INTRODUCTION:
The posterior inclination of the tibial component is an important factor that can affect the success of total knee arthroplasty. It can reduce the posterior impingement and thus increase the range of flexion, but it may also induce instability in flexion [1], anterior impingement between the polyethylene post of postero-stabilizing knee prosthesis, and anterior conflict with the cortical bone and the stem. Although the problem is identified, there is still a debate on the ideal inclination angle, but also the surgical technique to avoid an excessive posterior inclination.

The effect of the posterior inclination has been estimated clinically, on cadaver models, and with finite element models. However, to analyze the biomechanics of the knee after total knee arthroplasty, most cadaver or computer models use either passive movements, constant forces, or fixed predetermined loading, which may not consider the patellar force.

Therefore, the aim of this study was to predict the effect of a posterior inclination of the tibial component on the contact pattern on the tibial insert, using a numerical musculoskeletal model of the knee joint.

METHODS:
A 3D finite element model of the knee joint was developed to simulate an active and loaded squat movement after total knee arthroplasty (Fig. 1). The geometry of the tibia, femur and patella were reconstructed from CT data of a cadaver leg. The tibial, femoral and patellar components of a mobile ultra-congruent knee prosthesis (FIRST, Symbios, Switzerland) were positioned in the reconstructed bones according to manufacturer recommendations. This prosthesis had congruent tibio-femoral surfaces from 0 to 90 degrees of flexion, and a less congruent radius of the femoral component thereafter. The prosthesis had also a posterior stabilizing system from 90 degrees of flexion, and thus the anterior and posterior cruciate ligaments were not retained. An active (quasi-static) squat movement was performed in the sagittal plane, starting from full extension to 90 degrees of flexion. Flexion was actively controlled by the quadriceps muscle, which balanced the bodyweight. The quadriceps was divided in 4 parts: rectus femoris, vastus intermedius, vastus lateralis and vastus medialis. The insertion and direction of each muscle were estimated from bony landmarks on the reconstructed bones. Muscle activations were estimated from EMG data and were synchronized by a feedback algorithm. Frictionless contacts were considered at the tibio-femoral and patello-femoral articulart surfaces. Half of the bodyweight (BW = 800 N) was applied on the humeral head center. The polyethylene tibial insert was elastic, while metal parts, as bones, were rigid. The patella ligament was characterized by a nonlinear deformation law [2]. Two inclinations of the tibial tray were considered: 0° (no inclination) and a posterior inclination of 10°. During the entire range of flexion, the following quantities were calculated: the tibio-femoral and patello-femoral contact forces, and the contact pattern on polyethylene insert. The antero-posterior displacement of the contact pattern was also measured, zero corresponding to a perfect centering of the contact pattern in tibial insert. Abaqus 6.7 was used for all analyses.

RESULTS:
The tibio-femoral and patello-femoral contact forces increased during flexion and reached respectively 4 and 7 BW at 90° of flexion. They were slightly affected by the inclination of the tibial tray. Without posterior inclination, the contact pattern on the tibial insert remained centered (Fig 2). The contact pressure was lower than 5 MPa below 60° of flexion, but exceeded 20 MPa at 90° of flexion. The posterior inclination displaced the contact point posteriorly by 2 to 4 mm (Fig. 3).

DISCUSSION:
The inclination of the tibial tray displaced the contact pattern towards the posterior border of the tibial insert. However, event for 10° of inclination, the contact center remained far from the posterior border (12 mm). There was thus no instability predicted for this movement. The method used here provided an implicit estimation of the joint forces and articular contact pattern, which were in good agreement with the literature [3-5]. For this analysis, motion was restricted to 90° of flexion in the sagittal plane, which is however a reasonable estimate of a chair-rising activity.

REFERENCES: