THE EFFECTS OF ONE AND TWO BUNDLE POSTERIOR CRUCIATE LIGAMENT RECONSTRUCTIONS ON BUNDLE TENSION

††Shearn, J (A-CSREF); *Grood, E (A-CSREF); **Noyes, F
+University of Cincinnati, Cincinnati, Ohio. 513.556.4175, Fax: 513.556.4162, shearnj@email.uc.edu

Introduction

The posterior cruciate ligament (PCL) is the primary restraint to posterior tibial translation, providing approximately 95% of the resistive force.(1) Injuries to the PCL often hamper the person’s ability to perform activities of daily living, thus requiring surgery.(2) PCL reconstructions are capable of restoring the normal knee kinematics,(3) but over time the abnormal posterior translation frequently returns. The failure of the reconstruction is attributed to graft elongation,(4) which we believe to be caused by nonuniform load sharing within the graft. The use of a two-bundle reconstruction may provide improved load sharing, which would reduce or eliminate the recurrence of abnormal posterior translation. The purpose of this study was to determine the effects one and two-bundle PCL reconstructions on bundle tension.

Methods

Eleven specimens from eight donors (3 male, 5 female) with a mean age of 72.6 years (range 50 - 80 years) were tested (IRB Protocol #89-01-06-01-EF). Posterior motion limit tests were performed with the knee intact, PCL deficient and reconstructed. These tests were conducted with 100 N of applied posterior force as the knee was cycled from near full extension to 120° of knee flexion. Knee motions were recorded using a six-degree-of-freedom instrumented spatial linkage. After reconstruction, bundle tension was recorded using a strain gage load cell (ELW-B1-200L, Entran, Fairfield, NJ).

The reconstruction was performed using either a one or two bundle central third patellar tendon graft. The one- bundle graft was a 10 mm wide section of the patella - patellar tendon - tibia unit. The two-bundle graft was created by dividing the patellar bone block of the one-bundle graft into two 5 mm bone blocks and splitting the patellar tendon in two leaving a 10 mm tibial bone block. The femoral tunnel for the one-bundle reconstruction (OB) was drilled high and shallow in the notch, Figure 1. We studied two types of two-bundle reconstructions. One bundle in each type was placed high and shallow in the notch (S1), Figure 1. The OB and S1 bundle were position to reconstruct the anterolateral region of the PCL. The second bundle was either placed mid and shallow (S2) or mid and deep (D1), Figure 1. The tibial bone block in each reconstruction was placed in the center of PCL tibial footprint. The reconstruction was pretensioned to restore the posterior translation to within ± 1 mm of the intact knee at 90° with a 100 N applied posterior force. The S1-S2 reconstruction was tensioned to share load, and the S1-D1 reconstruction was tensioned so the S1 bundle carried 80% of the tension.

Figure 1: Femoral attachment sites

Statistical Analysis:

The peak bundle tension recorded for the S1 bundle in both two-bundle reconstructions and for the OB bundle was compared using an independent sample t-test. A regression analysis (bundle tension vs. flexion angle) was performed for the S1 bundle in each of the two-bundle reconstructions and on the OB bundle. The slopes generated from the regression analyses for both S1 bundles and for the OB bundle were compared using an independent sample t-test. All t-tests were corrected for multiple comparisons using the Bonferroni correction. The level of significance used was P < 0.05, and the analyses were performed using SPSS version 10.1 (SPSS Inc., Chicago, Illinois).

Results

The peak bundle tension for the OB bundle was 226 ± 26.1 N, Figure 2A. The peak bundle tension for the S1 bundle when paired with the S2 bundle was 136 ± 14.9 N which was significantly less than the peak bundle tension of the OB bundle (P = 0.048), Figure 2A. The peak bundle tension for the S1 bundle when paired with the D1 bundle was 253 ± 23.6 N which was significantly greater than the peak bundle tension in the S1 bundle when combined with the S2 bundle (P = 0.016), Figure 2A.

The slope generated for the OB bundle was 48.4 N/30°. The slope generated for the S1 bundle when combined with the S2 bundle was 17.2 N/30°, which is significantly less than the slope generated for the OB bundle (P = 0.009). The slope generated for the S1 bundle when combined with the D1 bundle was 67.5 N/30°, which was significantly greater than the slope generated for the S1 bundle when combined with the S2 bundle (P = 0.006) and was not significantly different than the slope generated for the OB bundle.

Discussion

The use of a two-bundle PCL reconstruction has the potential to produce more uniform load sharing, thus reducing the peak fiber stress. From this study, the placement of the second bundle was critical to the tension generated in the anterolateral region of the PCL. The addition of a shallow bundle produced a significant decrease in the S1 bundle tension, but the peak bundle tension generated in the second shallow bundle was high, Figure 2B. This configuration shows little promise for restoring the long-term knee kinematics. The excessive tension in the second shallow bundle will compromise this bundle thus placing the entire load on the S1 bundle. The addition of a deep bundle did not significantly alter the bundle tension in the S1 bundle tension. This configuration did not improve the load sharing, and it also shows little promise for restoring the long-term knee kinematics. From this work, a second bundle placed between our shallow and deep locations may improve load sharing and restore the long-term knee kinematics.

Acknowledgements

This work was supported by the Cincinnati Sportsmedicine Research and Education Foundation.

References


**Cincinnati Sportsmedicine and Orthopaedic Center, Cincinnati, Ohio.