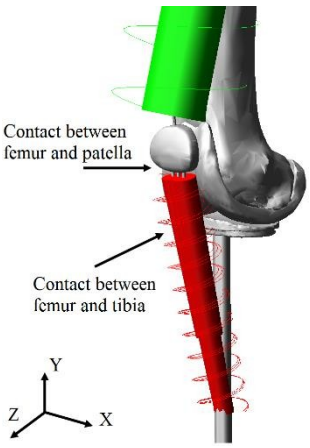
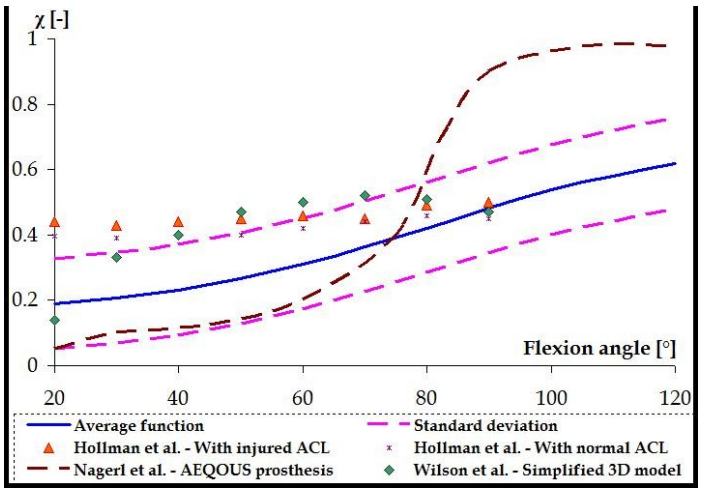
Analysis of local kinematical features (slide-roll) of the human knee joint by means of multi-body modelling

In the case of normal flexion or extension of the human knee joint the local kinematics of the tibiofemoral joint can be characterized as partial rolling and sliding. This particular movement is under the control of the connecting femoral-tibial surfaces and the connecting ligaments. The precise ratio of the slide-roll phenomenon throughout the active functional arc of the knee is currently unknown, although it is commonly accepted by the early works of Zuppinger and Braune that up to 20-30˚ of flexion angle rolling is dominant, while beyond these angles the roles invert, and sliding becomes prevailing.



By summarizing the findings of the experimental and mathematical (numerical) literature, in case of experimental testing of prosthesis materials the slide-roll ratios are widely applied between 0.3-0.46 (0 means pure roll and 1 means pure slide) but only in the range of 0 to 30º flexion angle due to the firm belief that in the beginning of the motion, rolling is dominant. At higher flexion angles, presumably, the slide-roll ratio changes significantly, but the results related to the slide-roll ratio above 30º of flexion angle are rather limited.



The ratio has been determined by means of a complex multi-body system, built and simulated, by the MSC.ADAMS. The slide-roll ratio curves has been introduced in the active functional arc of the knee in case of several commercial- and one prototype prostheses. By these curves it becomes possible to estimate the applicable sliding-rolling ratio with respect to the flexion angle.

According to the authors in this special field, higher slide-roll ratio generates higher wear rate as well, thus depending on the testing angle, a proper ratio has to be applied during tribological tests. Up to 50˚ of flexion angle 0.3-0.46 slide-roll ratio is adequate as it was presented by earlier authors, above this specific angle the currently determined slide-roll ratios are more precedent since at 120˚ of flexion angle the ratio can easily reach 0.7.

As further aims, the complete soft-tissue system will be generated around the existing system to evaluate the effect of the extra connecting ligaments on the slide-roll ratio, and the dependency on the coefficient of friction must also be determined.

Selected publications on the topic:

- I. Bíró, **G. Fekete**: Approximate method for determining axis of finite rotation of human knee joint. *Acta Polytechnica Hungarica*. Accepted, 2014. IF (2013): 0.471
- **G. Fekete**, B. M. Csizmadia, M. A. Wahab, P. De Baets, G. Katona, L. V. Vanegas-Useche, J. A. Solanilla: Sliding-rolling ratio during deep squat with regard to different knee prostheses. *Acta Polytechnica Hungarica*, 9 (5), pp. 5-24, 2012. IF (2012): 0.588
- **G. Fekete**, B. M. Csizmadia, P. De Baets, M. A. Wahab: Multibody dynamic models in biomechanics: Modelling issues and a new model. *Sustainable Construction and Design*, 3 (2), pp. 128-137, 2012.