THE ROLE OF PATELLAR TENDON IN LOADING THE CRUCIATE LIGAMENTS AT THE KNEE DURING QUADRICEPS CONTRACTION

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Introduction

Injury of the cruciate ligaments at the knee is a common problem, particularly, in young athletes. Understanding situations that result in loading of the ligaments will help in protecting them from injury or during rehabilitation.

During quadriceps contraction, the patellar tendon force provides extending moment at the knee as well as a force component that can translate the lower bone (or tibia) relative to the upper bone (or femur) in the sagittal plane [Masouros, 2010].

The purpose of this analytical study is to analyze the role of patellar tendon in terms of its ability to translate the tibia, thus, loading the cruciate ligaments.

Methods

Mechanics of the knee was analyzed in the sagittal plane during flexion. Equilibrium was considered due to four types of forces: a patellar tendon force (P), a ligament force (L), a tibio-femoral contact force (C) applied by the femur normal to the tibial surface, and a posteriorly acting external flexing load (R) applied '*dr'* cm below the tibial surface.

In the calculations, a balance between the force components parallel to the tibial surface determined the need of a ligament force. No ligament force was required when R exactly balanced an anterior tangential component of P (or P_t). R smaller than P_t required a force in the anterior cruciate ligament (ACL). R greater than P_t required a force in the posterior cruciate ligament (PCL).

Moment arms and orientations of the patellar tendon used for calculations during flexion were obtained from experimental measurements in the literature [Herzog, 1993].

Results and Analysis

Figure 1 shows the forces parallel to the tibial surface ($R - P_t$) per unit of R plotted against increasing distance '*dr'* from 20 to 50 cm. The calculations were repeated for 0, 30, 60, 70, 90 and 120^o flexion angles of the joint.

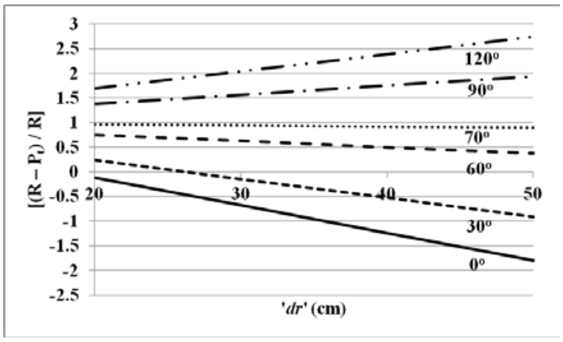

Figure 1: The force ratio [(R-P_t)/R] plotted against the distance 'dr' at different flexion angles.

With reference to figure 1, negative values for the force ratio [(R–P_t)/R] suggested the need for a force in the ACL, while the positive values suggested the need for a force in the PCL. For all flexion positions the force ratio varied linearly with the position of external load on the tibia. ACL force was required at 0^o for all load placements and at 30^o for all loads placed 27cm or more distally on the tibia. PCL force was required in all other situations presented in the figure.

Conclusions

The analysis suggests that the loading of the cruciate ligaments depends on the flexion angle as well as on the position of the external load on the tibia. Far distal placements of flexing loads can load the ACL significantly at low flexion angles. The PCL is stretched during mid-to-high flexion range for all positions of the external loads on the tibia. However, in the mid-flexion range, the effect of variation in the placement is small.

Therefore, rehabilitation exercises requiring protection of the ligaments need to pay attention to the position of external flexing load on the tibia as well as the flexion angle at which the exercise is performed.

Reference

Herzog *et al*. J Anatomy, 182:213-230, 1993.

Masouros S *et al*. Orthop Trauma, 24(2):84-91, 2010.