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Abrasiveness of high-strength sutures used in rotator cuff surgery: are they all the same?

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Background: The suture–tendon interface remains the most common point of failure in rotator cuff repairs via suture pullout. Several high-strength braided sutures are available for rotator cuff surgery and are more abrasive than monofilaments. However, a comparison of these sutures has not been performed in a tissue model.
Methods: Ninety infraspinatus sheep tendons were randomized among 9 groups of sutures (n = 10), including FiberWire (Arthrex, Naples, FL, USA), Collagen Coated FiberWire (Arthrex), Orthocord (DePuy Mitek, Raynham, MA, USA), MaxBraid (Biomet, Warsaw, IN, USA), Force Fiber (Teleflex, Research Triangle Park, NC, USA), ULTRABRAID (Smith & Nephew, Memphis, TN, USA), Phantom Fiber BioFiber (Tornier, Bloomington, MN, USA), and Ti-Cron (Syneture, Mansfield, MA), with Surgipro (Syneture) monofilament as a control. Each suture was cycled 50 times through the tendon, which was fixed to a mechanical testing system under a constant load in saline solution. The distance cut through the tendon was measured and divided by the distance of suture sliding to determine displacement (mm/cm). Twist angle and picks per inch of each suture were measured using digital photography. One-way analysis of variance was used to compare the displacement and twist angle between sutures.
Results: Collagen Coated FiberWire was the most abrasive of the high-strength sutures. Four of the sutures (Collagen Coated FiberWire, Phantom Fiber BioFiber, FiberWire, Ti-Cron) had a mean displacement rate greater than 0.150 mm/cm. The remainder of the sutures had a mean displacement rate less than 0.050 mm/cm (Orthocord, Force Fiber, MaxBraid, ULTRABRAID). The difference in the displacement rates between these 2 groups was significant ($P < .0001$) and was related to both the twist angle and the picks per inch.
Conclusion: Significant differences in suture abrasiveness were identified among high-strength braided sutures and correlated with lower twist angle and lower picks per inch.
Level of evidence: Basic Science Study, Biomechanics.

Keywords: Shoulder; rotator cuff; braided suture; abrasion; repair strength

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Arthroscopic repair is a popular modality for the treatment of rotator cuff injuries. Trends toward arthroscopic repair may be attributable to improved techniques, sutures,

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and anchors in addition to favorable outcomes and patient preference.[8,19,20,25-27] The advent of high-strength, abrasion-resistant suture material has decreased the incidence of suture breakage as the primary mode of failure, but recurrent tears after arthroscopic repair still occur.[1,3-5,10,11,28] The suture–tendon interface remains the most common point of failure in recurrent rotator cuff tears, with high strength sutures generally pulling through the tendon.[4,9]

Although the newer high-strength ultrahigh-molecular-weight polyethylene (UHMWPE) sutures have superior breaking strength and holding power, they also are more abrasive to rotator cuff tissue and joint cartilage than monofilament suture.[18,29] Sliding knots with braided sutures have demonstrated weakening of the suture–tendon interface, specifically with a sliding mattress knot having significantly weaker pullout strength compared with static mattress knots.[24] High-strength braided sutures also result in increased glove tears compared with monofilament.[17]

Although Kowalsky et al[18] demonstrated the UHMWPE/braided polyester suture, FiberWire (Arthrex, Naples, FL, USA), has increased abrasive properties compared with monofilament suture on the suture tendon interface, no study has used a tissue model to evaluate potential abrasive differences between various commercially available high-strength braided sutures. Since the publication of that report, multiple high-strength sutures are now available for surgical repair of rotator cuff tears. Given the importance of the suture–tendon interface on the integrity of rotator cuff repairs, we evaluated the abrasive properties of an assortment of commercially available high-strength sutures.[4,5,9,13] The purpose of this study was to classify these new high-strength sutures based on their abrasiveness toward the rotator cuff tendon, because this may have a clinical effect on the quality of the suture–tendon interface after repair.

Materials and methods

Infraspinatus tendons from 45 shoulders of 10-month-old sheep obtained from a slaughterhouse were dissected, and a wide osteotome was used to remove the remaining muscle tissue. The most distal aspect of the tendons was trimmed perpendicular to their long axis at the point where they began to insert onto the greater tuberosity. This created samples with maximum tendon thickness and uniformity at their distal extent. Each tendon was cut in half longitudinally, yielding 2 distinct grafts from each shoulder. All tendon grafts were visually inspected for any abnormalities or defects, and defective tendons were discarded. Infraspinatus sheep tendons were used because they are a well-established model for testing the biomechanical properties of different sutures and stitches for rotator cuff repair and because they have histologic characteristics and pullout strength similar to human supraspinatus tendons.[12-14,18,21-23]

The 90 grafts were randomly divided into 9 groups of 10. Each group had 1 of 9 sutures passed through them. The nine sutures tested were:

1. FiberWire (Arthrex, Naples, FL, USA)
2. Collagen Coated FiberWire (Arthrex)

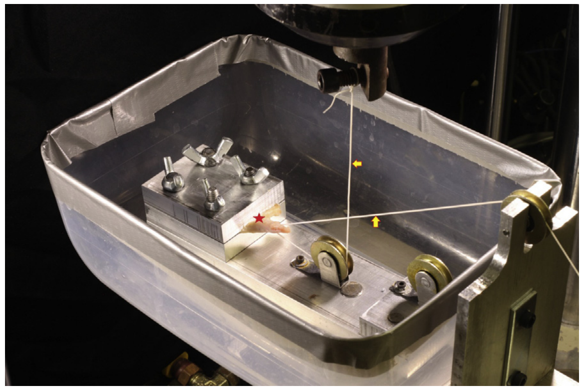

Figure 1 Testing apparatus. The tendon is marked with *red star*. Suture is denoted by the *yellow arrows*.

3. Orthocord (DePuy Mitek, Raynham, MA, USA)
4. MaxBraid (Biomet, Warsaw, IN, USA)
5. Force Fiber (Teleflex, Research Triangle Park, NC, USA)
6. ULTRABRAID (Smith & Nephew, Memphis, TN, USA)
7. Phantom Fiber BioFiber (Tornier, Bloomington, MN, USA)
8. Ti-Cron (Syneture, Mansfield, MA, USA)
9. Surgipro monofilament as the control (Syneture)

A #7 Mayo needle was used to pass each suture through the middle of the tendon 1 cm proximal to the end of the tendon. The smoother tip of a Mayo needle and the creation of smaller holes in the tendon reduce the risk of tendon failure compared with other suture-passing instruments.[6] After suture passage, testing was performed with the grafts in a physiologic solution to more closely represent in vivo conditions as described in previous works.[29] In sum, 10 specimens were created for each of the 9 sutures.

Before biomechanical testing, the proximal end of the tendon graft was rigidly fixed in a custom clamp and connected to the base of the abrasion jig. One of the suture free ends was passed through a pulley and attached to the actuator of a uniaxial mechanical testing system. The other free end was attached to a 1.5-kg counterweight and hung freely off the side of the jig with the use of pulleys. The thickness, length, and width of the tendon were measured with a Vernier caliper (0.01-mm resolution).

After the tendons were clamped, each trial was conducted in a phosphate-buffered saline solution at ambient temperature to create physiologic testing conditions (Fig. 1). One of the 9 sutures was cycled back and forth through the center of a tendon at a rate of 0.6 Hz and an excursion of 4 cm per cycle. The counterweight provided a constant load of 14.7 N to the end of the suture for each trial. This protocol does not represent physiologic rates and loads present during postoperative rotator cuff surgery as described in previous studies.[5,12,15,24] Instead, this protocol replicates the model for an environment of maximal abrasion, as described in previous works, to delineate differences in the abrasive properties of each suture.[2,18,29]

Each trial consisted of 50 cycles of the suture moving back and forth through the center of the tendon. After 50 cycles, a Vernier caliper (0.01-mm resolution) was used to measure the displacement of the suture as the suture cut through the tendon. Each measurement of displacement was repeated 3 times by a single observer to increase the reliability of the measurement, and the average of the measurements was recorded and transferred to Excel software (Microsoft Corp, Redmond, WA, USA). The