# Effect of UHMWPE Patellar Component Thickness on Quadriceps Tendon Force Following Total Knee Arthroplasty

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**Statement of Purpose:** Anterior knee pain and patellar fracture are significant complications following total knee arthroplasty (TKA) surgery. The inability to freely flex/extend the knee has a critical influence on patients' daily activities, including walking, lifting, rising from chair, etc., which is one of the most common mechanical indications for TKA revisions. A Patellar component with poor sizing in TKA surgery may cause post-operative complications, including excessive quadriceps tendon force, patellofemoral joint reaction force, and joint pain in TKA patients during knee joint motion. Hence, the objective of the current study was to quantitatively evaluate the effect of patellar button thickness on the variation of the quadriceps tendon force (TF) during knee joint flexion/extension in gait cycle using computational TKA analyses.

**Methods:** The basic 3D finite element model was developed through MRI reconstruction of an average-sized cadaveric lower extremity (81 years old, female, height 167cm, weight 63kg) from the LHDL database [1], to represent the realistic anatomical components of the human knee joint (Fig.1). The femur, tibia, and patella were resected following the specific surgical procedures for the Stryker Triathlon TKA device (Stryker Corp., Kalamazoo, MI), which was inserted into the natural knee model and aligned using HyperMesh (v10.0, Altair Eng. Inc., Troy, MI). Material properties of Co-Cr, Ti alloy and UHMWPE were used for the femoral, tibial component and tibial insert, respectively. Muscular and ligamentous structures were modeled as isotropic hyperelastic materials quantified by experimental material testing data [2], to simulate the non-linear mechanical behavior.

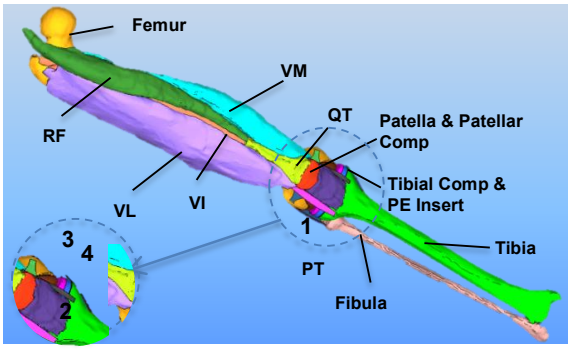


*Fig.1 3D FE model of the articular knee joint (1: LCL/MCL; 2: Retinaculum; 3: MPFL/LPFL; 4: Femoral Component)*

Kinematic data from the same TKA device was obtained during a force-controlled ISO 14243-1 experimental gait simulation test using the Instron-Stanmore knee simulator (Intron Corp., Canton, MA). A motion tracking system was concurrently used to define the displacement boundary conditions for femur and tibia during knee flexion/extension, to initialize quadriceps tendon elongation and patellar tracking.

Moreover, using the geometrical morphing function in HyperMesh, two additional patellar buttons with various thickness (±2mm) were created, thus generating 3 FE models in total for further evaluation. The quasi-static FE analyses were then conducted using Abaqus/Explicit (v6.10ef1, Simulia Corp., Providence, RI). The TF magnitude in each case was converted and calculated through its internal force.

**Results:** Von-Mises stress distribution was obtained throughout the volume of the quadriceps tendon during the knee flexion/extension of full gait cycle. In all 3 cases, the peak stress occurred at 65% of the gait cycle when femur reached a maximum flexion angle (60°), specifically at the anterior attachment site between the quadriceps tendon and the patella. All three cases presented similar curves for the TF variation (Fig.2), especially within the stance phase. However, compared with the peak TF value in swing phase obtained from the case with original patellar button thickness (403.6 N), both models with altered thickness levels showed higher TF magnitudes (547.9 N and 583.5 N). Specifically, the thinner patella case revealed highest TF magnitude among the three (583.5N).

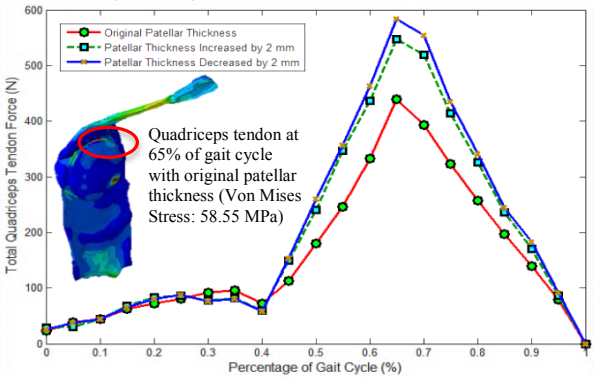


*Fig.2 The variation of quadriceps tendon force during the gait cycle*

**Conclusions:** Patellar component thickness has a significant effect on the quadriceps tendon force within the swing phase of gait cycle. A thicker patella after TKA surgery may tighten the quadriceps tendon, while a thinner patella may lead to dysfunction of the extensor mechanism due to ineffective moment arm, causing abnormal TF magnitudes. With further studies, the effect of a wider range of patellar button thicknesses on patellofemoral joint reaction forces should be considered for achieving an optimum thickness values.

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**References:**

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[2] Staubli HU, Am J Sports Med 1999; 27(1):27-34.