The Journal of Foot & Ankle Surgery 53 (2014) 298–302

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Collagen Ribbon Augmentation of Achilles Tendon Tears: A Biomechanical Evaluation

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ARTICLE INFO

Level of Clinical Evidence: 3

Keywords:
box weave
cadaver
early motion
Krackow suture
mechanical testing
xenograft

ABSTRACT

Early motion of a repaired Achilles tendon has been accepted to improve both clinical and biomechanical outcomes. It has been postulated that augmenting a primary Achilles tendon repair with a collagen ribbon will improve the repair construct's initial strength, thereby facilitating early motion. The purpose of the present study was to compare the failure load of Achilles tendon defects repaired with suture, with or without augmentation with a collagen ribbon. Ten matched pairs of cadaveric feet and tibiae underwent simulated Achilles tendon tear in the watershed area and were then repaired with 4-strand Krackow sutures only or were sutured and augmented with a box weave collagen ribbon xenograft. The specimens were prepared for testing by keeping the insertion of the Achilles to the calcaneus intact and dissecting the gastrocnemius at its origin, leaving the repair undisturbed. The mean load at failure for the augmented (suture plus collagen ribbon) specimens was 392.4 ± 74.9 N. In contrast, the mean load at failure for the suture-only (control) construct was 98.0 ± 17.6 N ($p < .001$). The augmented specimens demonstrated a greater mean strength of 4.1 ± 0.9 N (range 3.2 to 5.6). After cyclic loading, the mean gap across the Achilles repair was significantly smaller in the augmented group than in the control group ($p = .006$). We have concluded that box weave collagen ribbon augmentation of the primary suture Achilles tendon repairs can provide enhanced gap resistance and strength under cyclic loading and ramped tensile testing.

Early exposure to a tensile load has been convincingly demonstrated to improve the microscopic parallel orientation of the repair tissue in tendons (1). In turn, an improved biomechanical structure will correlate with greater tensile failure loads. These findings have supported the accepted protocol in the treatment of tendon tears of early, protected motion. We also know that early motion of a repaired structure must be balanced against the risk of disrupting the surgical repair site. Failure at the repair site can manifest by gapping or complete failure, both a significant compromise of the original surgical intent. The treatment strategies for Achilles tendon tears have included surgical repair or temporary protected ambulation. In both cases, the tendon will be exposed to load early in the healing cascade. Debate has continued surrounding which modality provides the best benefit to risk ratio. In the case of surgical repair, the disrupted tissue ends will be debrided and reapproximated. The tension of the overall Achilles complex will be set to match the contralateral side. Strategies to enhance the surgical repair have included variations in suture material, suture thread patterns through the tissue, and tissue augmentation.

The published reports of tissue augmentation of Achilles tears have included the use of allograft, autograft, and xenograft material. The surgical techniques have included wraps, weaves, and onlay augmentation of suture repairs. In the present report, we describe the use of a xenograft collagen ribbon (Trellis™ Collagen Ribbon, Wright Medical Technology, Arlington, TN) used in a weave box pattern to augment a simulated acute Achilles tendon tear. The strength of the augmented construct was compared with that of a simulated acute Achilles tear repaired with an accepted suture material only (Krackow) repair.

Materials and Methods

Ten matched pairs of fresh frozen human cadaveric feet and tibiae from males aged 25 to 55 years, to represent patients with the "most typical" acute defect, were received frozen (MERI, Medical Education & Research Institute, Memphis, TN) and stored frozen

Financial Disclosure: Research support was received from Wright Medical Technologies in support of this project.

Conflict of Interest: Dr. Blum is a paid employee and stockholder of Wright Medical Technology, Inc. Drs. Berlet, Hyer, and Lee are paid consultants of Wright Medical Technology, Inc.

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http://dx.doi.org/10.1053/j.jfas.2014.02.001

(−20°C) until use. The limbs were thawed to an ambient temperature (15°C to 25°C) in a refrigerator and/or under ambient conditions. The dissection and repair were conducted immediately after the specimens had reached an ambient temperature. The specimens were tested at an ambient temperature within 18 hours of repair. The 2 specimens that had been tested more than 2 hours after repair were refrigerated overnight (4°C). One of us (T.H.L. or C.F.H.) prepared each pair of limbs and executed the surgical maneuvers, and another 1 of us (B.E.B.) performed the biomechanical testing and statistical analyses of the results. A defect was sharply created 5 cm above the calcaneal Achilles insertion in the Achilles tendon of each specimen. The Achilles tendon was repaired with suture only (4-strand Krackow; no. 2 Ethibond EXCEL®, Ethicon, Somerville, NJ) or with the suture method augmented with a xenograft collagen ribbon configured in a box weave pattern. Collagen ribbons, 5 mm wide × 1.3 mm thick × 22 cm long (Trellis™ Collagen Ribbon) were hydrated in saline in accordance with the product instructions for use (10 to 60 minutes). In the augmented group, primary suture repair was performed first. Then, a small trans-Achilles tunnel was created both superiorly and distally to the Krackow suture repair. The collagen ribbon was passed from medially to laterally through the proximal tunnel. Next, the ribbon was brought distally, and the ends were passed through the tunnel, one from

Fig. 1. (*A–D*) Box weave pattern of collagen ribbon.