Knee Extensor Moment Arm with and without a Knee Prosthesis

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Introduction

The aim of this study was to evaluate if there are differences in the moment arm (MA) of knees with and without total knee replacements (TKR’s). Any change in moment arm affects the torque that can be exerted at the knee.

Methods

Three fresh-frozen whole cadaver legs were cut just below the greater trochanter of the femur. The femur was held stationary with its long axis horizontal and attached to a table. The leg was initially allowed to hang under its own weight with the knee flexion angle set at $90^\circ$. The knee was extended at a rate of 3 deg/sec. Spatial kinematic measurements were made using a four-camera, 60 Hz video system with retroreflective markers attached to the distal femur, proximal tibia, and patella. All knees underwent a PCL retaining TKR (Natural Knee II, Sulzer Orthopedics Inc.) and the measurements were repeated. The MA of the knee-extensor mechanism was calculated based on the distance between the patellar tendon with respect to the instantaneous screw axis (ISA) of the tibia relative to the femur [1].

Theory

It can be shown that the MA of a muscle force is equal to the perpendicular distance from the line of action of the muscle force to the ISA of the body, multiplied by the sine of the angle between these two lines. It can also be shown that MA of the knee-extensor mechanism is described by the MA of the patellar tendon calculated with respect to the ISA of the tibia relative to the femur [1] or $d \sin \theta$ in Figure 1.

Results

The peak values of the patellar-tendon MA ranged from 4 to 6 cm for the unimplanted knees tested, (Figure 2). The largest MA was found near $45^\circ$ of knee flexion. The peak values of the MA for the same knees with TKRs ranged from 4 to 7 cm. The MA of the TKR was greater at $90^\circ$. The shape of the MA curves for the knees with and without TKR differed: The MA of the normal knees decreased at high flexion angles whereas the MA of TKR knees was fairly constant at flexion angles greater than $60^\circ$.

Relevance

The results of this study indicate that implantation of a knee prosthesis did not alter the MA, except at higher flexion angles. Torque is the MA multiplied by the quadriceps force. Therefore, the ability of the knee to exert torque is essentially the same for knees with and without total knee replacements except at flexion angles near $90^\circ$. At $90^\circ$ the MA for the TKR’s was greater, therefore, the quadriceps force required to produce the same torque as those without TKRs is less. This may be advantageous for people with TKR’s in activities such as rising from a chair since less quadriceps force is required at large flexion angles.