

Working Together to Solve Problems on Knee Arthritis

Research Collaboration - Musculoskeletal Research Center (MSRC) with Steadman♦Hawkins Research Foundation and the Stavros Niarchos Foundation

A patient specific model uses the geometry of the knees obtained from MRI. To date, a pioneering patient specific model has been built of a normal subject consisting of the articular geometry, primary ligaments, and geometry of the quadriceps insertions and patellar tendon.

This model was used to test the effect of a theoretical adhesion of the patellar tendon to the tibia over a range of severity. The analysis began with normal patellar tendon geometry and advanced a theoretical patellar tendon adhesion superior on tibia (Figure 1). Normal patellar tendon angle was matched to the data from the information acquired in the MRI data collections. In the unloaded and loaded states at 20 degrees of knee flexion, patellar tendon angle was within the span of the MRI measurements for non-weight bearing (NWB) and full weight bearing (FWB). Patellar tendon angle and patellofemoral load was calculated with the knee at 20 degrees of flexion and 600N applied to the quadriceps. This condition was chosen as similar in knee angle and muscle force to the instant of foot flat following heel-strike during the early stance phase of walking. The calculations were repeated as the virtual insertion of the patellar tendon was moved superior relative to the tibia (Figures 2). Patellofemoral load increased as the virtual insertion of the patellar tendon was moved superior (Figure 3, zero in the figure corresponds to the normal baseline condition).

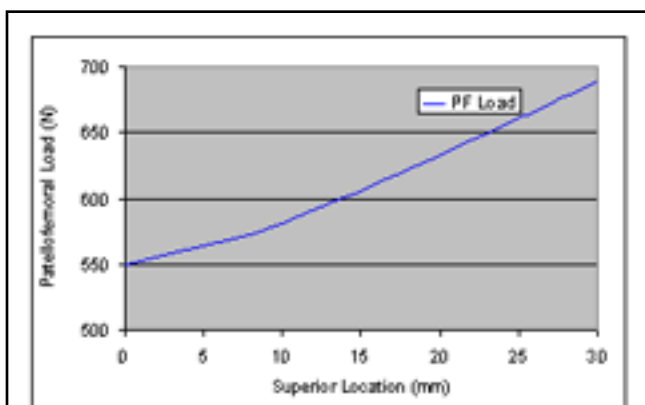
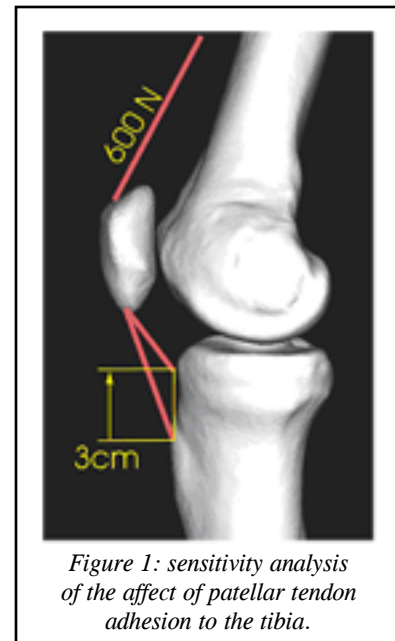


Figure 2: Patellofemoral load increased after the patellar tendon adhesion was moved superior.

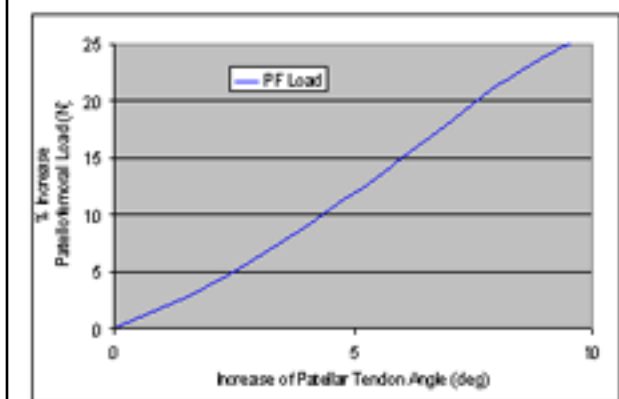


Figure 3: Patellofemoral load increased with patellar tendon angle.

Patellofemoral load increased because the angle of the patellar tendon relative to the tibia increased, causing a decrease in the angle between the quadriceps tendon and the patellar tendon. Patellofemoral load increase about 5% for every two-degree increase of patellar tendon angle (Figure 3).

These data provide the accuracy needed to detect a patellar tendon adhesion that will create a significant change in patellofemoral loading. Specifically, even a change as small as four degrees can increase patellofemoral load by 10%.

In addition, other changes were noted in knee mechanics with addition of a patellar tendon adhesion to the normal knee anatomy. Specifically, anterior tibial translation, ACL load, and patellar tendon load all increased with patellar tendon angle. Tibiofemoral load increased as well mainly due to the increase of ACL force. Notably, the increase in anterior tibial translation that occurred when quadriceps load was applied to the model masked an increased patellar tendon angle measured in the unloaded condition. For instance, moving the virtual insertion 1cm superior increased patellar tendon angle by 6 degrees before quadriceps load was applied. After 600N was applied to the quadriceps, the net increase in patellar tendon angle was only about 3 degrees. This occurred because the steeper patellar tendon angle increased shear anterior shear force on the tibia, thus translating the tibia further forward than in the normal condition.

In addition, an approximate calculation was made to demonstrate the strength needed for an adhesion to redirect the line of action of the patellar tendon (Figure 4). Quadriceps force during walking normally far exceeds the 600N used in the