INTRODUCTION

The increased popularity of high velocity sports has produced an increased number of injuries to the medial knee structures, especially the superficial medial collateral ligament (sMCL) [1, 2]. While the majority of the MCL injuries can be treated non-operatively, some acute and chronic injuries require operative intervention [3]. There have been a number of reconstruction methods proposed and implemented to date. A quantitative method of evaluating an anatomical reconstruction of the MCL structures and the relative forces experienced by each individual ligament has been recently developed [4]. To our knowledge, validation of an anatomical medial knee reconstruction via direct measurement of the load sharing characteristics of the individual medial knee structures in the intact and reconstructed state has not been previously performed. Therefore, the purpose of our study was to measure the force experienced by the intact proximal and distal divisions of the sMCL and the posterior oblique ligament (POL) and compare the proportional distribution in a reconstructed state under various loading conditions to validate that an anatomical medial knee reconstruction technique restores the normal force relationships among structures of the medial knee.

METHODS

The non-paired, fresh-frozen cadaveric knees, with no evidence of prior injury or disease, were utilized for this study. The femur was sectioned 20 cm proximal to the knee joint and potted in polymethylmethacrylate (PMMA) for secure fixation in a customized knee testing apparatus. A previously described customized knee testing apparatus firmly secured the femur at a horizontal angle, which allowed uninhibited movement of the tibia at the measured knee flexion angles [4]. After the knee was aligned in the testing apparatus, buckle transducers were securely fastened to the POL and the proximal and distal divisions of the sMCL (Figure 1A), and the respective reconstructed ligaments (Figure 1B).

This technique consisted of a reconstruction of the sMCL and POL using two separate grafts with four 7 x 25 mm reconstruction tunnels (Figure 1B). The semitendinosus was harvested and subsequently sectioned into two parts; 15 cm for the sMCL graft, and 11 cm for the POL graft. Each end of the harvested tendons was tubularized using No. 2 continuous braided polyester/polyethylene sutures. The grafts were secured into their respective tunnels with 7 mm bioabsorbable interference screws at the distal aperture of the tunnel.

Figure 1 Intact (A) and reconstructed knee (B).

The buckle transducers consisted of a crossbar and a rectangular stainless steel frame containing semiconductor strain gauges. The use of these devices has been previously described in detail [4, 5]. The buckle application consisted of placing the frame over the ligament of interest and inserting the crossbar both below the ligament and above the frame. Ligamentous tension, caused by loading of the specific ligament, pushed the crossbar against the frame, similar to a three-point bending. This deformation of the buckle frame induced a voltage response in the strain gauge contained within the buckle frame. There was a linear relationship between the applied load and voltage output, which was converted to kN according to a conversion factor determined by post-test calibration of each buckle with a known load. [5]. Buckle transducers have been reported to be repeatable to within 0.7 percent using a similar biomechanical testing protocol [5].

RESULTS

For both a 10 Nm applied valgus moment and 5 Nm applied external rotation torques; there were no significant differences in observed load when comparing the intact to the reconstructed states (Figure 2). With an 88 Nm applied anterior and posterior drawer moment, there was also a restoration of native forces when comparing the reconstructed to the intact states. Forces observed on the POL with an applied valgus moment as well as external rotation were not significantly different between the intact and reconstructed states. The maximum load of 17N for the intact and 18N for the reconstructed state were noted at 30° of knee flexion with an applied valgus load. Forces observed on the proximal division of the sMCL with an applied valgus moment as well as external and internal rotation were not significantly different between the intact and reconstructed states. The maximum load of 82N for the intact and 92N for the reconstructed state were noted at 90° of knee flexion with an applied external rotation torque. Forces observed on the distal division of the sMCL with an applied valgus as well as external and internal rotation were also not significantly different between the intact and reconstructed states. The maximum load of 113N for the intact and 120N for the reconstructed state were noted at 90° of knee flexion with an applied external rotation torque.

DISCUSSION

This is the first study to directly measure the forces in the medial knee ligaments in the intact and reconstructed state. We conclude that our anatomical reconstruction technique sufficiently restores the normal load distribution on the proximal and distal divisions of the sMCL as well as the POL. The data gathered in this biomechanical study validates that our anatomical reconstruction technique restores the normal force relationships among medial knee structures.

REFERENCES


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