

# Histologic Presentation of Achilles Allograft 11 Years After Its Use in Posterior Cruciate Ligament Reconstruction

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Use of allografts for cruciate ligament reconstruction in the knee is increasing in popularity, but graft selection remains controversial. There is a dearth of information on long-term outcomes of allografts for cruciate reconstruction. Allografts are particularly useful in posterior cruciate ligament (PCL) reconstructive surgery because this procedure is often performed with concomitant ligament reconstructions.<sup>1</sup> In these situations, the supply of allografts may be inadequate. In addition, depending on the fixation method, autografts (eg, bone–patella tendon–bone, hamstring) may not be long enough for PCL reconstruction.

Several investigators have reported favorable clinical outcomes with use of allografts in PCL reconstruction. Not well documented, however, are the long-term histologic outcomes of allografts used for ligament reconstruction and the ability of allografts to fully incorporate into host tissue. Although several investigators have documented histologic analyses of allografts used for anterior cruciate ligament (ACL) reconstructions, there has not been the same emphasis on PCL allografts.<sup>2-5</sup> We are unaware of any previous reports on the long-term *in vivo* histologic presentation of tendon allografts used for PCL reconstruction. In addition, there are no such long-term histologic studies of allograft incorporation for any ligament reconstruction.

In the present study, described here, we performed a histologic analysis of a freeze-dried Achilles tendon allograft harvested 11 years after it was used for PCL reconstruction.

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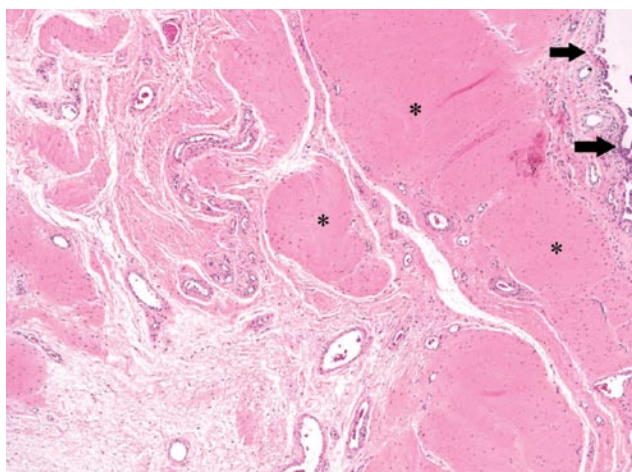
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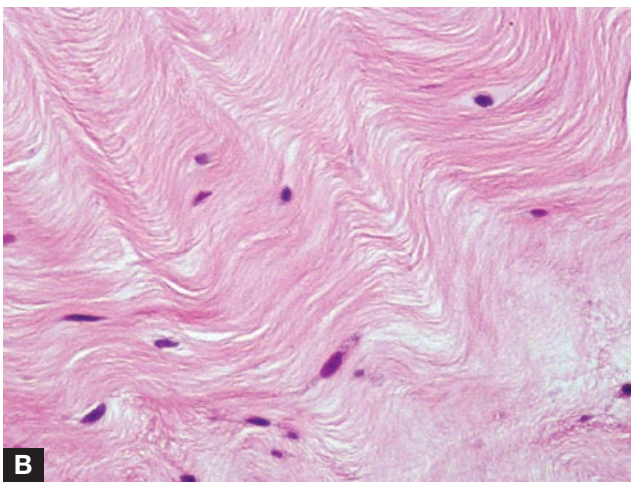
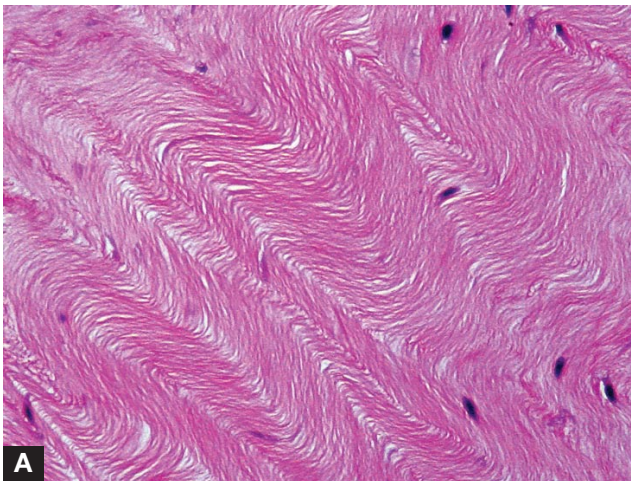
## CASE REPORT

A woman in her late 30s sustained an anterior knee dislocation after a motor vehicle accident. Clinical examination and magnetic resonance imaging confirmed ruptures of the PCL, the ACL, and the medial collateral ligaments. There was also a disruption of the popliteal artery. After leg revascularization, a combined ACL/PCL reconstruction was performed with 2 freeze-dried Achilles tendon allografts.

The patient did well initially, but her knee pain worsened approximately 10 years after the initial surgery. She denied mechanical complaints and any symptoms of knee instability but noted knee pain unresponsive to anti-inflammatory medication and other conservative treatment modalities. On physical examination of the knee, a minimal effusion was present, and crepitus was noted on passive range of motion. Knee ligament evaluation involved the Lachman test (3+) and the anterior drawer test (no firm endpoint). The result on the posterior drawer test was comparable to that for the contralateral limb. In addition, the knee was stable to varus/valgus loading, and external rotation at both 30° and 90° was identical to that of the left knee. Radiographs of the right knee were consistent with tricompartmental posttraumatic osteoarthritis, and the patient was scheduled for a total knee arthroplasty.



**Figure 1.** Low-power view of cross-section of posterior cruciate ligament allograft shows vascularized fibrocollagenous tissue focally lined by synovial-like cells (arrows); hypovascularity, hypocellularity, and high density of collagen are evident in middle of graft (asterisks), and periphery is hypervascular (hematoxylin-eosin, original magnification  $\times 10$ ).

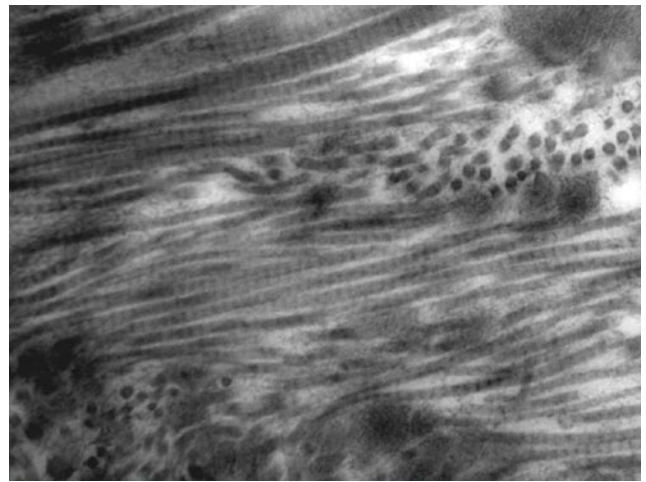


**Figure 2.** (A) Low-power view of center of graft shows collagen fiber crimping pattern characteristic of normal cruciate ligaments (hematoxylin-eosin, original magnification X10). (B) Higher power view shows dense fibrocollagenous tissue with parallel fibers and less vascularity (hematoxylin-eosin, original magnification X25).

During surgery, the PCL was found to be intact throughout its substance and fully incorporated at both the femoral and tibial interfaces. Also evident was tricompartmental arthritis, most severely in the medial compartment. The ligament was sacrificed and sent to the pathology department for formal histologic analysis. The ACL graft was found to be attenuated and nonfunctional.

### SPECIMEN ANALYSIS

On gross examination, the allograft was described as a fragment of tan-white fibrous tissue 4×2×1.5 cm in size. Under light microscopy, the histologic aspects of the tissue were indistinguishable from those of normal, native cruciate ligament. The allograft consisted of vascularized viable fibrocollagenous tissue with a focal, synovial-like cell lining. As in normal cruciate ligaments, relative hypovascularity and high collagen density are evident toward the middle of the graft, and hypervascularity and increased cellularity are evident toward the periphery (Figure 1). In addition, the synovial



**Figure 3.** Electron microscopy shows characteristic banding pattern of collagen with uniform diameter and parallel arrangement of fibrils (original magnification X45,000).

lining of the graft is present as a single layer of cells without hypervascularity. In the hypocellular, central portions of the graft, collagen fibers are longitudinally arranged in the crimping pattern characteristic of normal cruciate ligaments<sup>6,7</sup> (Figures 2A, 2B). In addition, Sharpey's fibers were identified near the bony insertion of the allograft. The histologic findings under light microscopy were consistent with those of native cruciate ligaments in terms of vascularity, cellularity, fibroblast arrangement, and collagen fiber pattern.

The specimen was also examined with electron microscopy. Multiple samples showed the characteristic cross-striations with periodicity found in native ligaments. In addition, collagen fibril had a relatively uniform diameter (range, 30–40 nm) and a regularly arranged appearance (Figure 3).

### DISCUSSION

Controversy exists over the preferred graft choice for PCL reconstruction. As highlighted by Hoher and colleagues,<sup>8</sup> an “ideal” PCL graft would have both structural and geometric properties identical to those of an intact PCL, would be simple to harvest, and would have fast graft healing and incorporation. As no single graft has all these characteristics, the orthopedic surgeon's goal is to use a graft that provides a stable knee with restoration of normal knee kinematics. Allograft benefits (ie, decreased operative time, improved cosmesis with no donor-site morbidity, less knee stiffness) must be balanced against the risks (ie, immune response in host, disease transmission).

In histologic studies in which allograft versus autograft incorporation and remodeling have been analyzed, results suggest that allograft takes longer to incorporate and may be prone to attenuation.<sup>1,9</sup> Nevertheless, both autografts and allografts undergo similar incorporation, which includes graft necrosis, cellular repopulation, revascularization, and collagen remodeling.<sup>9,10</sup> Amiel and colleagues<sup>11</sup> were the first to describe these steps; they termed the histologic and biochemical changes that tendinous grafts undergo

to become more “ligament-like” when placed in a new anatomical environment as ligamentization. Shino and colleagues<sup>10</sup> suggested that slower maturation and incorporation of allografts continue until approximately 52 weeks after surgery, at which point the histologic appearance of the allograft is similar to that of a normal ACL (if indeed incorporation was successful). In a more recent study, Jackson and colleagues<sup>12</sup> analyzed the histologic, ultrastructural, and biomechanical properties of patella tendon allografts and autografts for ACL reconstruction in a goat model. At 6 months, the 2 groups (allografts, autografts) were similar histologically, but electron microscopy analysis revealed a persistence of large-diameter collagen fibrils in the allograft group. In addition, at 6 months, maximum load to failure and anteroposterior translation were less favorable in the allograft group. It remains to be seen whether allografts ever fully mature, as autografts do.

Our report is unique because we analyzed a freeze-dried Achilles tendon allograft significantly longer after PCL reconstruction (>10 years) than has been reported in previous cases. Using light microscopy, Lee and colleagues<sup>4</sup> found that maturity and normocellularity were maintained in an ACL allograft 2.5 years after surgery. In the present case, microscopy analyses showed successful allograft incorporation resulting in a normal-appearing ligament with a structure maintained for more than 10 years. Soft-tissue allografts used for ligament reconstruction can incorporate fully with cellular structure and be indistinguishable from native cruciate ligaments. Full graft incorporation without signs of degeneration or host rejection are apparent even over periods longer than 10 years. Allograft rejection occurs at some level, but the extent of rejection and its clinical consequences are unknown.

Allograft choice, preparation, and local cellular milieu are likely important factors, among others, in determining whether an allograft will successfully regenerate into a functioning ligament, as in the case reported here, or will not incorporate and likely fail. Our patient’s case indicates that an allograft can remain successfully incorporated for extended periods, thus further supporting allograft use in

ligament reconstruction. Additional studies are needed to evaluate and predict which factors help optimize the environment for full allograft incorporation in ligamentous reconstruction.

## AUTHORS’ DISCLOSURE STATEMENT AND ACKNOWLEDGMENTS

The authors report no actual or potential conflict of interest in relation to this article.

The patient was informed that data concerning her case would be submitted for publication, and her written consent was obtained.

This investigation was performed in the Department of Orthopaedic Surgery, Hospital for Joint Diseases, New York University, New York, New York.

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*This paper will be judged for the Resident Writer's Award.*

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