HYBRID FIXATION IMPROVES STRUCTURAL PROPERTIES OF A SOFT TISSUE GRAFT CONSTRUCT USED FOR ACL RECONSTRUCTION

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INTRODUCTION

ACL reconstruction is an accepted method of treatment for acute and chronic anterior cruciate ligament (ACL) tears. Hamstring tendon reconstruction has gained popularity versus bone-patellar-bone reconstruction because of problems with kneeling pain, patellar fracture, quadiceps atrophy, and limited range of motion. The fixation site of ACL grafts remains the weakest component during the immediate postoperative period after reconstruction. Cyclic loading of the graft construct during early post-operative rehabilitation may cause failure or loosening if fixation is inadequate. The objective of this study was to quantify the structural properties of three types of tendon graft fixation constructs for ACL reconstruction.

METHODS

Eighteen porcine femora were used for three experimental study groups: 1) Closed loop and button suspension with supplemental biodegradable interference screw (Hybrid) fixation; and 3) Biodegradable interference screw fixation (BIF). (Figure 1) Quad-stranded grafts were harvested from the flexor tendons of the second, third, and fourth digits from 6 cadaveric forearms. Gross examination of the specimens revealed no prior disease or injury to the flexor tendons. Each end was sewn with #2 ticon to facilitate handling. Tendon grafts were constructed by pairing a flexor digitorum profundus tendon and flexor digitorum sublimis tendon from a digit for each test. The quad-stranded grafts were then measured for length and circular diameter using a graft preparation board. The cross-sectional area was obtained by using an area micrometer and averaging three neighboring regions of each graft.

The length of graft in the femoral tunnel was standardized at 30mm. A standard closed loop length of 25 mm was selected, as was an interference screw size of 7 x 30 mm. The femoral tunnel was drilled into the femoral footprint with a drill sized to the measured diameter of each graft. Each graft was pretensioned with an 80 N force for two minutes prior and during insertion. (Figure 2)

The specimens were secured in an aluminum pot and fixed with a threaded bolt through the diaphysis as well as plaster of Paris. A custom testing setup, a video digitizing system, and Instron machine (Instron Corporation, Canton, Massachusetts) were used to quantify the graft fixation complex’s structural properties. (Figure 2) Each specimen was cycled to 2 mm at 20 mm/min for 30 cycles after an 80 N preload was applied. The load to failure test followed at 20 mm/min.

Structural properties including linear stiffness, yield load, ultimate load, yield deformation, and ultimate deformation were determined from the load-deformation curves. Quasi steady state cyclic stiffness was determined from the load-cycle curve obtained during cyclic testing when the force amplitude changed < 1 % for two consecutive cycles.

Statistical analysis comparing the mean cross-sectional area of each graft and the structural properties of the graft constructs was performed. Statistical analysis using ANOVA with Tukey post hoc test for individual comparisons was performed. A p-value of less than 0.05 was used as the level of significance.

RESULTS

There were no statistical differences (p < 0.05) between the three experimental groups with regard to the cross sectional area and diameter of the grafts. The Hybrid fixation group demonstrated significantly greater structural properties compared to the CLBS or the BIF group (p < 0.05). (Figure 3) The ultimate load (Mean ± SEM) was 1184 ± 88N, 813 ± 83N and 561 ± 62N for the Hybrid fixation group, CLBS group and BIF group, respectively. The yield load was 551 ± 25N, 350 ± 16N and 319 ± 23N for the Hybrid fixation group, CLBS group and BIF group, respectively. The quasi steady state cyclic stiffness was also greatest for the Hybrid fixation group 165 ± 11N/mm compared to CBIS 122 ± 8 N/mm and the BIF 95 ± 9 N/mm group (p < 0.05). The decrease in stiffness at steady state was greater in the IF group 34.4 ± 4.1 % when compared to initial stiffness (p < 0.05).

DISCUSSION

ACL soft tissue graft fixation combining a suspensory type implant with an interference screw (Hybrid) provides superior structural properties when compared to each individual mode of fixation. It is important to maintain tension between the two fixation sites in order to avoid sequential failure and promote load sharing of the reconstructed graft complex. Interference screw fixation alone may predispose to graft loosening during post-operative rehabilitation. The working length of the native ACL is preserved with Hybrid graft fixation compared to suspensory fixation.

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