Biomechanical Comparison between 4-strand Posterolateral Corner Reconstruction and Modified Larson’s Procedures after Cyclic Loading

Introduction: The posterolateral corner (PLC) resists varus rotation, external tibial rotation, and, to a lesser extent, posterior tibial translation. Several biomechanical studies have shown the LCL, popliteus tendon, and PFL to be the important stabilizing structures of the posterolateral knee [1]. There are several studies of kinematics of PLC reconstruction. However, most authors studied non-anatomic PLC reconstruction [2,3]. The Larson’s PLC reconstruction is commonly used, but is not an anatomic procedure [4,5]. We have developed a new 4-strand anatomic PLC reconstruction [6]. It is important to evaluate the biomechanical properties of these reconstruction techniques under simulated postoperative loading conditions. There have been no studies of the stability of isolated PLC reconstructions under cyclic loading. We hypothesized that our 4-strand PLC reconstruction would give better external rotatory stability than Larson’s reconstruction after cyclic loading. The aim of this study was to test the hypothesis.

Methods: Fourteen fresh-frozen cadaveric knees were used. The knee was mounted in a 6 degree of freedom rig and laxity testing was performed using following [7]: 5-Nm external tibial forces and 90-N posterior tibial loads. Knee kinematics was recorded with an active optical tracking system (Polaris, NDI, Canada) for the intact, PLC-deficient, modified Larson’s PLC reconstructed and 4-strand PLC reconstructed knees. The modified Larson’s PLC reconstruction was performed with the semitendinosus tendon [8] (Fig 1-a). The graft was passed through a fibular tunnel and the midpoint of the graft was fixed there with an interference screw. Both the anterior and posterior bundles of the graft were held together and the isometric point was located on the femur. Two tunnels were drilled from the isometric point, each exiting at a different point on the medial femoral cortex. The anterior (LC) tunnel was tensioned progressively by an adjustable screw fixation at 20° flexion to match the varus laxity of the intact knee subjected to 5-Nm varus moment. The posterior (popliteus complex) graft was tensioned progressively at 90° flexion to match the external rotation laxity of the intact knee at 5-Nm torque. For the 4-strand PLC reconstruction (Fig 1-b), the femoral tunnels were drilled at the LCL and popliteus tendon attachments [6]. After the fibular tunnel was created, a tibial tunnel was drilled to the posterior popliteal tibial sulcus. The semitendinosus (light gray in Fig 1b) and gracilis tendon (dark gray in Fig 1b) grafts were passed through these tunnels and tensioned independently by adjustable screws in the same manner as before. The kinematic data were analyzed by using two-way repeated measures analyses of variance. Significance was set at p<0.05.

Results after cyclic loading: With external tibial torque, the external rotation-versus-flexion curves were significantly different between the PLC-deficient, the modified Larson’s and 4-strand reconstruction (p=0.0001) (Fig 2). The rotational laxity after 4-strand reconstruction was significantly less than in the PLC-deficient knee (p=0.0001) and modified Larson’s reconstruction (p=0.0094). In response to posterior load, the coupled external rotation-versus-flexion curves were significantly different among the 3 groups (p<0.0001) (Fig 3). The coupled external rotation laxity after 4-strand PLC reconstruction was significantly less than when PLC-deficient (p=0.0138). However, the coupled external rotation laxity after modified Larson’s reconstruction was not significantly less than when PLC-deficient (p=0.2163). There was no significant difference of coupled external rotation between the modified Larson’s and 4-strand PLC reconstructions (p=0.1940).

Discussion: This study showed that the rotational knee laxity in response to both an external rotation torque and tibial posterior translation force after cyclic loading were significantly closer to normal after the 4-strand PLC reconstruction than after the modified Larson’s reconstruction, although there were no significant differences between the two procedures for posterior tibial translation. A 4-strand ‘anatomic’ PLC reconstruction may produce a better biomechanical outcome, especially during external rotation and posterior translation (drawer) tibial load. We suggest that this relates to load-sharing among four grafts crossing the joint. Cyclic loading in vitro may give more realistic assessment than ‘time zero’ tests of knee stability after PLC reconstruction, because it represents an attempt to model the mechanical effects of loads imposed post surgery.

Fig. 1 a. Modified Larson’s PLC recon. b. 4-strand PLC recon.
Fig. 2 Increase of rotation over intact under 5-Nm external rotation after cyclic loading of 5-Nm external tibial rotation (mean (SD), n=14)
Fig. 3 Increase of the coupled external rotation over intact under 90-N posterior load after cyclic loading of 5-Nm external tibial rotation (mean (SD), n=14)


Miyashin1228@gmail.com