J Shoulder Elbow Surg (2018) ■■, ■■–■■

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

ORIGINAL ARTICLE

Mechanical and imaging evaluation of the effect of sutures on tendons: tape sutures are protective to suture pulling through tendon

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Background: High-strength sutures, including #2 and tape-type, are popular when performing arthroscopic rotator cuff repair. Although the most common mechanism of anatomic failure of rotator cuff repair is suture pulling through tendon, the effect of sutures on the suture–tendon interface has rarely been investigated. We evaluated the effect of commercially available modern high-strength standard #2 and tape-type sutures on tendon.
Methods: Isolated sutures (FiberTape, #2 FiberWire [Arthrex Inc., Naples, FL, USA], Ultratape, and #2 Ultrabraid [Smith & Nephew, Andover, MA, USA]) and suture-tendon constructs using sheep infraspinatus tendons were evaluated using mechanical testing and imaging (microcomputed tomography) techniques.
Results: For the 4 suture–tendon constructs evaluated, maximum and residual displacements were all less than 3 mm. Whether evaluating isolated sutures or suture–tendon constructs, tape-type sutures had smaller displacements than standard #2 sutures when products from the same company were compared. On initial suture passing and after mechanical testing, hole volume was larger in constructs with tape-type rather than standard #2 sutures comparing within the same company. Collectively, constructs with larger hole volumes after mechanical testing had stiffer sutures. The percentage difference in hole volume was larger for standard #2 than tape-type sutures: FiberWire (43%), Ultrabraid (17%), FiberTape (11%), and Ultratape (9%).
Conclusions: Tape-type sutures created larger final holes than standard #2 sutures from the same company. When initially passed through the tendon, tape-type sutures produced larger holes than standard #2 sutures; however, standard #2 sutures enlarged their initially smaller holes more and displaced more than tape-type sutures during cyclic loading, which suggests that tape-type sutures may be protective to suture pulling through tendon.
Level of evidence: Basic Science Study; Biomechanics

Keywords: Suture pulling through tendon; tape suture; rotator cuff repair; shoulder; tendon; suture; mechanics; imaging

This study was performed under the guidance of the Animal Welfare and Ethical Review Body.

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https://doi.org/10.1016/j.jse.2018.03.004

With the advent of arthroscopy and related technologies, surgical repair of rotator cuff tears has become extremely common.[11] Historically, the most common suture used has been a braided #2 suture (eg, #2 Ethibond; Ethicon, Somerville, NJ, USA). A number of high-strength standard sutures were subsequently introduced and popularized.[6,7] More recently, tape-type sutures, composed of the same materials but stiffer than standard sutures, have been used and proposed to provide a wider contact area at the tendon–bone interface, leading to superior fixation with better force distribution at the rotator cuff footprint.[1]

Furthermore, the wider flat shape of tape-type sutures compared with standard #2 sutures has been proposed to limit the suture from pulling through the tendon when subjected to load. Broader contact at the suture–tendon interface provided by tape-type sutures theoretically distributes load across a larger suture-tendon interface, reducing stress and preventing the suture from pulling through the tendon. In contrast, tape-type sutures, when passed through the tendon, could create a larger hole through the tendon due to their size. This larger defect may, in fact, compromise the suture–tendon interface and create a mechanical scenario opposite to their proposed advantage.

In addition, the composition and construction of standard or tape-type suture (eg, material properties and morphologic structure) likely affect the suture–tendon interface, particularly when placed under cyclic loading. However, this suture pulling through tendon characteristic of sutures (ie, standard #2 sutures or tape-type sutures) has rarely been evaluated. This characteristic is extremely relevant because the most common mechanism of anatomic failure of rotator cuff repair is the suture pulling through the tendon.[3,13]

Our purpose was therefore to biomechanically evaluate the effect of commercially available, modern, high-strength standard #2 sutures and tape-type sutures on tendon, with a particular focus on the size of the holes created through the tendon. We hypothesized that tape-type sutures would create larger holes than standard #2 sutures.

Materials and methods

Suture samples

Isolated sutures and suture-tendon constructs were evaluated using mechanical testing (Fig. 1). Microcomputed tomography (microCT) imaging techniques were also used to evaluate suture–tendon constructs that underwent mechanical testing and suture–tendon constructs that underwent suture passing but without mechanical testing (Fig. 1). We evaluated 1 tape-type suture and 1 standard #2 suture from 2 different companies: T1 (tape 1) FiberTape and S1 (standard 1) #2 FiberWire (Arthrex Inc., Naples, FL, USA); T2 (tape 2) Ultratape and S2 (standard 2) #2 Ultrabraid (Smith & Nephew, Andover, MA, USA). These sutures were selected because they are the only commercially available sutures composed of the same basic materials that have both standard #2 and tape-type sutures. We used 44 samples of each suture type (Fig. 1): 24 samples for mechanical testing of suture–tendon constructs and microCT analysis of constructs with mechanical testing, 12 samples for mechanical testing of isolated sutures, and 8 samples for microCT analysis of constructs without mechanical testing.

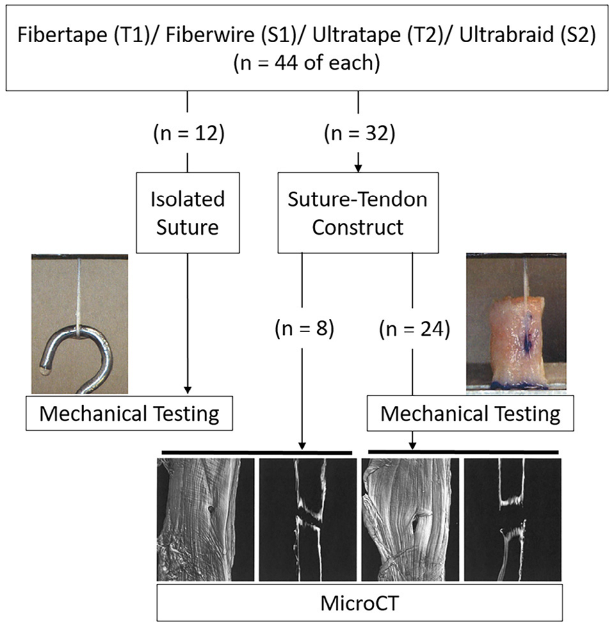

Figure 1 Study protocol. *T1*, tape 1; *S*1, standard 1 (both Arthrex Inc., Naples, FL, USA); *T2*, tape 2; *S2*, standard 2 (both Smith & Nephew, Andover, MA, USA).

Suture–tendon constructs

Sheep were euthanized according to standards of the Animal Welfare and Ethical Review Body and the infraspinatus tendons were obtained from the shoulders of 32 Bluefaced Leicester × Suffolk sheep (4.5 years old). The infraspinatus tendon was isolated proximally from the muscle tissue and distally from the greater tuberosity. Each tendon was split longitudinally into 2 strips of equivalent width (minimum 1 cm). Thus, 4 tendon strips were obtained from each sheep. Sheep infraspinatus tendons were chosen because they were commonly used in previous studies as a well-established model for biomechanical testing of rotator cuff, in particular for their similarity in histologic and mechanical properties to human supraspinatus tendon.[8,9,15]

Tendons were mounted on an Acufex Graftmaster III (Smith & Nephew), and sutures were passed perpendicularly through the tendon centered in the width of the tendon and 1 cm medial to the distal end. To eliminate any possible effect of arthroscopic suture passing instruments, sutures were passed through the tendon using a standardized tapered needle swaged on the suture end. Once sutures were implanted, suture–tendon constructs were frozen and stored in a −20°C freezer.

Mechanical testing

Mechanical testing was performed using an Instron model 8872 (Instron, Norwood, MA, USA) with a 1 kN dynamic load cell and