



University
of Basel

Department of
Biomedical Engineering



A MIRACLE for Shaping the Future of Surgery

The University of Basel's MIRACLE^{II} flagship project is developing a unique, novel system for minimally invasive robotic bone surgery. This system combines robotics, artificial intelligence (AI), virtual and augmented reality, laser cutting, and 3D printing to benefit patients. The project showcases the latest AI-driven implant designs for on-site 3D printing and robot-guided laser bone surgery, both of which were developed by the MIRACLE^{II} project at the University of Basel.

The MIRACLE^{II} system is a modular system that combines robots, AI, VR, lasers and 3D printers for minimally invasive bone cutting. This makes planning faster and easier, enhances surgical precision and allows for functional cuts and implant integration. It also speeds up implant design and production, reduces collateral damage, minimizes the need for additional operations and subsequently costs, and shortens rehabilitation time. The system comprises four modules, two of which will be presented at the Swiss Pavilion: VR planning and implant design; patient-specific implant production; robotic guidance; and laser cutting and monitoring. These modules can be combined according to the requirements of a specific patient.

At the centre of the display is a knee phantom representing the knee's anatomy and surgical site for our research. Inside the knee phantom, but still visible to the audience, is our miniature robot, equipped with a laser pointer for demonstration purposes. This setup enables visitors to grasp how the robot would function during genuine cartilage and bone surgeries. The robot is made from titanium and aluminium.

In addition, a pre- and postoperative skull including a 3D-printed Polyetheretherketone (PEEK) implant will be presented. Recent advances in medical imaging, computer-assisted virtual surgical planning and 3D printing have the potential to transform how surgeons use patient information to provide personalised treatment. PEEK is a high-performance thermoplastic polymer that is mainly used in reconstructive surgeries as a reliable alternative to other materials applied for customised implants.

Last but not least, visitors will have the opportunity to use a VR headset to observe the first patient to receive a 3D-printed implant in Switzerland in 2023, as well as to see how implants are planned and designed in virtual reality.

In order to make laser bone surgery minimally invasive, new solutions must be developed for all four of these technologies and they must be integrated into one modular system. This is obviously a bold endeavour, which is why we see ourselves as the Mars Mission in the field of medical robotics research.

Press kit: <https://dbe.unibas.ch/en/public/events/expo-2025-osaka/>