CHAPTER **49**

EQUINE XENOGRAFTS FOR RECONSTRUCTIVE SURGERY

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INTRODUCTION

Xenografts, tissue derived from animals, have been used for replacement or augmentation in human surgery for several decades. In fact, their use first appeared in the European literature as early as 1881. Tissues of bovine, porcine, and equine origin, as well as allografts, have been implanted to repair or reconstruct heart valves, ventricular septal defects, damaged tendons, ruptured ligaments, and skin deficits. They have also been utilized as dural substitutes to protect the brain.

These graft tissues function as collagen scaffolds (Table 1) so the host can rebuild the structures that are damaged or absent (1). Since these xenografts are dramatically foreign to the human host, one of the main problems with their implantation is the immunogenic reactions that they stimulate. This is largely thought to be due to the cellular components, glycoproteins, and proteoglycans that make up the matrix of these animal tissues. The result of this host reaction and inflammatory infiltration is a weakening of the repair, particularly the graft-host junction, increasing the possibility of failure due to rupture, rejection or inflammatory breakdown (2).

Normally, there is an anticipated loss in strength and mass at the graft interface during the initial phases of remodeling (3) (Table 2). This is largely due to the initial process of organized removal and digestion, mediated by a number of different proteolytic enzymes belonging to the metalloproteinase family (4-7). This digestive activity can be prolonged or magnified by the immunogenic response, reaction to toxic chemical stabilizers such as gluteraldehyde, or by the sterilization process especially when ethylene oxide is used to avoid the degradative effects of heat sterilization. The result is an accelerated degradation of the implanted collagen scaffold that can result in scar formation and suboptimal repairs (8).

THE IDEAL XENOGRAFT

Ideally, then, the need is for a bioimplant that can resist reactive breakdown and maintain strength against expected anatomic forces in this histologic environment as the repair process matures (9). The ideal graft should also be relatively easy to store, prepare and use (10). Equine pericardium, processed with proprietary technologies, appears to fulfill these prerequisites (OrthADAPT; Synovis Orthopedic and Wound Care, Inc. Irvine, CA). The tissue itself is naturally clean with minimal fatty deposits and intrinsically strong for holding sutures and resisting applied forces during healing. It is composed of highly organized collagen, mostly Type I, and has over 20 years of history as being utilized successfully in cardiac and neurosurgery (Figure 1).

The three-step patented processes begin with decellularization followed by a stabilization technique involving the creation of flexible collagen cross-linking through the use of nontoxic chemicals. Step three, the sterilization, is achieved with a nondestructive liquid

Table 1

	Product	Tissue Source	Cross-linking Agent	Sterilization
	**OrthAdapt Bioimplant®** (Synovis Orthopedic & Woundcare, Inc.) Manufactured by Synovis	Equine – Pericardium	EDC+	EDC+
	**CuffPatch®** (DePuy Orthopedics/Johnson & Johnson) Manufactured by DePuy	Porcine – Small Intestine Submucosa	EDC	Gamma Radiation
	**TissueMend®** (TEI Biosciences) Manufactured by TEI Biosciences	Bovine – Fetal Dermis	None	ETO
	**GraftJacket®** (Wright Medical Technologies) Manufactured by LifeCell Corp.	Human Donor – Dermis	None	None (Aseptically Processed)
	**Pelvicol®** (C. R. Bard) Manufactured by C. R. Bard)	Porcine – Dermis	HMDIC	Gamma Radiation
	**ZCR Collagen Repair Patch®** (Zimmer) Manufactured by Tissue Science Lab	Porcine – Dermis	Diisocyanate	Gamma Radiation

Table 1. Available Tissue Graft Products.

Table 2

Time After Operation	Maximum Load to Failure (n)	Cross-sectional Area (mm2)
0 weeks (n = 10)	267 ± 82	24.4 ± 3.6
6 weeks (n = 6)	44.8 ± 4	18.9 ± 8.6
9 weeks (n = 6)	105.6 ± 43	26.5 ± 9.6
12 weeks (n = 6)	237.8 ± 59.8	37.5 ± 7.5
24 weeks (n = 6)	313.8 ± 164.4	29.5 ± 9.8
52 weeks (n = 5)	684.9 ± 252.8	27.8 ± 7.0
ACL (n = 12)	1531.3 ± 180.3	35.0 ± 1.8
Achilles Tendon Graft (n = 12)	1120.1 ± 223.4	27.9 ± 4.9

Table 2. Degradation of Collagen Implants. (from Weiler A, Hoffmann RFG, Stahelin AC, et al. Biodegradable implants in sports medicine: The biomechanical base. J Arthro Rel Surgery 2002;16:305-21).

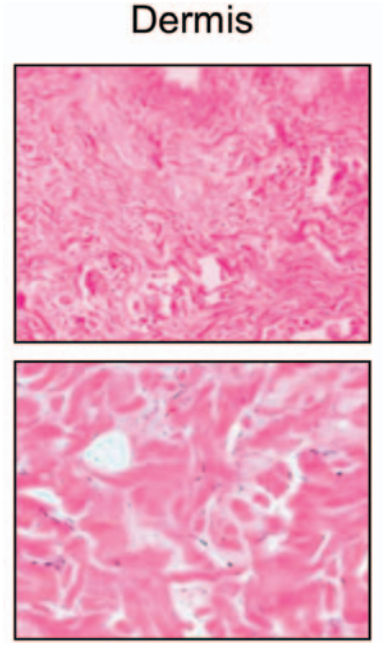

Figure 1A. Architecture comparison of biologic tissue grafts. Dermis.

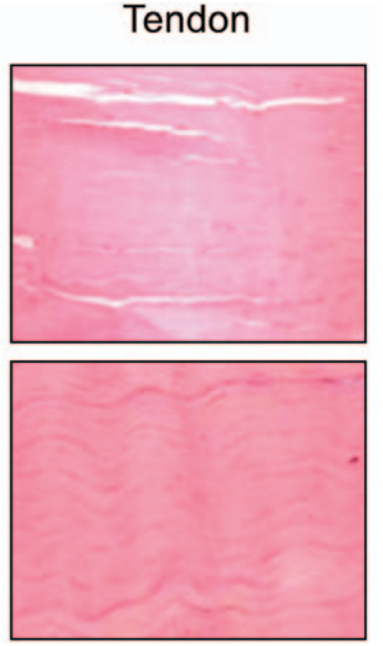

Figure 1B. Tendon.

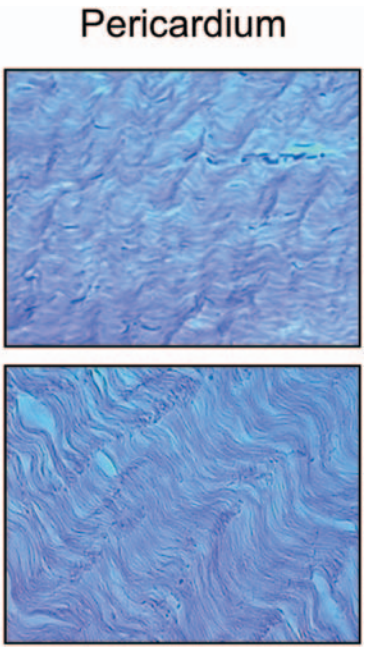

Figure 1C. Pericardium.

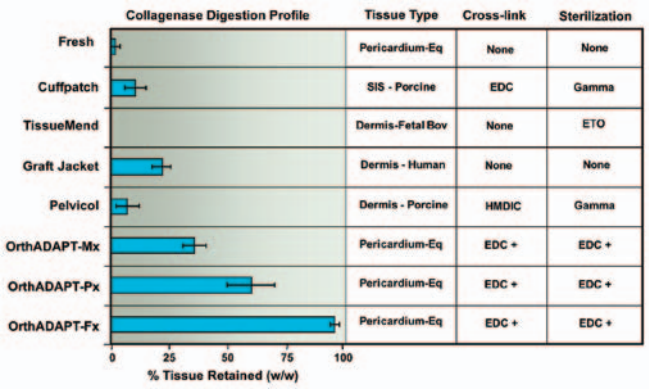

Figure 2. Comparing stability of biologic implants.

chemical technology. The result is a strong, reinforced, and pliable collagen matrix that supports cellular ingrowth and resists premature degradation (Figure 2).

The bioimplant, which is safe and nontoxic, now has the capability to become incorporated into the native tissue with minimal reaction, allowing for a stronger repair over time. The graft itself remains strong for retaining suture until the healing has provided adequate strength to allow early function. It is thin, pliable, has good tensile strength, and does not tend to calcify during healing (11,12). The fact that it can be stored at room temperature and has a three-year shelf life as well as minimal time needed for preparation make this bioimplant economically attractive.

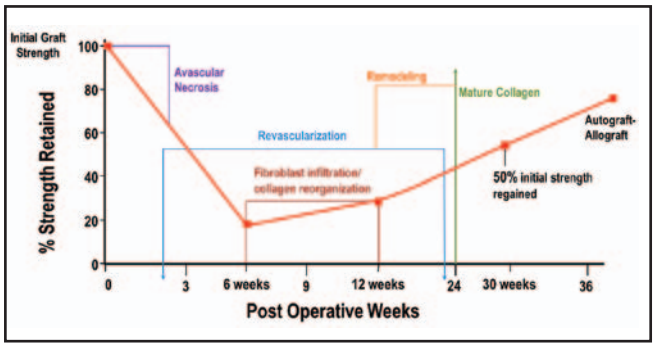

Figure 3. Revascularization/remodeling of autografts-allografts.

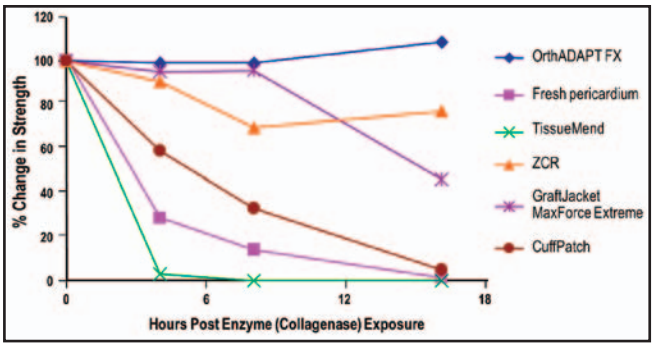

Figure 4. Comparing strength of biologic implants.

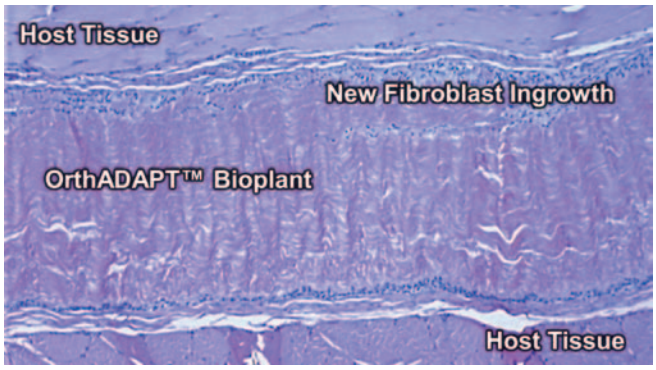

Figure 5. Biocompatibility of OrthADAPT implant. Animal study shows minimal inflammatory cell, surrounding bioimplant with evidence of fibroblast ingrowth at two weeks.

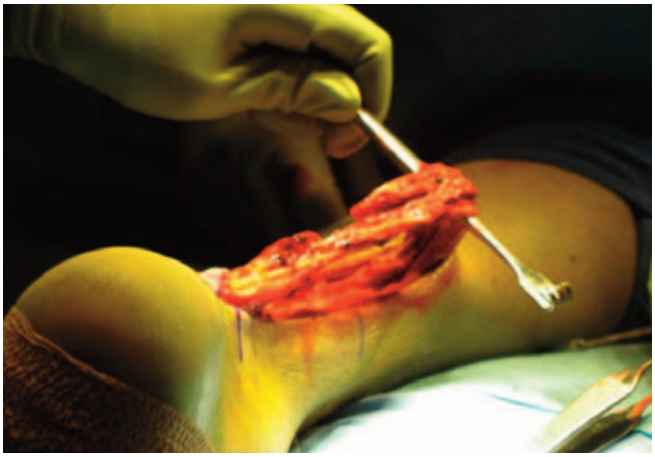

Figure 6A. Achilles tendon augmentation.

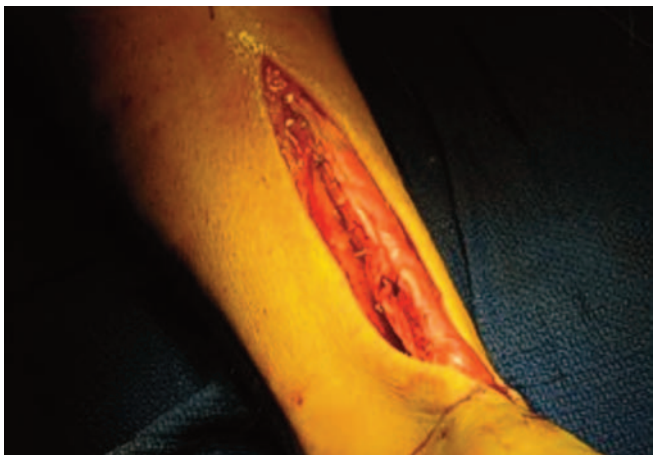

Figure 6B. Achilles tendon augmentation.

Its ability to maintain strength during the healing process of this biocompatible equine xenograft is superior to that of both autografts and allografts (Figure 3). These grafts degrade and weaken over the first three weeks and then gradually strengthen gaining about 50% of their initial strength at 30 weeks (13-17). OrthADAPT has little loss of strength during the first 18-24 hours of enzyme exposure (Figure 4) (18).

It has been hypothesized that a collagen-based scaffold used to reinforce a tendon repair should possess similar viscoelastic behavior as a normal tendon in order to provide the same function (19). The OrthADAPT bioimplant may be more functionally suitable for the reinforcement of tendon repair since its viscoelastic load-elongation behavior more closely resembles that of human tendon (20-23).

APPLICATIONS

Biocompatibility means that there is very little reactive inflammatory cell infiltrate about the graft-host interface, allowing for early fibroblast ingrowth especially over the first two weeks, as well as early revascularization. This speeds the healing process towards a strong repair for damaged tendons and ligaments, including interpositional replacement (Figure 5).

Uses for this specially-processed equine xenograft include: Achilles tendon repair (Figure 6), posterior tibialis tendonitis reconstruction (Figure 7), peroneal tendon augmentation and repair (Figure 8) as well as reparation of damaged or ruptured structures such as extensor tendons

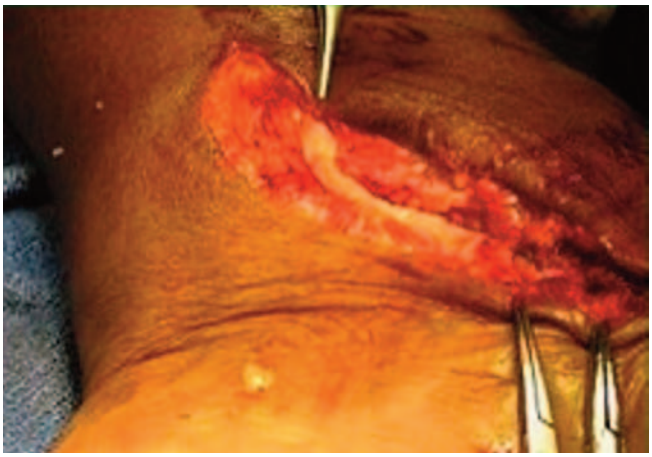

Figure 7A. Posterior tibial tendon repair.

Figure 7B. Posterior tibial tendon repair.

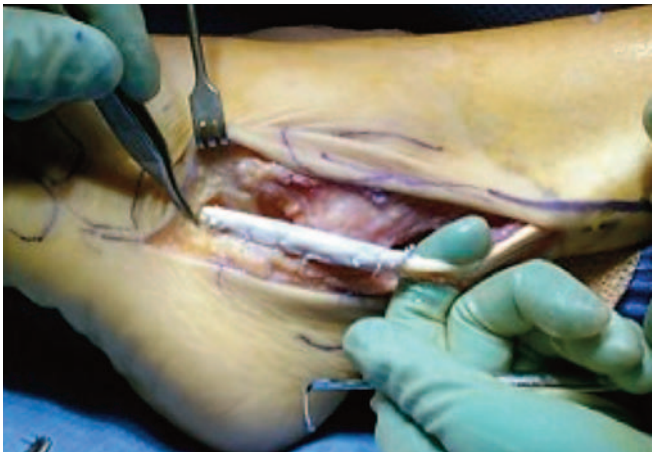

Figure 8. Peroneus brevis repair.

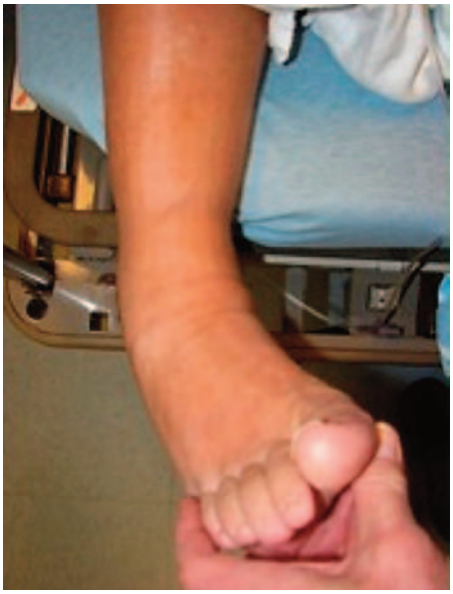

Figure 9A. Modified Brostrom graft stabilization.

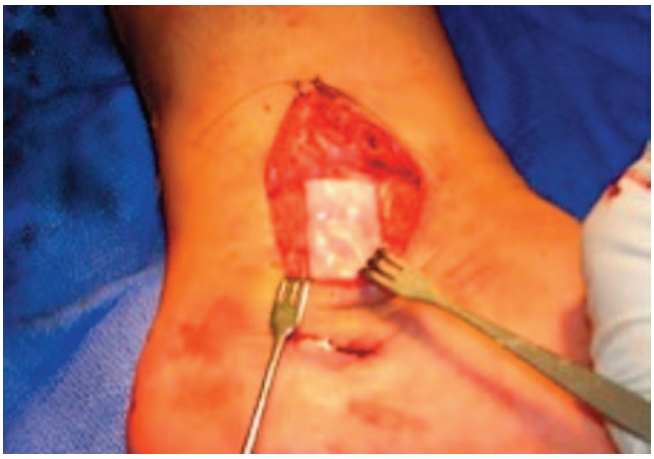

Figure 9B. Modified Brostrom graft stabilization.

Figure 10. Modified Chrisman and Snook ankle stabilization with Xenograft.

and others. For ligament reconstruction in the foot/ankle one of the more attractive applications is the lateral ankle stabilization procedures such as the Brostrom (Figure 9) or modified Chrisman and Snook (Figure 10). Finally some off-label uses include plantar fascia repairs and interpositional arthrografts.

CONCLUSION

Desirable characteristics such as biocompatibility, thinness, strength, pliability, stability, and the ability to resist rapid degradation make this patently-processed equine pericardial xenograft ideal for a variety of soft tissue repairs and augmentaions, particularly tendons and ligaments (Figure 11). Other uses remain to be identified and evidence tested.

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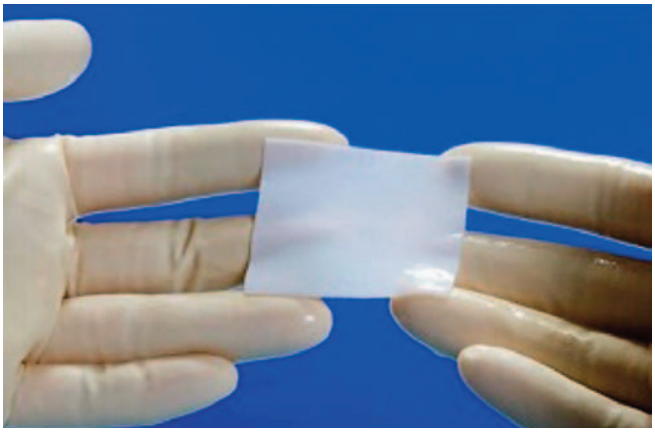

Figure 11A. OrthADAPT pericardial Xenograft.

Figure 11B. OrthADAPT pericardial Xenograft.

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