High-Tensile Strength Tape Versus High-Tensile Strength Suture: A Biomechanical Study

LCDR Ryan J. Gnandt, M.D., USN, LT Jennifer L. Smith, M.D., USN, Kim Nguyen-Ta, M.S., LCDR Lucas McDonald, M.D., M.P.H.&T.M., USN, and LCDR Lance E. LeClere, M.D., USN

Purpose: To determine which suture design, high-tensile strength tape or high-tensile strength suture, performed better at securing human tissue across 4 selected suture techniques commonly used in tendinous repair, by comparing the total load at failure measured during a fixed-rate longitudinal single load to failure using a biomechanical testing machine. **Methods:** Matched sets of tendon specimens with bony attachments were dissected from 15 human cadaveric lower extremities in a manner allowing for direct comparison testing. With the use of selected techniques (simple Mason—Allen in the patellar tendon specimens, whip stitch in the quadriceps tendon specimens, and Krackow stitch in the Achilles tendon specimens), 1 sample of each set was sutured with a 2-mm braided, nonabsorbable, high-tensile strength tape and the other with a No. 2 braided, nonabsorbable, high-tensile strength suture. A total of 120 specimens were tested. Each model was loaded to failure at a fixed longitudinal traction rate of 100 mm/min. The maximum load and failure method were recorded. **Results:** In the whip stitch and the Krackow-stitch models, the high-tensile strength tape had a significantly greater mean load at failure with a difference of 181 N ($P = .001$) and 94 N ($P = .015$) respectively. No significant difference was found in the Mason—Allen and simple stitch models. Pull-through remained the most common method of failure at an overall rate of 56.7% (suture = 55%; tape = 58.3%). **Conclusions:** In biomechanical testing during a single load to failure, high-tensile strength tape performs more favorably than high-tensile strength suture, with a greater mean load to failure, in both the whip- and Krackow-stitch models. Although suture pull-through remains the most common method of failure, high-tensile strength tape requires a significantly greater load to pull-through in a whip-stitch and Krakow-stitch model. **Clinical Relevance:** The biomechanical data obtained in the current study indicates that high-tensile strength tape may provide better repair strength compared with high-tensile strength suture at time-zero simulated testing.

See commentary on page 364

For the repair of tendon and musculotendinous injuries, surgeons have the options of using different suture materials, suture designs, and repair techniques. The optimal repair also may depend on the anatomy and mechanics of the specific tendon or musculotendinous unit that is being repaired.[1,2] Variability exists in soft-tissue repair and the causes can be multifactorial. Different suture materials, sizes, and designs as well as the different suturing techniques lead to a variability of results. For example, in published reports of pectoralis major repair alone, the use of both absorbable[3,4] and nonabsorbable[5,6] suture material has been reported with sizes ranging from No. 1 to No. 5.[7] In a clinical scenario, one must consider the forces that will be applied to the repair when selecting the suture material, size, technique, and now even design, with the use of polyblend suture and suture tape.[7,8]

Suture tape consists of a high-strength, nonabsorbable polyblend suture core, centrally incorporated within a flat braided construction of an ultra-high molecular weight polyethylene (UHMWPE) fiber blended with fibers of one or more long chain synthetic polymers, preferably polyester.[8] The larger tissue

From the Orthopaedic Surgery Department, Dana C. Covey Orthopaedic Biomechanics Laboratory, Naval Medical Center San Diego, San Diego, California, U.S.A.

The authors report they have no conflicts of interest in the authorship and publication of this article.

The views and opinions expressed in this article are those of the authors and are not necessarily representative of the official policy or views of the Department of the Navy, the Department of Defense, nor the U.S. Government.

Received February 10, 2015; accepted August 7, 2015.

Address correspondence to LCDR Lance E. LeClere, M.D., USN, US Naval Academy, Naval Health Clinic Annapolis, 250 Wood Road, Annapolis, MD 21402, U.S.A. E-mail: LeClere.Navy.Sports@gmail.com

Published by Elsevier Inc. on behalf of the Arthroscopy Association of North America

0749-8063/15109/$36.00

http://dx.doi.org/10.1016/j.arthro.2015.08.013

contact area of a suture tape theoretically allows force to be spread across a broader tissue area, thereby potentially allowing for improved performance in securing tissue. A variety of clinical and biomechanical studies have compared repair techniques across different tissue types with various materials and methods.[1,2,9-18] To our knowledge, no study had been conducted focusing on the suture−tendon interface and comparing high-tensile strength suture and high-tensile strength tape across 4 different models of human tissue repair while matching the compared human tissue samples perfectly for anatomic site, tissue quality, and repair technique.

In this study we sought to determine which suture design, high-tensile strength tape or high-tensile strength suture, performed better in securing human tissue across 4 selected suture techniques commonly used in tendinous repair, by comparing the total load at failure measured during a fixed-rate longitudinal single load to failure using a biomechanical testing machine. Given the larger surface area of suture to tissue contact, we hypothesized that high-tensile strength tape would perform better at securing human tissue, with a greater total load at failure across all of the suture techniques tested.

Methods

Tissue Dissection

Tissue specimens were obtained from the lower extremities of 9 cadavers with a mean age of 74 (range, 53 to 89 years), of which 7 were female (11 experimental tissue set groups) and 2 were male (4 experimental tissue set groups). Fifteen individually numbered fresh-frozen human lower extremities available for use were dissected to obtain the knee extensor mechanism (quadriceps muscles, quadriceps tendon, patella, patellar tendon, and tibial tubercle) and the ankle plantar−flexion mechanism (gastrocsoleus complex, Achilles tendon, and calcaneus). The samples were thawed overnight and were kept moist with normal saline throughout the testing process. The patella was transected transversely to separate the patella−quadriceps tendon bone−tendon unit from the rest of the knee extensor mechanism. The superior hemipatella and quadriceps tendon were then split longitudinally down the midline to create a paired set of specimens. The remainder of the knee extensor mechanism was then transected transversely through the midpoint of the patellar tendon. The 2 resultant specimens were then split longitudinally down the midline, through the inferior hemipatella and proximal patellar tendon, as well as the distal patellar tendon and tibial tubercle. This produced 15 matched sets of patella−patellar tendon specimens and 15 matched sets of tibial tubercle−patellar tendon specimens. Finally, each calcaneus−Achilles tendon specimen was split longitudinally down the midline through the Achilles tendon and calcaneal bone segment producing 15 matched sets of calcaneus−Achilles tendon specimens (Fig 1).

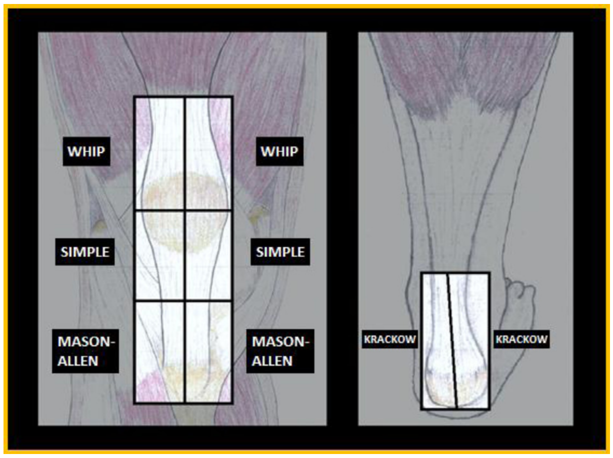

Fig 1. The knee extensor mechanism and Achilles−calcaneus tissue specimens were dissected and sectioned as illustrated to produce the paired bone−tendon tissue samples (illustrations by R.J.G.). Within each matched set, one sample was sutured with a high-tensile strength tape and the other with a high-tensile strength suture.

Study Design

This study was approved the institutional research board (NMCSD.NHU.2013.0006). A braided nonabsorbable polyblend high-tensile strength suture and a braided nonabsorbable polyblend high-tensile strength tape from the same manufacturer were selected to minimize any variances in manufacturing materials and methods. The suture selected was a No. 2 FiberWire (Arthrex, Naples, FL). This suture consists of a multistrand, long-chain UHMWPE core with a braided jacket of polyester and UHMWPE. The suture tape selected was 2-mm FiberTape (Arthrex). This is a 2-mm wide, ultra-high strength tape using a similar long chain polyethylene structure as the FiberWire suture.[8]

The dissection technique produced 60 paired sets of bone−tendon tissue samples, with each set matched for tissue type and quality. One sample of each pair was sutured with high-tensile strength tape and the other with high-tensile strength suture. In total, 120 samples of lower-extremity human cadaveric bone−tendon units were tested (15 specimens tested with suture and 15 specimens tested with tape for each of the 4 tissue repair models).

The sutured bone−tendon tissue samples were loaded onto an ADMET eXpert 2653, 50kN-Q Dual Column Universal Electromechanical Testing Machine (ADMET; Norwood, MA), equipped with ADMET grips and fixtures (Fig 2). The testing system was calibrated according to ASTM International and International