Augmentation of Achilles Tendon Repair Using a Decellularized Porcine Dermal Graft Compared to Two Other Collagen Xenografts

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Introduction: Complete rupture of the Achilles tendon in the young, active patient is often surgically repaired by suturing the tendon fragments end-to-end. The repair can be augmented using a collagen graft to form a stronger construct. In this study, we employ a canine model to examine a new decellularized porcine dermal graft in comparison to two control xenografts currently in clinical use. We hypothesized that the experimental porcine collagen graft would allow vascularization and repopulation by fibroblasts with minimal inflammatory response.

Materials and Methods: Under an IACUC-approved protocol, the left Achilles tendon in 9 adult male hound-type canines (25-33kg) was surgically transected to simulate a complete tendon rupture and was immediately repaired using a Kessler suture technique and augmentation with 1 of 3 processed acellular collagen xenografts. In the canine, the Achilles (calcaneal) tendon is composed of the medial and lateral gastrocnemius tendons, both of which were transected transversely 3 cm proximal to the tuber calcanei and repaired separately. Three of the dogs received an experimental, non-cross-linked porcine dermal graft (BIOTAPE XM™, Wright Medical Technology); 3 received a multi-layered porcine small intestine submucosa graft (Restore® Orthobiologic Soft Tissue Implant, DePuy); and the other 3 dogs received a cross-linked equine pericardium graft (OrthADAPT™ FX Biocompatible, Pegasus Biologics). After the tendons were apposed, the entire anastomosed site was covered with one of the rectangular collagen grafts as a complete circumferential wrap. The long edges of the rectangular graft were joined with a continuous pattern of fine suture. In this manner, the graft acted as a sleeve over the repair site, overlapping each end of the transected tendons by approximately 1.5 cm and secured at each end with simple interrupted sutures. To protect the tendons during the initial healing period, the tarsocrural joint was fixed in full extension by inserting a screw through proximal calcaneus into the distal tibia. Cefazolin was administered for five postoperative days and cefazolin intraoperatively. The dogs were allowed unrestricted activity and were evaluated for wound healing and weight bearing. The screw was removed after 4 weeks, allowing full use of the repaired tendon.

Results: There were no intraoperative or postoperative complications. All incisions healed normally, and no drainage occurred throughout the study. The dogs were weight bearing on the limbs within 3 days and continued to use the limb throughout the 6-week period. At the time of screw removal, all tendons exhibited normal tension comparable to the contralateral limb with none of the tarsocural joints exhibiting hyperflexion. Throughout the remainder of the study, all of the tarsocural joints maintained normal stance position. Thus clinically none of repaired tendons failed. At necropsy, the tendon bundles were hypertrophied relative to the contralateral unoperated tendons for all animals in the three augmentation graft groups (p≤0.032, Friedman test). Those treated with the equine pericardium graft (mean width = 1.7 cm) tended to be more hypertrophied than those with porcine dermal grafts (1.2 cm) (p=0.072).

Histologically, healing was evident at the anastomosed tendon ends in all of the animals in a similar manner by 6 weeks and consisted of neovascularization and fibroblastic proliferation, bridging the tendon defect and incorporating the cut tendon surfaces. There were distinct differences among the 3 grafts with regard to the degree of inflammation, incorporation by the host, and remodeling and replacement of the implanted collagen matrices.

Most of the porcine dermal graft was still evident surrounding the tendon and was substantially repopulated with fibroblasts and blood vessels (Figure 1). There was also a mild, scattered infiltrate of lymphocytes and plasma cells. There were focal sites of incorporation of the graft into tendon. In contrast, the porcine small intestine submucosa graft was no longer evident at 6 weeks except for a layer of fibrous tissue surrounding the tendon with aggregates of lymphocytes, plasma cells, and macrophages scattered throughout (Figure 2).

The cross-linked equine pericardium graft demonstrated a pronounced foreign-body response and little incorporation or replacement by host tissue (Figure 3). Both the inner surface of the graft facing the tendon and its outer surface were lined with foreign-body granulomas composed of giant cells and macrophages, completely separating the graft from the tendon and adjacent tissues. The graft appeared intact at 6 weeks with little cellular or vascular infiltration. There were, however, foci of infiltration by granulocytes and areas of mucoid degeneration.

Discussion: The 3 xenograft materials demonstrated marked differences in their rates of remodeling and replacement and the nature and degree of inflammatory response, although clinically, a similar functional result was obtained at this early time point. Achilles tendon function of the tarsocural joint at 6 weeks is dependent on the presence of the graft material, the non-absorbable tendon sutures utilized, and the early fibroblastic healing of the tendon, which at this point has most likely not regained full tendon strength. For this reason, concerns arise regarding the small intestine submucosa graft that, as reported previously, dissipates rapidly and with the equine pericardium, which had little host incorporation and induced a florid foreign-body reaction at both the outer surface of the graft and at the tendon-graft interface. In contrast, the porcine dermal graft was substantially intact, repopulated with blood vessels and fibroblasts and demonstrated only a mild scattered inflammatory response. Thus, the durability and biocompatibility of the porcine dermal graft may be important for continued augmentation of the injured site until complete tendon healing and function is achieved.

Acknowledgement: Funded by Wright Medical Technology, Inc. Arlington, TN.