Biomechanical Comparison of Screw and Spiked Washer versus Suture-Post for Tibial Sided Fixation in ACL Reconstruction

Dean Wang, MD, Daniel V. Boguszewski, PhD, Nirav B. Joshi, MD, Keith L. Markolf, PhD, Frank A. Petrigliano, MD, David R. McAllister, MD.
UCLA, Los Angeles, CA, USA.

Disclosures:  D. Wang: None.  D.V. Boguszewski: 5; MTF.  N.B. Joshi: None.  K.L. Markolf: None.  F.A. Petrigliano: 5; MTF.  D.R. McAllister: 1; DJO. 2; MTF/Conmed, Biomet. 3B; MTF, Biomet. 3C; Smith & Nephew. 7; Elsevier.

Introduction: Rigid tibial fixation of a tendon graft is one of the most important factors influencing the mechanical performance of the graft in the immediate post-operative period after an anterior cruciate ligament (ACL) reconstruction [1]. During the 12 week process of osseointegration, fixation must be secure enough to prevent graft slippage and/or local elongation at the fixation site. Spiked washer and suture-post fixation are two common methods used for tibial soft-tissue graft fixation. With the suture-post, non-absorbable suture is placed into the free ends of the tendon graft and tied around a screw and washer, which functions as a post [2]. However, the sutures at the graft ends can tighten and compress into the graft tissue as they are subjected to tensile forces, which can result in increased anterior knee laxity after ACL reconstruction. In contrast, a screw and spiked washer has demonstrated high fixation strength by directly compressing the graft tissue onto cortical bone [3,4]. Spiked washer fixation does not rely on sutures, thus eliminating possible laxity due to suture tightening. The objective of this study was to directly compare spiked washer and suture-post tibial fixation by measuring anterior knee laxity during cyclic anteroposterior (AP) tibial loading of an ACL-reconstructed knee.

Methods: Fresh-frozen human cadaveric knees were tested using a six degree-of-freedom robotic manipulator that applied 250 cycles of AP tibial force (±134 N) at 30° flexion (Figure 1). Two components of anterior knee laxity were evaluated: initial (first cycle) anterior tibial translation (ATT) and the increase in ATT after 250 loading cycles. Ten intact knees (mean age 34 years, range 21-45) were tested to collect baseline ATT data of the native ACL. Then, a single knee (male, 44 years of age) was selected to test all ACL reconstructions. Each reconstruction was performed using a human doubled tibialis tendon allograft. An EndoButton was used for femoral fixation while the tibial end was fixed with either a screw and spiked washer (n = 10) or a suture-post construct (n = 10). After ACL reconstruction, cyclic AP testing was performed to collect ATT data. A one-way ANOVA was used to compare means for ATT and cyclic increases in ATT between the native ACL group and both fixation method groups. Post hoc comparisons were made using Tukey’s HSD procedure. The level of significance was set at p < 0.05.

Results: Mean peak first cycle ATT of the native ACL knees was 4.8 ± 1.8 mm; corresponding means for ACL-reconstructed knees with spiked washer and suture-post fixation were 2.3 ± 0.9 mm (p < 0.007 vs. native) and 11.0 ± 2.5 mm (p < 0.001 vs. native and spiked washer), respectively. The mean increase in ATT from cycle 1 to 250 of the native ACL knees was 0.3 ± 0.2 mm, while the mean increases with spiked washer and suture-post fixation were 3.4 ± 1.0 mm (p < 0.001 vs. native) and 7.8 ± 1.3 mm (p < 0.001 vs. native and spiked washer), respectively. A comparison of mean curves for intact and ACL-reconstructed knees (Figure 2) illustrates the differences between the two tibial fixation constructs and the intact...
knee, both in terms of final ATT and cyclic increases in ATT. The low initial stiffness (slope of the force vs. ATT curve) with the suture-post construct was likely a result of suture whipstitch tightening around the graft tissue as cyclic anterior tibial force was applied. At the conclusion of testing, clear evidence of tightening was observed after removal of the sutures, as deep suture grooves were imprinted into the ends of the graft tissue (Figure 3).

**Discussion:** Compared to spike washer fixation, the first cycle ATT with a suture-post was 4.6 times greater and the increase in ATT during 250 AP loading cycles was 2.0 times greater. Increased laxity from suture-post fixation can, in part, be attributed to progressive suture tightening around the graft tissue during testing. This resulted in loss of graft tension, which manifested as increased anterior laxity. This finding is important clinically, as increases in post-operative knee laxity have the potential to lead to knee instability and eventual clinical failure. Due to the high compliance of the suture-post fixation technique, its suitability for soft tissue graft fixation in ACL reconstruction is questioned.

**Significance:** Use of suture-post fixation in ACL reconstruction could lead to increased postoperative knee laxity and possibly early clinical failure.

![Figure 1. Six degree-of-freedom robot used to apply 250 cycles of ±134 N anteroposterior tibial force while recording anterior tibial translation.](image)
Figure 2. Tracing of 250 AP loading cycles (tibial translation vs. applied tibial force). Curves represent the mean of all 10 specimens. Suture-post fixation shows significantly greater first cycle ATT and increase in ATT over 250 cycles compared to both the native ACL and spiked washer fixation (p < 0.001). Peak posterior displacement was consistent for all tests.
**Figure 3.** A double stranded tibialis graft with suture-post fixation after completion of cyclic testing and suture removal. Whipstitch tightening within the graft tissue is apparent, as evidenced by deep grooves near the graft ends.