DEPARTMENT FOR BIOMEDICAL RESEARCH
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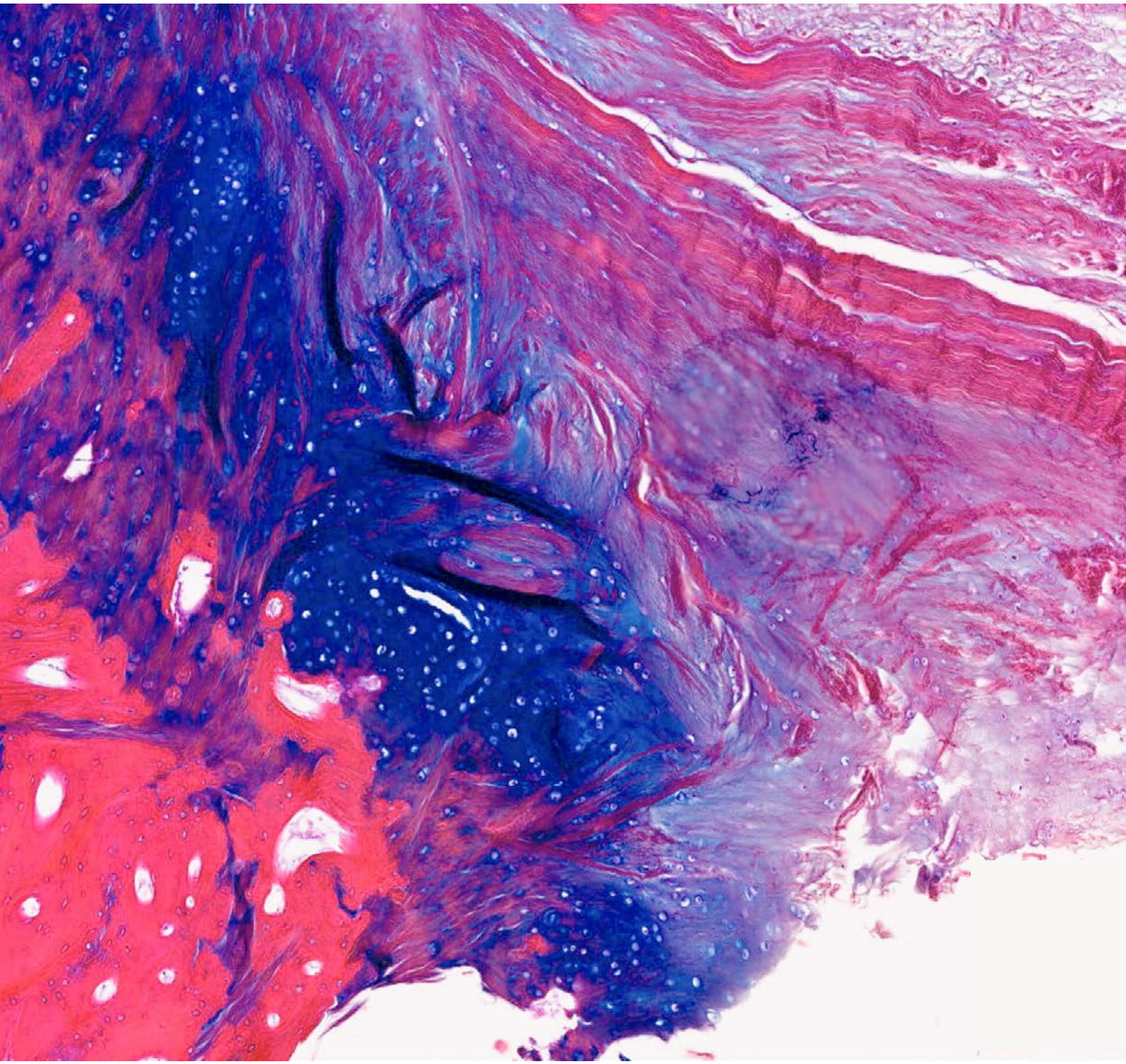
Annual Report
2025



Bone & Joint (BNJ)

Participating Labs

- **Gantenbein Lab**
  Tissue Engineering for Orthopaedics & Mechanobiology (TOM)
- **Saulacic Lab**
  Cranio-Maxillofacial Research

Program Contact

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Selected Collaborators

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The skeletal system is subject to traumatic conditions (fractures and large bone defects) and pathologies due to degeneration (osteoporosis, osteoarthritis, and intervertebral disc degeneration. The demand for improved and efficient treatments is increasing as the population of older adults grows and wants to stay physically active. However, surgical procedures for repairing large bone defects or degenerated spinal discs still require significant improvement. The regeneration of skeletal tissues is the focus of the Bone & Joint Research Program. To this aim, strategies based on cells, materials, and growth factors are currently employed, ex vivo (2D/3D cell cultures and bioreactors) and *in vivo*. Translational orthopaedic research, which has been a long tradition in Bern, requires interactions between surgeons and scientists. The Bone & Joint Research Program will continue to extend this tradition and provide clinicians with tools to improve patient treatment.

Research Highlights 2025 / Outlook 2026

The TOM Lab successfully completed a recent Marie Skłodowska-Curie training Network Project "disc4all". Within this consortium, the group published several articles, including work on previously neglected cell population, the chondrocytes of the cartilaginous endplates. The group presented novel mechanobiological data on these cells under cyclic compressive loading and in organ explant culture.

Furthermore, the group positioned itself at the forefront of advancing spine research toward improved spinal fusion by investigating biologics to identify effective strategies for enhancing ossification in elderly patients. This research has been awarded in 2025 a SNSF Spark project under the leadership of PD Dr. Sonja Häckel. The research will elaborate on mixtures of bone morphogenic protein 2 (BMP2) combined with L51P, a BMP2 analogue that blocks multiple inhibitors of the BMP pathway. Recent in vitro studies indicate promising results in combination with an EP4 agonist, KMN-159, which acts synergistically with L51P. Even stronger ossification was observed in annulus fibrosus cells, suggesting the possibility of directing fibrous annulus fibrosus cells toward an osteoblastic phenotype.

Research on intervertebral disc (IVD) regeneration using silk and hydrogel materials has been initiated within a SNF weave agency project, in partnership with Dr. Michael Wöltje from the Technical University (TU) of Dresden (Germany). In this project, a biomimetic hydrogel composed of of hyaluronic acid and collagen type 2 is combined with silk fibres to improve cell delivery systems for the IVD. The translational application of stem cell technology to sort a seldom population of progenitor cells from the IVD is the focus of the SNF Bridge Discovery project "SORTHODISK". This interdisciplinary project integrates stem cell technology with novel non-fluorescent cell sorting methods. In this model, human donor IVDs obtained from spine surgery are used, and bovine IVDs from one-year-old cattle serve as an experimental

model. The project aims to advance sorting methods while improving knowledge of the culture conditions and transcriptomic profile of these autochthonous progenitor cells. Extracellular vesicles (EVs) may represent a promising future avenue for regenerative clues.

Titanium remains the standard material for osteosynthesis plates and screws. 3D-printed titanium implants with trabecular structures are designed to mimic the natural porosity of cancellous bone, providing a scaffold that supports vascularization and new bone ingrowth. The group findings indicate that trabecular structures functionalized with growth factors provide a favorable scaffold for bone integration. Uptake and release kinetic studies of BMP-2 showed a burst release following adsorption on calcium phosphate, whereas co-precipitation and simple adsorption resulted in a less pronounced early release of BMP-2. Functional assays demonstrated that BMP-2 containing coatings significantly enhanced cellular ALP activity across all surface morphologies. Incorporation of growth factors into 3D structure of the calcium phosphate proved to be a suitable strategy, while methods such as co-precipitation offered enhanced coating stability.

There is a strong incentive to develop new internal bone fixation systems that are mechanically stable yet degradable following complete bone healing. An SNF Sinergia project in collaboration with the Swiss Federal Institute of Technology (ETH) in Zurich, the University of Zurich, and the University Hospital Bern has advanced the development of a magnesium-based degradable osteosynthesis system composed of crystalline magnesium alloys. The material consists of ultra-high-purity magnesium, calcium, and zinc and avoids the use of rare-earth elements. Significant improvements have been achieved through the implementation of coating systems (e.g., PEO – plasma electrolytic oxidation; PCL – polycaprolactone). Previous models (calvarial and zygomatic arch defect models, as well as a mandibular fracture model) demonstrated comparable fracture consolidation at the magnesium osteosynthesis site compared with titanium.

Selected Publications

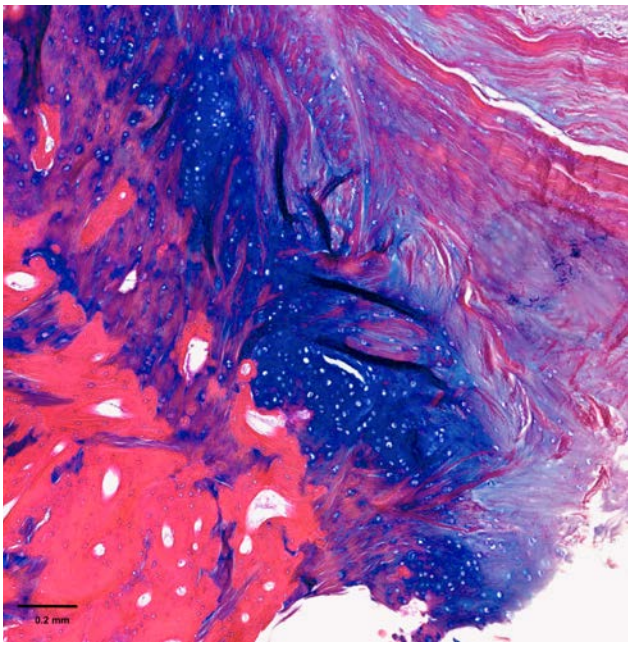
Chen S, et al. Therapeutic Approaches for Enhancing Spinal Fusion in Low Back Pain: A Review With a Focus on the Elderly. *JOR Spine.* 2025;8(4):e70136. PMID:41235064. 10.1002/jsp2.70136 [Epub 2025/11/14]

Crump KB, et al. TNF induces catabolism in human cartilaginous endplate cells in 3D agarose culture under dynamic compression. *Sci Rep.* 2025;15(1):15849. PMID:40328789. 10.1038/s41598-025-00538-w [Epub 2025/05/07]

Fujioka-Kobayashi M, et al. Combined use of deproteinized bovine bone mineral and alpha-tricalcium phosphate using gelatin carriers. *BMC Oral Health.* 2025;25(1):275. PMID:39984888. 10.1186/s12903-025-05644-9 [Epub 2025/02/22]

Lang KN, et al. Bi-Layered Biphasic Calcium Phosphate Bone Substitute to Improve Bone Formation in Lateral Jaw Defects Applying the Principle of Guided Bone Regeneration (GBR)-A Pre-Clinical Randomized Controlled Study. *Clin Oral Implants Res.* 2025;36(9):1115-1125. PMID:40474362. 10.1111/clr.14460 [Epub 2025/06/06]

Stirnimann A, et al. Advancing Intervertebral Disc Biology via Omics: Implications for Nucleus Pulposus Progenitor Cell-Based Regeneration. *JOR Spine.* 2025;8(4):e70130. PMID:41112064. 10.1002/jsp2.70130 [Epub 2025/10/20]



Enthesis tissue explants stained with Alican blue and Orange G (Rochester University protocol), digitized using an automatic slide scanner (NanoZoomer, Hamamatsu, Japan). Magnification: x20, zoomed. Scalebar: 0.2mm.