INTRODUCTION

Acellular biological matrices have been used frequently in the augmentation of tendon and ligament injuries to reduce the retear rate and to improve clinical outcome. These matrices are designed to serve two functions: provide immediate augmentation to the repair site through load sharing and suture retention as well as provide a biological scaffold for cell and vascular ingrowth, remodeling of the extracellular matrix, and regeneration of new host tissue. A number of commercially available matrices have been used, albeit with varying degrees of success. The disparity in clinical outcomes is likely due to the different physical and biochemical properties of individual matrices as a result of tissue origin, graft processing, the use of cross-linking agents to strengthen the original tissue, and collagen structure. In the present study, a sheep Achilles tendon repair model was used to compare the biomechanical characteristics of two collagen matrices: a bovine dermis matrix and a human allograft dermis matrix. We hypothesized that Achilles tendon repair augmented with these matrices would be improved independently of the matrix used.

METHODS

Acellular matrices: the bovine dermis matrix (TissueMend®, TEI) and the human allograft dermis matrix (GraftJacket®, TEI) were obtained from the manufacturers and hydrated before the surgical procedure according to the manufacturers’ instructions.

Surgical procedure: Eight pairs of fresh-frozen sheep Achilles tendons were harvested with the calcaneus attached. A simulated Achilles tendon rupture was created 3 cm proximal to the calcaneal insertion. The rupture was repaired using Krackow locking loop stitch with #2 Fiber Krackow sutures.

Mechanical testing: After repair, the specimen was mounted in a MTS servo-hydraulic testing system using custom designed grips to ensure anatomical alignment. The tendon was preloaded to 10 N for 30 sec followed by cyclic loading for 20 cycles from 5 N to 30 N under load control at a rate of 5 N/sec. The tendon was then tested to failure at a constant displacement rate of 6 mm/sec. Force and displacement data were collected at 20 Hz and the mode of failure was recorded.

Data analysis: Force and displacement data were imported into Microsoft Excel for analysis. Static creep, cyclic creep, cyclic construct stiffness, linear construct stiffness, maximum load to failure, and displacement at maximum load were determined (n = 8 for all parameters with the exception of n=5 for cyclic stiffness). Paired t-tests and RM-ANOVA were performed using SYSTAT 12. The significance was determined at p<0.05.

RESULTS

Tendons augmented with TissueMend showed 47% less elongation than those augmented with GraftJacket after the initial holding phase (Table 1). This lower creep for the TissueMend group was statistically significant (p=0.029). Similarly, the creep of TissueMend augmented tendons during cyclic loading was statistically lower than those GraftJacket augmented tendons at cycles three through 20 (Fig. 1) (p ≤ 0.002 for each cycle). All 16 samples survived the cyclic loading and were loaded to failure afterwards.

Augmentation with TissueMend resulted in a similar failure load to GraftJacket (p=0.431, Table 1 & Fig. 2). The construct displacement was similar in both groups (p=0.054). Cyclic stiffness and linear construct stiffness were similar for TissueMend and GraftJacket (p=0.095 and p=0.084, respectively, Table 1). All constructs failed by suture pulling though the augment material followed by breakage of Krackow sutures.

DISCUSSION

We investigated two commercially available tendon augment grafts on their ability to enhance tendon repair at time zero. While the matrices alone may exhibit differences in mechanical properties, the true comparison resides in a model where matrices are tested in their realistic compositional and collagen structure likely contribute to the mechanical difference observed in the study.

In addition to strengthening the repaired tendon at the time of surgery, these biological matrices are also designed to promote constructive tissue remodeling. In the future, prospective, randomized clinical trials are desired to further elucidate the function and efficacy of these matrices in the repair and regeneration of ruptured tendons.

REFERENCES