Knotted with FiberWire® #2 versus Knotless with FiberWire® #2 and Knotless with FiberTape® - A Biomechanical Study

Arthrex Research and Development

Objective

The purpose of this study was to evaluate and compare a knotted technique using FiberWire #2 to a knotless technique using either FiberTape or FiberWire #2.

Materials and Methods

Specimen Preparation:

Test blocs used in this study were made of two solid rigid polyurethane foam layers; the top layer had a density of 20 pcf and a height of 3 mm and the main layer had a density of 10 pcf and a height of 40 mm. All test blocs used in this study were prepared in the same way using a mallet and a punch as described in the surgical technique. Each surgeon performed three knotted procedures using 5.5 mm Corkscrews with their own preferred arthroscopic knots with FiberWire #2 and three knotless specimens using a 5.5 mm SwiveLock with either FiberTape or with FiberWire #2.

Mechanical Testing:

Surgeons prepared 205 specimens in total for testing (see Table 1). Testing blocs were secured to a dynamic tensile testing system (ElectroPuls E10000; Instron, UK) with the sutures attached to a hook on a metal rod (see Figure 1). Specimens were each preloaded at 5N at 1 mm/s to remove any initial slack. After preloading, each specimen was pulled to failure at a constant displacement rate of 1 mm/s. Max load was defined as the load at which the suture or eyelet failed. Point of failure was noted. Load over extension were recorded for each specimen and used to calculate load at 3 mm (termed clinical failure), max load and stiffness. Stiffness of each specimen was compared to the average construct stiffness evaluated from Burkhart et al. (2013) of 70N/mm [1].

Analysis:

Statistical analysis was performed using Sigma Plot Statistics for Windows, version 12.0 (Systat Software Inc., USA). Groups were compared using t-test. The significance level was set at P=0.05. Data analysis was performed with Matlab (R2015b, USA) for each set of data and the mean, standard deviation (std), confidence interval (C.I.), highest and lowest values were calculated.

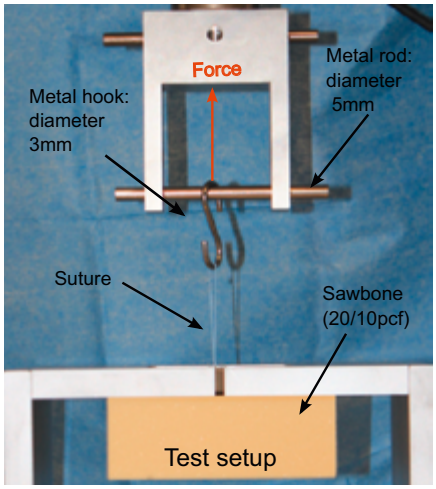


Figure 1: Test setup

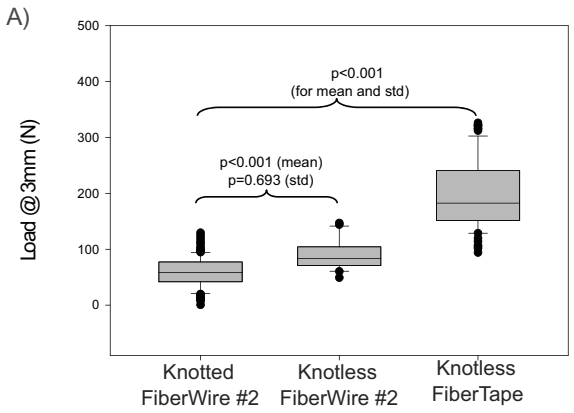
Results

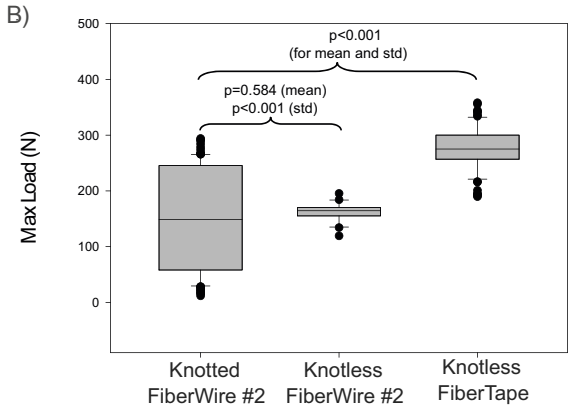
Technique		Load at 3mm (N)	Max Load (N)	Extension (mm)	Stiffness (N/mm)
Knotted FiberWire #2 N=105	C.I	54.0 - 64.6	132.7 - 168.9	11.1 - 14.5	24.1 - 27.3
	Mean	59.3	150.8	12.8	25.7
Knotless FiberWire #2 N=21	C.I	77.9 - 101.0	154.8 - 169.5	7.2 - 9.7	43.3 - 55.9
	Mean	89.5	162.2	8.5	49.6
Knotless FiberTape N=79	C.I	185.2 - 212.3	267.6 - 284.5	6.3 - 7.7	102.4 - 113.6
	Mean	198.7	276.1	7.0	108

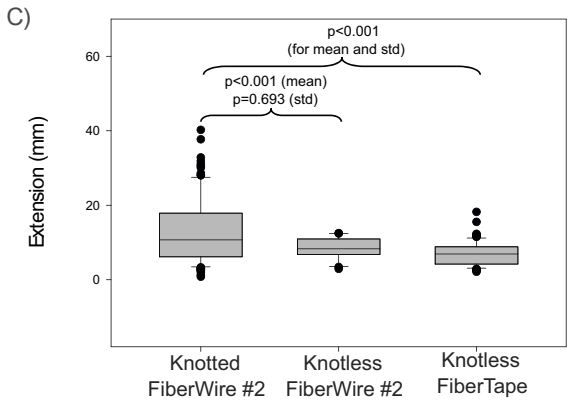
Table 1: Overview for all results

Knotted FiberWire failed 62 percent of the time due to knot slippage, 36 percent due to suture rupture and less than 3 percent due to eyelet plane breakage. Knotless FiberWire mostly failed due to suture slippage as well and 10 percent of samples failed due to anchor pull-out. In the knotless FiberTape specimen, 79 percent of anchors were pulled out and other causes of failure were suture slippage and bone bloc failure. There was no statistical difference between knotted and knotless FiberWire regarding the average ultimate load ($p=0.584$). Differences between knotted and knotless FiberWire regarding the standard deviation were neither significant in clinical failure ($p=0.693$) nor extension ($p=0.693$). Regarding the standard deviation and mean load values of the knotless FiberTape samples, there were significant differences (all $p<0.001$).

Arthrex® Research







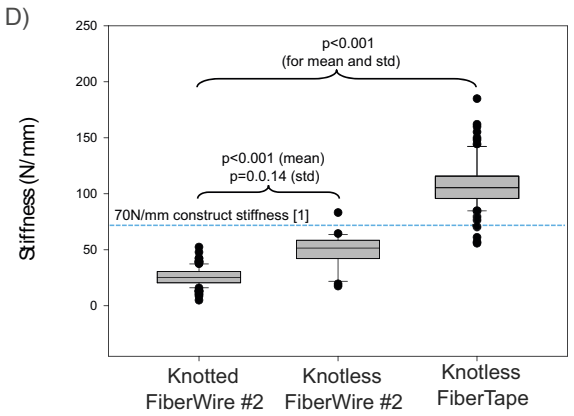


Figure 2:
Whisker bars plotted with black horizontal lines signify the median. The box extends from the 25th to the 75th percentiles, and the bars mark the 10th and 90th percentiles. Outliers are denoted as circles. For each technique the data are diagrammed for A) Mean load at 3 mm displacement B) Mean max load. C) Extension at max load and D) Stiffness.

Conclusion

Knotless technique using FiberTape withstood the highest load at clinical failure, showed the highest ultimate load in total, the least slippage and the greatest stiffness compared to all other constructs. Notably, unlike the other two techniques, the knotless anchor with FiberTape had a higher stiffness than the 70N/mm reference [1]. The ultimate load values of knotless FiberTape constructs were more consistent and therefore more reproducibility than the knotted technique which produced a large range of values. Considerable variations in knot strength between arthroscopic knots tied by surgeons is thought to be the reason for this [2].

Acknowledgments

Arthrex are grateful to the surgeons who took part in this study.

References

[1] S. B. Stephen, J. D. Patrick, K. John and H. T. Bryan, “Biomechanical Validation of Load-Sharing Rip-Stop Fixation for the Repair of Tissue-Deficient Rotator Cuff Tears,” The American Journal of Sports Medicine, vol. 42, no. 457, 2013.

[2] T. H. Bryan, M. D. Jeffrey, S. Lillian, L. Walt and S. B. Stephen, “Knot Strength Varies Widely Among Expert Arthroscopists,” The American Journal of Sports Medicine, vol. 42, no. 8, 2014.

Arthrex® Research