pp. 11104/1-11104/12, Mar. 2021. doi.org/10.1115/1.4049396

[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

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

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