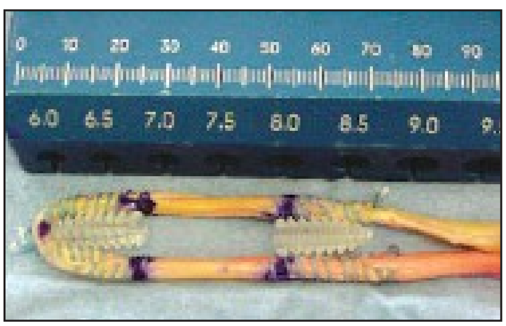
A Biomechanical Comparison of Femoral RetroScrew Placement in a Porcine Model

Arthrex Research and Development

Objective

This study evaluates Femoral RetroScrew fixation of a whipstitched human anterior tibialis bundle in a porcine model. This study consisted of two groups: an anterior placed bundle which represents a traditional fixation and a double bundle with concentric screw placement (Figure 1) [1, 2]. The purpose of this study is to compare the cyclic displacement, stiffness, and ultimate strength of graft placements using a Femoral RetroScrew.

Figure 1: Whipstitched graft with concentric femoral screw placement (left) and concentric tibial screw placement (right)



Methods and Materials

Testing was performed using the methods of Chang et al. [4]. Twelve anterior tibialis allografts were tested (LifeNet, Virginia Beach, VA). Grafts were trimmed and whipstitched on both sides with #2 FiberWire.

Femoral tunnels were prepared using instruments from the ACL Reconstruction System. Skeletally mature fresh frozen porcine femurs were used (Frontier Biomedical, West Logan, UT). The femoral RetroScrew Driver was attached to a MARK-10 Torque Gauge (MARK-10 Corp., Copiague, NY) and a Femoral RetroScrew was inserted either anterior or central to the graft. Peak torque during insertion was measured for each specimen. The repaired tendons were fixed in an Instron materials testing system (Instron, Canton, MA) 3 cm from the femoral socket using cryo-clamps (Figure 2). Each specimen was mounted on the Instron and a tensile load applied in line with the femoral socket. Constructs were precycled sinusoidally at 1 Hz from 10 to 50 N for 10 cycles. Constructs were then cyclically loaded 500 times from 50 to 250 N at 1 Hz. After cycling, a single-cycle load-to-failure test was conducted at 20 mm/min. Data was collected at 500 Hz every 10 cycles.

Statistical comparisons of data were made with a Student's t-test and significance level of 0.05.

Figure 2: Repaired tendon fixed in the Instron System for testing

Results

All specimens failed at the repair sites as the grafts slipped past the screws. All numerical data is listed in Table 1. There is no significant difference in insertion torque, cyclic displacement, cyclic stiffness, yield load, or peak load between groups ($p > 0.05$). However, pull-out stiffness is significantly different between groups ($p < 0.05$). The centrally placed RetroScrews have significantly greater pull-out stiffness than the anterior placed RetroScrews. On average, the centrally placed RetroScrews out-performed the anteriorly placed RetroScrews in strength, graft displacement and stiffness.

Table 1: Concentric and eccentric placed anterior tibialis tendon data

	Concentric	Eccentric	
Insertion Torque (in - lbf)	22.7 ± 5.9	22.0 ± 4.1	n.s
Cyclic Displacement (mm)	2.5 ± 0.4	2.7 ± 0.5	n.s
Cyclic Stiffness (N/mm)	253.0 ± 25.1	250.5 ± 39.3	n.s
Peak Load (N)	1247.4 ± 197.1	1044.1 ± 241.5	n.s
Yield Load (N)	1247.4 ± 197.1	1021.1 ± 237.2	n.s
Pull-out Stiffness (N/mm)	201.9 ± 19.8	161.2 ± 36.8	$p < 0.05$

Discussion

Although the difference in the groups for cyclic displacement, cyclic stiffness, yield load, and peak load are not statistically different, on average the centrally placed RetroScrews out-performed the anteriorly placed RetroScrews in strength, graft displacement, and stiffness. While it has been shown that interference screw fixation strength and insertion torques are much higher than would be expected using human cadaveric bone [3, 4, 5], we feel that the porcine model is the optimum substitute for young human cadaveric specimens due to its size, shape, consistent bone quality, availability, cost, and pathology. Chang et al. examined failure mode, maximum load at failure and displacement during cyclic loading of doubled tibialis anterior grafts in a porcine model using Tibial RetroScrews with a distal 17 mm Bio-Cortical Screw backup [4]. They found a RetroScrew and backup Bio-Cortical Screw ultimate load (779 ± 178 N) and construct cyclic displacement (1.8 ± 0.5 mm) lower than we found on the femoral side, but within clinically accepted values [6]. The lower ultimate loads found by Chang et al. are most likely due to the lower bone mineral density of porcine tibias relative to femurs. Only tibias with bone mineral densities of 1.3 or less were used in Chang's study [4].

The lower cyclic displacement found by Chang et al. can be explained since Chang et al. pulled a tendon looped over a post whereas we pulled individually clamped tendon arms. This creates slightly different strains on each tendon limb and thus a slightly larger displacement. Both studies likely used slightly different tendon gauge lengths. In this study, all but two constructs' cyclic displacements can be attributed to tendon stretch. Two constructs in the concentric group slipped less than 0.1 mm.

Additionally, Chang et al. found a stiffness for the RetroScrew construct (204 ± 53 N/mm) similar to the stiffness of the native ACL (242 N/mm, Woo et al.) and similar to what was found in this study [7].

Shino and Pflaster studied eccentric and concentric screw placement for hamstring graft fixation in human cadaveric tibial tunnels [1]. While they found overall yield and ultimate loads quite lower than this study, they found significantly greater construct stiffness for concentrically placed vs. eccentrically placed screws. They did not find a significant difference between screw placements for yield load, slippage, or ultimate load.

Conclusion

The RetroScrews placed centrally, on average, have a greater fixation strength, graft displacement, and stiffness than the anterior placed RetroScrews. The differences between groups are not statistically significant except for a statistically greater pull-out stiffness for the centrally placed RetroScrews.

References

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