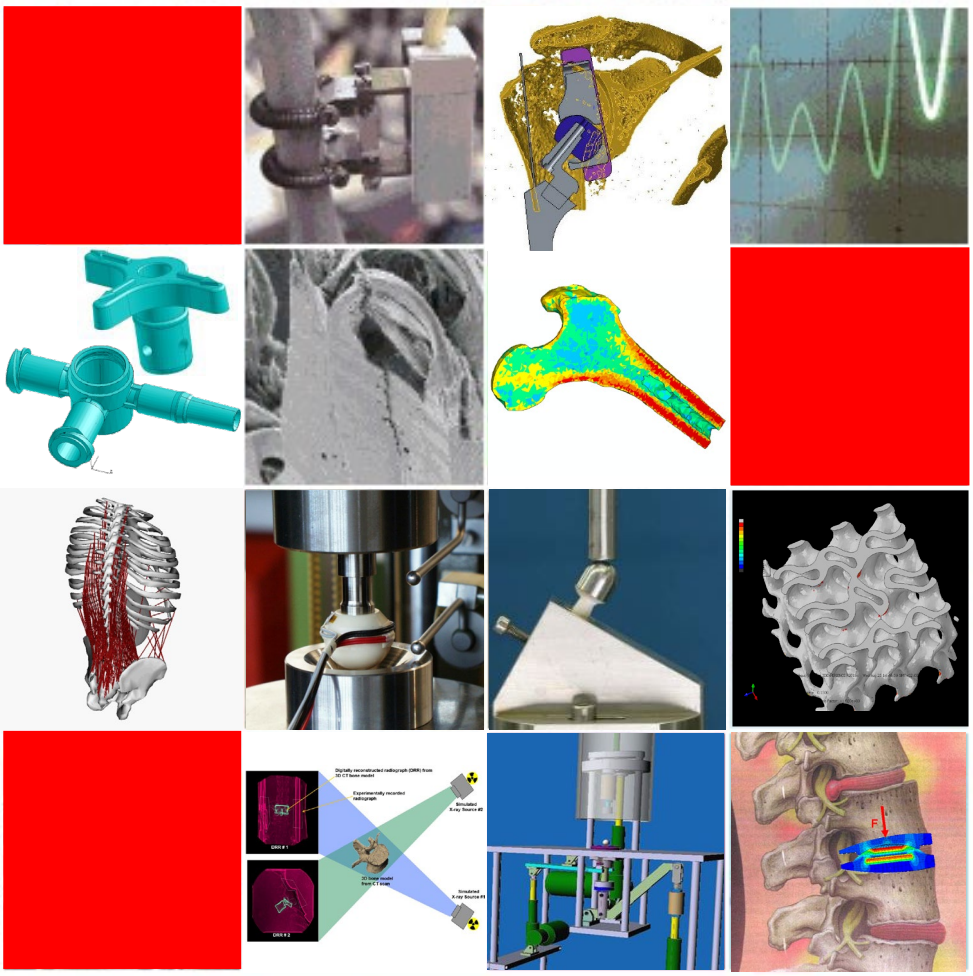
Empa

Materials Science and Technology

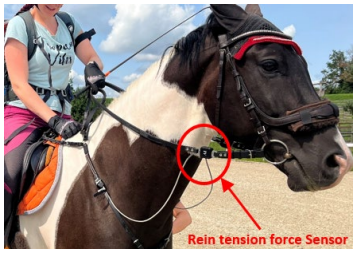
Biomedical Engineering



Research & Development activities of the Laboratory for *Mechanical Systems Engineering*

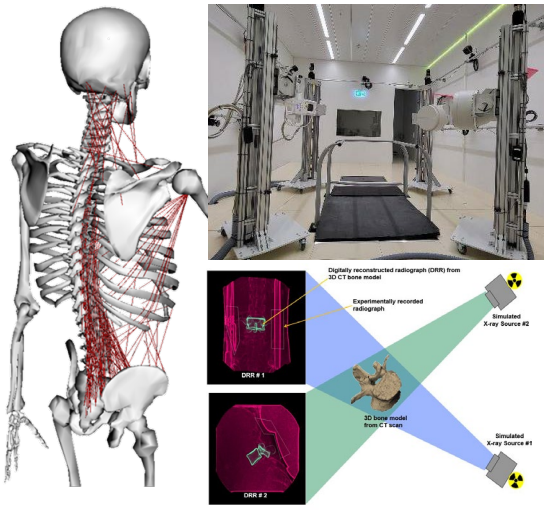
10-2024

- **Measurement of service loads** on sport goods (e.g. bicycles, skis, kickboards, reins) or rehabilitation accessories (e.g. crutch, wheel chair)



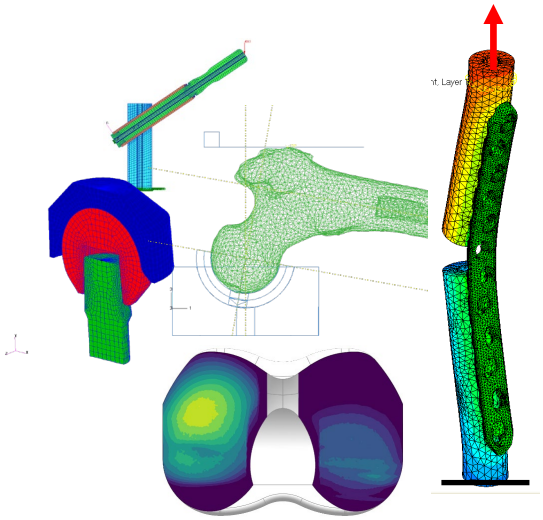
- **Dynamic X-ray Imaging** and **Rigid body simulation**

In 2023 the Lab funded the **Dynamic Imaging Center** (sited at *Sitem-Insel* in Bern in collaboration with *Inselspital*) with equipment capturing 3D in vivo kinematics. The equipment includes a Dynamic biplane X-ray imaging (DBRI) system, 16 camera motion capture system, split-belt treadmill / force plates, and 16-channel muscle EMG system. The data can be used to predict muscle and reaction forces in the body for a given movement using Rigid body simulation (OpenSim®).



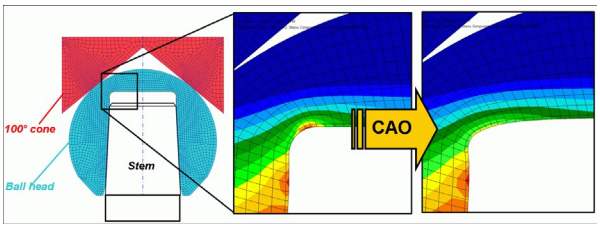
- **Finite Element analysis** (FEA) of trauma implants, instruments, joint replacements, dental implants, bones and soft tissues.

Geometrical (contact with friction) and material non-linearities can be considered. The results of the FEA (Abaqus®) are stress and strain distributions, deformations and contact forces. Furthermore, wear simulations using a customized algorithm can be performed.

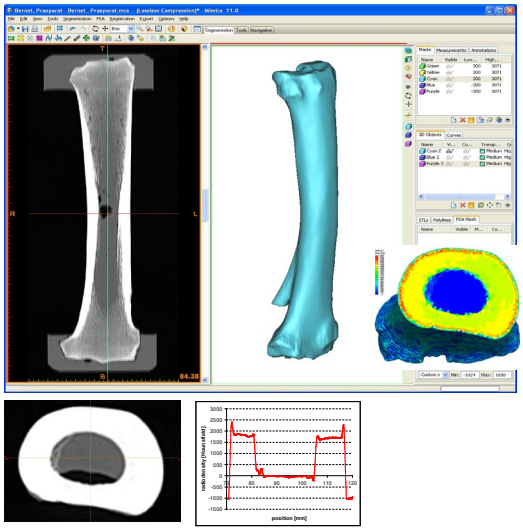


- **Topology and shape optimisation** of medical devices.

The figure shows the optimized shape of the chamfer between the conical bore and the bottom of the bore hole of a hip joint ball head (CAO by Mattheck).



- **3D-Modeling** based on Computed Tomography (CT) scan of bones.



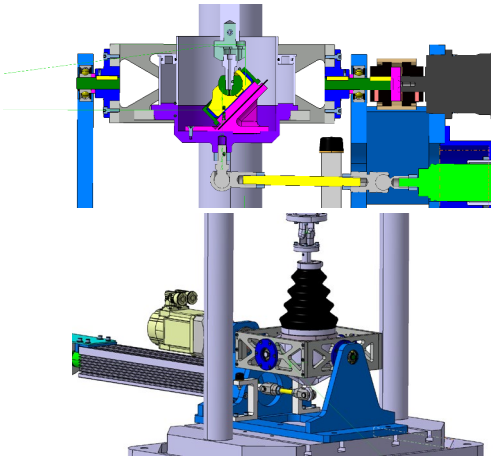
The upper figure shows the lateral image of a long bone (equine radius) and the surface model of the bone based on gray values for bone material density. The lower figures show a CT scan slice - diaphysis (1), the corresponding density profile measured along a path from the left to the right (2) and a longitudinal section of the FE model using Young's modulus distribution derivated from the density profile (3). Software: Mimics® Base, Analysis, Anatomical Reverse Engineering, Design, FEA Modul.

- **Static, creep, wear and fatigue tests** as well as durability tests using variable load levels. The laboratory performs these tests with up to 4 channels simultaneously.

The Laboratory has long time experience in performing mechanical experiments on structures using force, displacement and strain measurement sensors (strain gage or contact-free like laser or video extensometer). Implants may be tested in physiological solution at 37°C in order to simulate real in vivo conditions.

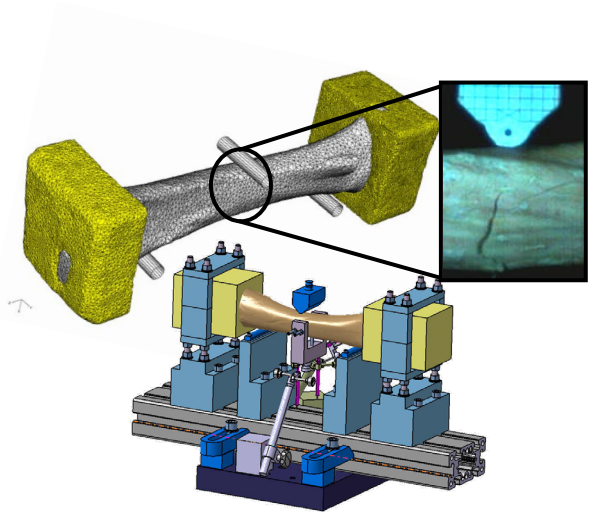
The laboratory is accredited in accordance with SN EN ISO/IEC 17025:2005 Mechanical testing of metallic materials, structural components and constructions / medical components – implants (STS0053 , type C). All used test machines and devices are categorized in precision class 1.

- **Test simulators** are developed to allow specific loadings and motions according to customer specifications (e. g. 4 degrees-of-freedom wear simulator). A Design/Workshop Group at Empa provides support in CAD and manufacturing.



► **Tests with special requirements.** The laboratory possesses test facilities for impact characterisation with optional recording possibility by high-speed video camera and subsequent video tracking.

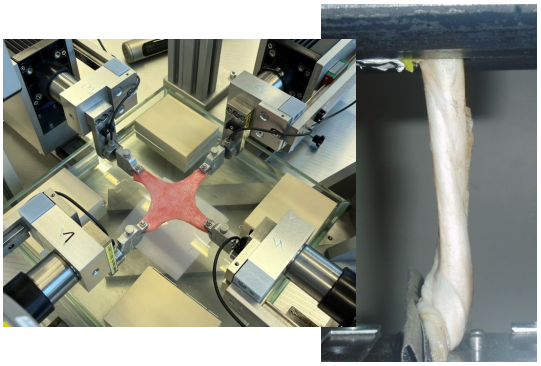
The figures show a high-speed video image of the crack propagation in a long bone which was loaded by an impactor and a 3 point-bending test setup used for bone charaterization.



► **Mechanical properties of soft tissues**

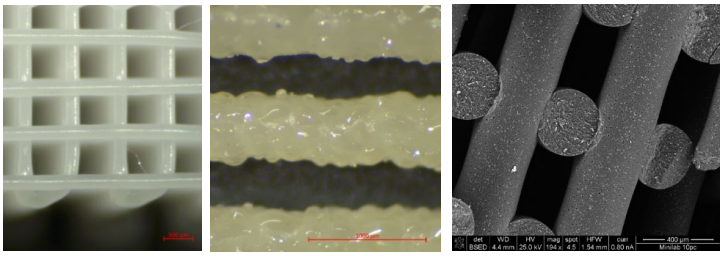
The left figure shows the biaxial testing of soft tissues in order to determine the hyperelastic material properties. Different grip systems allow to fix also soft tissues like urinary bladder, cornea, cell membranes or scaffolds.

The right figure shows a tension test on a sheep calcaneus tendon. The grips were optimized to assure the muscular side fixation.



► **3D-printed Bone scaffolds**

Development and fabrication of polymer-based bone scaffolds with different concentration of bioactive particles (using 3D Bioplotter)



The **Laboratory for Mechanical Systems Engineering** is perfoming contract assignments and Research & Development collaborations with medical technology companies, academic institutions or foundations.

Should you have any further questions or wish to have quotation for services or proposals for R&D collaborations, please do not hesitate to contact us.

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