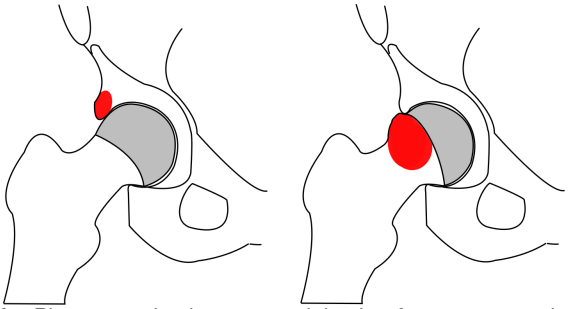
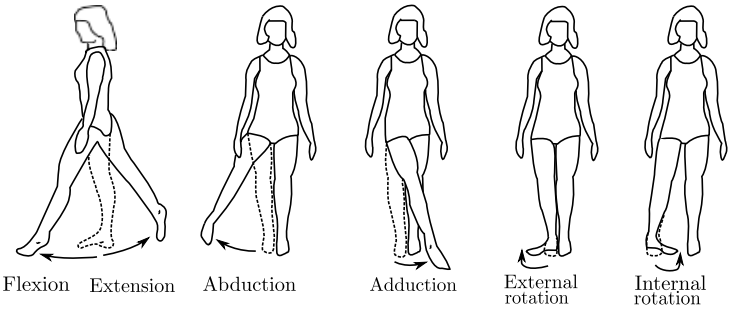
Femoroacetabular Impingement (FAI) /Range of Motion (ROM) analysis

It is widely accepted nowadays that FAI is one of the most common cause of osteoarthritis in hip joints. FAI denotes contact of the femoral head and the acetabular rim resulting in unnatural stresses that cause pain. One indicator for FAI is the reduced range of motion during flexion, abduction and internal rotation. To develop an optimal surgery that recovers the full ROM, the surgeon therefore needs a tool to predict the effect of an intervention on the joint dynamics.



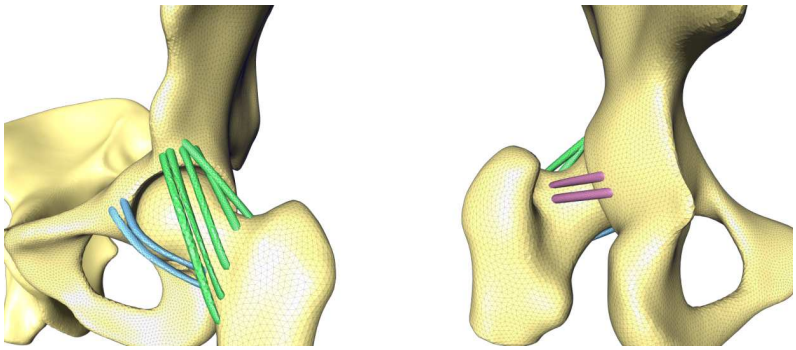
Left: *Pincer-type impingement* originating from an excessively deep acetabulum. Right: *Cam-type impingement* caused by a diminished femoral neck offset.



The range of motion can be quantified by measuring the maximal deflection angles of the six motions illustrated in the picture.

Heterogeneous Finite Element Model

For virtual testing we use a heterogeneous finite element model consisting of bones and ligaments.

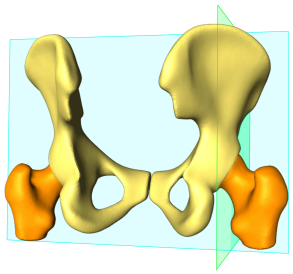


The geometric model comprises the pelvis, femur and the major iliofemoral, pubofemoral and ischiofemoral.

Features:

- Bones as geom. exact St.Venant–Kirchhoff
- Ligaments as Cosserat rods
- Dynamic large deformation contact.
- Heterogeneous coupling of bones and ligament.
- Fast multigrid solvers.

Virtual ROM analysis



- Identify rotational centre and planes of motion.
- Evolve the FE model with rotational Neumann forces.
- Evaluate impingement zones.

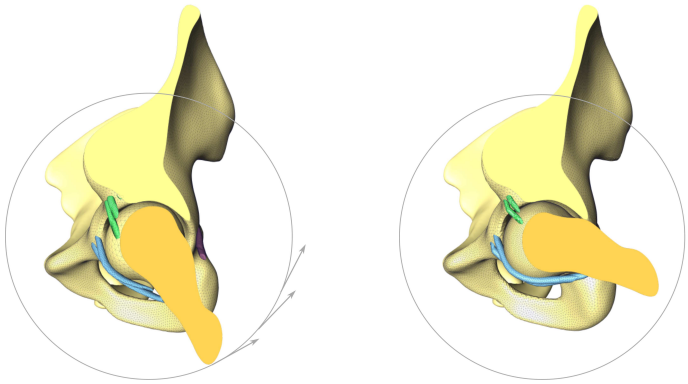
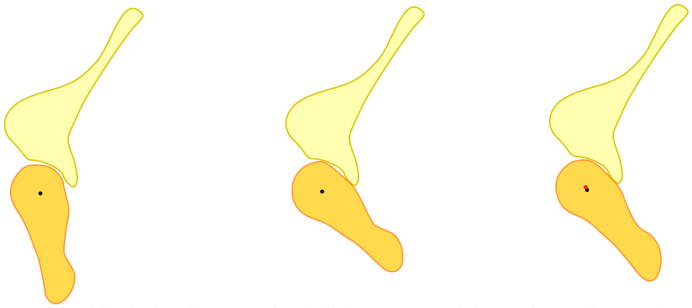


Illustration of the rotational Neumann boundary conditions and the extended position in the sagittal plane.

Comparison of the FE model to state-of-art approaches

Practically all avaiable tools for FAI analysis assume that the hip joint is a perfect ball and socket joint with fixed rotational centre. Hence the ROM analysis is performed by rigid body rotation until collision is detected. In a first experiment we compare our “flexbile centre” approach to this method and observe a displacement of the centre about 2mm during extension.



Range of motion analysis in the sagittal plane. The black dot denotes the initial centre and the red one the moving centre of femoral head. From left to right: a) Initial position. b) Extension position with fixed rotational centre. c) Extension position for flexible centre.