Arthrex ACL TightRope and Biomet ZipLoop with ToggleLoc: Mechanical Testing

Arthrex Research and Development

Objective

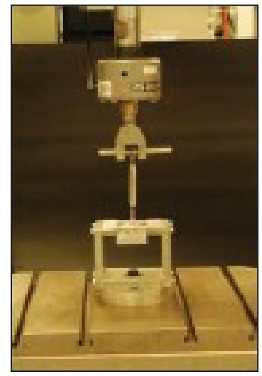
To compare the mechanical loading capabilities of two knotless suture/button constructs for ACL reconstruction. The constructs tested are the Arthrex ACL TightRope and the Biomet ZipLoop w/ToggleLoc.

Methods and Materials

Mechanical Testing: Mechanical testing of the knotless suture/button constructs was performed using an Instron 8871 Axial Table Top Servohydraulic Dynamic Testing System (Instron, Canton, MA) with a 5kN load cell attached to the cross-head. The buttons were held under a metal plate, while the suture loop was passed through a 4.5 mm hole. The suture loops were tightened over a hook fixture secured to the cross-head, as shown in Figure 1. Each sample was precycled from 10 - 50N at 1 Hz for 10 cycles, to remove slack from the constructs. Cyclic loading was performed from 50 - 250N at 1 Hz for 500 cycles. Post cycling, a load-to-failure was conducted at 20 mm/min. Load and displacement data were collected at 500 Hz. The ultimate load, load at 5 mm displacement, plastic cyclic displacement, and mode-of-failure were recorded for each sample.

Biomechanical Testing: Porcine femurs and bovine extensor tendons were used for this testing. The two knotless suture/button constructs were used to pull the tendons into 25 mm deep sockets. An adjustable angle fixture was secured to the testing surface of the Instron and the samples were oriented so that the direction of pull would be in line with the socket for a worst-case loading scenario. The free ends of the graft were secured to the cross-head in a vise fixture. The same loading profile used for the mechanical testing was used for the biomechanical testing. The ultimate load, plastic cyclic displacement, and mode-of-failure were recorded for each sample. Additionally, video tracking was used to determine the displacement at the fixation site.

Figure 1: Mechanical test set-up for the two knotless suture/button constructs



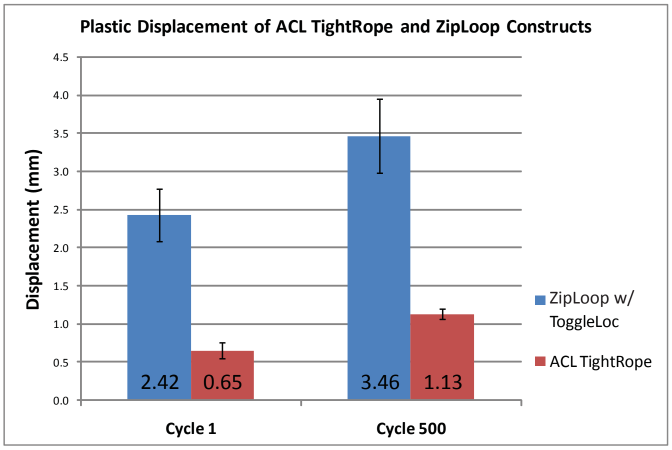
Results

The results of the mechanical testing are listed in Table 1. Although the ultimate load of the ZipLoop was larger than that of the ACL TightRope, this is irrelevant since the load at 5 mm displacement for the ZipLoop was almost half that of the ACL TightRope, which is highlighted in Table 1. Also, the ZipLoop had three to four times the cyclic displacement of the ACL TightRope. The displacement results are shown graphically in Figure 2. All differences were significant. The mode-of-failure for all samples of both constructs was the suture breaking.

Table 1: Mechanical testing results. X1 refers to the plastic displacement at the first cycle, and Xt is the plastic displacement after all 500 cycles

Mechanical Testing Results				
Construct	Ultimate Load (N)	Load at 5 mm (N)	Cyclic Displacement	
			X1 (mm)	Xt (mm)
ACL TightRope	993 ± 67	993 ± 67	0.65 ± 0.11	1.13 ± 0.007
ZipLoop w/ ToggleLoc	1276 ± 66	463 ± 45	2.42 ± 0.34	3.46 ± 0.48
Significance	p <0.001	p <0.001	p=0.024	p=0.024

Figure 2: The ACL TightRope had significantly lower plastic displacement than the ZipLoop

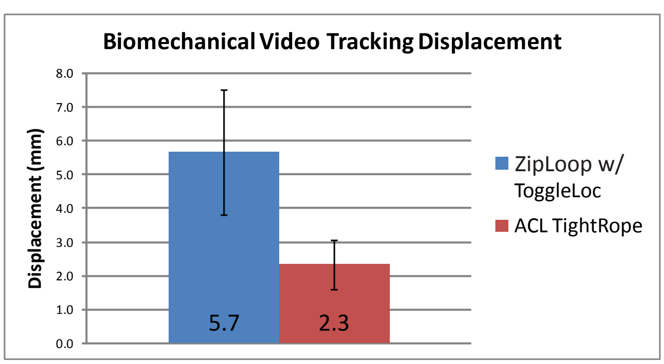


The biomechanical testing results are listed in Table 2. The ACL TightRope had significantly lower plastic displacement and video tracking values than the ZipLoop. Also, in the biomechanical model, the ACL TightRope had a higher average ultimate load. The mode-of-failure for the ACL TightRope samples were the suture or button breaking, and the mode-of-failure for all of the ZipLoop samples was the button cutting through the porcine bone. The digital video tracking displacement values are shown graphically in Figure 3.

Table 2: Biomechanical testing results

Mechanical Testing Results		
Construct	Ultimate Load (N)	Cyclic Disp. (mm)
ACL TightRope	849 ± 61	2.3 ± 0.7
ZipLoop w/ToggleLoc	655 ± 175	5.7 ± 1.9
Significance	p =0.145	p =0.044

Figure 3: The ACL TightRope had significantly lower graft displacement in biomechanical testing



Discussion

While the suture/button construct of the ZipLoop w/ToggleLoc had a larger ultimate load than the ACL TightRope in the mechanical test, the opposite was true when the constructs were tested biomechanically. The cause for this shift is because the mode-of-failure for the ZipLoop changed from one test to another. The off-center loading of the ToggleLoc results in a reduced load distribution area as compared to that of the ACL TightRope. In Figure 4, this effect is shown by the damage patterns in the foam block from the two button types.

Figure 4: Foam block button pull-through patterns of the ACL TightRope (left) and the ToggleLoc (right)

Porcine bone models are used extensively in biomechanical testing of ACL graft fixation devices because the biomechanical properties of this kind of bone tend to be more consistently superior to those of cadaver bones. The three samples of the ZipLoop all pulled through the cortical layer of the porcine bone at a mean load of 655N. The load required to pull the same button through the cortical layer of a human femur may be even lower.

Conclusion

The ACL TightRope has consistently and significantly lower plastic displacement values than the ZipLoop w/ToggleLoc. Also, in a biomechanical model, the Arthrex ACL TightRope provides a stronger and more secure repair than the Biomet ZipLoop w/ ToggleLoc.