

QUALIFICATION METHODS ON SPECIFIC STRUCTURES: KNEE PROSTHESES

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1. Introduction

Biomechanics is relatively new, multidisciplinary field that describes the mechanism of living systems based on biological and mechanical principals. The Biomechanical Research Team of the Szent István University has been carrying on a comprehensive study about the most complex joint of the human body, the knee. Regarding to their research they designed and built an experimental test rig [1].

In order to deal with the upcoming deformity due to incurable arthritis, total knee replacement (TKR) surgeries became absolute necessity. Before the actual implantation, the currently designed prostheses have to be qualified. Most of the prostheses found in the literature are abrasion-resistant [2]. These prostheses are qualified relating to the tribological issues but not the kinematics. These current prostheses are optimized against wear but due to the lack of proper kinematic design they are not able to reproduce the original movements of the knee [3]. According to our hypothesis, the movement of the knee is described only by the geometry of the condyles, while the ligaments and tendons have the role of a certain restrain. Some researchers design prostheses that are optimized for geometry [4], and for the qualification of these prostheses an experimental test rig has been created.

The Biomechanical Research Team used a cadaver knee for their experiments as the most accurate model to determine the movement of the human knee [5]. By the experimental results Prof. MD. Gábor Krakovits patented a new type of prosthesis and as follows a need to compare the movement of the newly developed prosthesis to cadaver models arose.

Beside the prototype, we would like to qualify several commercial prostheses types from the available manufacturers.

The aim of our research is to create an experimental test rig which is suitable to handle both cadaver experiments and prostheses qualification tests with equal ease.

The knee movement can be described by three parameters: flexion, rotation (about the tibia) and abduction (lateral displacement).

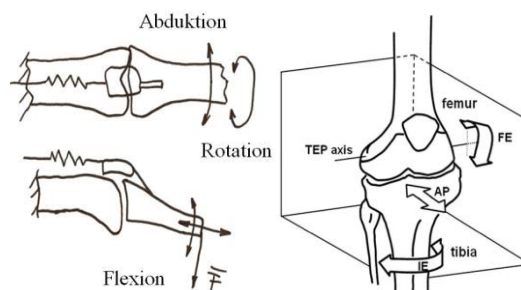


Fig. 1: Movement types of the knee

A suitable prosthesis is able to carry out approximately similar movement what is measured on a cadaver knee.

The test rig was designed to control only one force that constrains the knee to move by taking into account the comments of Prof. MD. Gábor Krakovits: “the kinematics of the prosthesis is constrained by its surface”. The rest of the motion – due to the construction of the rig – is unconstrained and the flexion is carried out by a stepper motor.

2. Experimental Results



Fig. 2: Test rig prepared for measurement

The complete test set up is shown on Figure 2. The rig includes two major parts: the prosthesis verifier part and the prosthesis moving part which is actually the stepper motor. The stepper motor assures the appropriate accuracy of the repetition during the tests. The structure is symmetric with guiding rails on both sides. The rotation measuring shaft is rigidly connected to the tibial component of the prosthesis which is the model of the actual bender. The measuring shaft is connected to the rig by a linear bearing system thus this shaft is allowed to move freely compared to the test rig. The rig is able to measure up to 120° of flexion angle, but due to anatomical reasons the qualification is only carried out up to 60°.

During the test, the rotation is measured as a function of the flexion angle. In addition, the force in the quadriceps model needed to carry out flexion movement is also registered. In order to validate the results compared to the cadaver measurements (see Figure 5), the same coordinate system has to be used as a basis for the experiments.

A setback device was designed and produced (see Figure 3 and 4), which makes the calibration possible without an actual prosthesis. The settings of the angles have to be repeated until the device shows zero in case of every rotation.



Fig. 3: Setback of the rig, calibration of „zero flexion to zero rotation” state

After the calibration the universal fixtures were placed into the rig shown on Figure 4, and they were adjusted likewise the prosthesis model. By doing so, the original zero position is ensured. Results of several prostheses alongside with the cadaver results are shown on Figure 5.

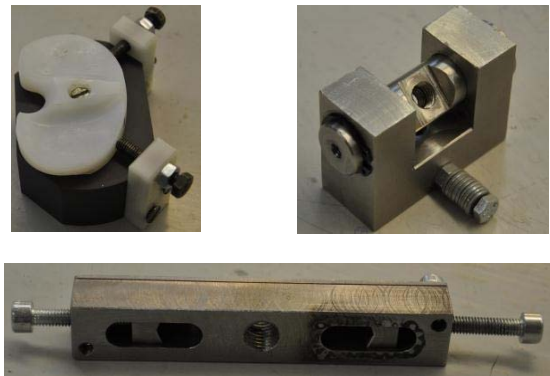


Fig. 4: Universal tibial (left leg) and femoral (left leg) fixtures with zero-position instrument

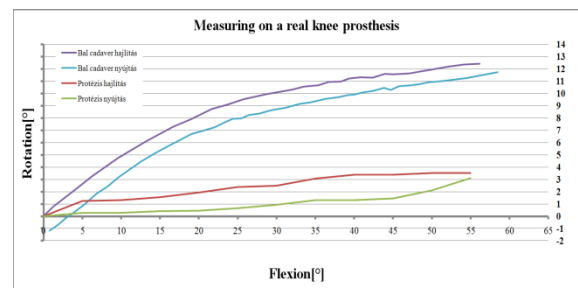


Fig. 5: Comparison of cadaver and commercial prostheses results related to rotation-flexion function

3. References

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