A BIOMECHANICAL STUDY OF POSTERIOR CRUCIATE LIGAMENT RECONSTRUCTION TECHNIQUES: ANALYSIS OF GRAFT PRETENSIONS AND LAXITIES

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INTRODUCTION: Controversy exists regarding both the tibial attachment and the site of the femoral tunnel placement for PCL reconstructions. The most common method of PCL reconstruction utilizes a trans-tibial tunnel from which the graft must make the "killer turn" around the posterior tibia. Loss of graft pretension due to friction at this corner, potentially high local tissue strains from the severe bend, and non-anatomic graft fiber insertion sites are all possible explanations for failure of this procedure to restore posterior laxity in the clinical setting. The tibial inlay technique is an alternative reconstruction which may avoid some of the potential problems encountered with the standard trans-tibial tunnel technique. With the tibial inlay technique, a small bony recess is created in the posterior tibia at the PCL's anatomic insertion site. The distal bone block from a bone-patellar tendon-bone graft is fixed flush to the tibial surface with a screw. With this configuration, fibers of the patellar tendon graft insert into the tibia as near as possible to the anatomic insertion site of the native PCL. This technique would appear to offer certain advantages which include more anatomic loading of the patellar tendon fibers at their insertions to the bone block, more accurate placement of the bone block at the PCL insertion site and avoidance of the acute bend of the graft which is inevitable with the trans-tibial tunnel technique. With regards to the femoral attachment site, one study has demonstrated restoration of posterior laxity with a centrally placed tunnel, while another study has advocated placing the tunnel eccentrically within the PCL footprint (at the origin of the anterolateral bundle of the PCL). We sought to determine the differences between these variables with regards to graft pretension and A-P laxity.

MATERIALS & METHODS: 12 cadaver knees had a load cell attached to a bone caps containing the femoral origin of the PCL. AP laxity testing with a 200 N force was performed at 0, 30, 60, 90 and 120 degrees of knee flexion. A posterior incision was made and a drill guide was used to drill an 11mm tunnel which exited at the center of the PCL's tibial footprint. A B-PT-B graft was placed with the proximal end attached to the PCL load cell which was centered in the native PCL's femoral footprint (TC), and a pre-tension was found which reproduced intact AP laxity within 1 mm at 90 degrees of knee flexion. A-P laxity tests were performed at this laxity match pre-tension. The graft was then repositioned with the femoral attachment located eccentrically (TE), in the distal and anterior portion of the native PCL, and testing was repeated. The knee was positioned at 90 degrees and 50 A-P loading cycles were applied. The graft was removed and the tibial tunnel was filled with a press-fit cylinder of high density foam. An osteotome was used to make a rectangular recess, precisely sized to hold the distal bone block of a B-PT-B graft which was fixed at the center of the PCL tibial insertion with a screw. The femoral side of the graft was attached to the PCL load cell which was centered in the native PCL's femoral footprint (IC), and testing was repeated. The graft was then repositioned with the femoral attachment located eccentrically (IE) and testing was repeated. The knee was positioned at 90 degrees and 50 A-P loading cycles were applied. RANOVA was used to determine statistical significance between groups.

RESULTS: The pretensions for each group are shown in Figure 1. The laxities for each group are shown in Figure 2; there was no difference at 90 and 120 degrees.

The pretensions for each group are shown in Figure 1. After 50 A-P loading cycles at 90 degrees, graft pretension deceased 14 N in TE (P<.002) and 8 N in IC (P<.002). AP laxity increased 0.8 mm in TE (P<.001) and 0.6 mm in IC (P<.0001). There were 2 graft failures in the tunnel group and 0 in the inlay group.

DISCUSSION: There are four important findings of this study: 1) When compared with the trans-tibial tunnel, the tibial inlay technique requires a lower graft pretension to restore normal laxity when using the central femoral tunnel. While the pretension values were lower for the eccentric femoral tunnel with the tibial inlay, this data did not achieve statistical significance. The decreased level of pretension may be the result of more solid bone to bone tibial fixation as well as the absence of the “killer turn” both of which could result in less tissue elongation during the tensioning process. Over time the lower graft pretension could result in less graft stretchout and improved clinical outcome. 2) There were no difference in the laxity patterns between the trans-tibial and tibial inlay reconstructions. This finding indicates that at time zero there is no difference between the reconstructions and that later differences in clinical outcome may be due to differences in biologic healing and graft wear. 3) The standard eccentrically placed femoral tunnel resulted in 1-2 mm of increased laxity at 0 and 30 degrees, and no difference at 60, 90 and 120 degrees of knee flexion. There was slight over-constraint in the IC group when compared to the intact PCL at 30 and 60 degrees. We feel that the disadvantage of the increased laxity at 0 and 30 degrees is more than offset by the advantage of decreased pretension required with the eccentric tunnel. Thus these findings agree with previous studies that support placing the femoral drill hole eccentrically in the femoral footprint of the PCL. 4) After 50 A-P loading cycles there was a significant decrease in pretension and a slight increase in laxity in both TE and IE. While there was no significant difference between the changes in laxity and pretension between the two reconstruction techniques, there were two graft failures at the “killer turn” with the trans-tibial tunnel and none with the tibial inlay reconstruction. This finding indicates that with repetitive loading the tibial inlay may be a superior reconstruction.

REFERENCES