IMPORTANCE OF THE EFFECTIVE LENGTH OF AN ACHILLES TENDON GRAFT ON ITS STRUCTURAL PROPERTIES

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Introduction
The clinical outcomes of reconstruction of the posterior cruciate ligament (PCL) remain inconsistent [1, 2]. Lipscomb et al [1] have reported that 60% of patients develop long-term degenerative changes in the patello-femoral and medial compartments after PCL reconstruction. Abnormal knee kinematics have been thought to be a major factor contributing to long-term arthritic changes in the knee [3]. A necessary condition for the restoration of normal knee kinematics is reproducing the load-deformation behavior of the native PCL. The length of a PCL graft between fixation points has a direct effect on its load-deformation behavior (i.e. a short graft is stiffer than a long graft). The objective of this study was to quantify the effect of changing the length of an Achilles tendon graft on its load-elongation behavior.

Methods
Five human cadaveric Achilles tendons and their bony attachment to the calcaneus were used in this study. The tendon was “tubed” tightly to fashion a graft that would fit an 11mm tunnel, as is done clinically. The bone block was potted in bone cement and the tendon was clamped using a sinusoidal clamp (Figure 1). For each graft, three different lengths were studied: 75mm (long), 48mm (medium), and 34mm (short). The long, medium and short grafts represented mid-tunnel fixation on the femur and tibia in a trans-tibial tunnel reconstruction technique (75mm), inlay fixation on the tibia and mid-tunnel fixation on the femur (48mm), and fixation at the articular surface of the tibia and femur (34mm), respectively. The long graft was tested first, followed by the medium and short grafts, with 30 minutes of graft recovery between each test. The graft was fixed in a materials testing machine (MTS, Minneapolis, MN) and was hydrated throughout the testing procedure with physiological saline solution. Preconditioning of the graft was performed by elongating the graft between 0 and 2 mm at 20 mm/min for 10 cycles. The graft was then displaced at a rate of 100 mm/min until a load of 400N was applied. A computer recorded the force-displacement data during the test. The linear stiffness of each specimen at each length was calculated from the linear region of the force-elongation curve. A repeated measures analysis of variance was used to detect statistically significant differences between the stiffness of the short, medium, and long grafts.

Results
The load-displacement curve for a typical specimen is shown in Figure 2. A non-linear toe region and a linear region were observed in all specimens. Longer grafts had larger overall displacement under the same load as compared to shorter grafts in both the non-linear and the linear regions.

Increasing the length of the graft from 34mm (short) to 48mm (medium) resulted in a decrease in stiffness of 29±30% (mean ± s.d., Figure 2). The long graft was 85±28% less stiff than the short graft. Statistically significant differences were found between the short and medium groups, the short and long groups, and the medium and long groups (p < 0.05).

Discussion
Our results indicate that graft length has a significant effect on the force-elongation behavior of the Achilles tendon graft. In order to restore the kinematics of the knee after PCL reconstruction, the structural properties of the graft must closely match those of the intact PCL. These results suggest that the fixation site may be an important variable affecting the stability of the knee and thus the clinical outcome of PCL reconstruction. Previous investigators studied the effect of anterior cruciate ligament graft fixation location on the force in the graft under anterior-posterior tibial loading [4, 5]. They found that graft fixation near the articular surface of the tibia and femur resulted in the largest graft forces, and as graft length increased, graft forces decreased. These results qualitatively agree well with ours in that a long graft is less stiff than a shorter one. In the future, optimal graft lengths should be found for different graft materials, so that the structural properties of the graft closely match those of the ligament being replaced.

References

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