Case Report
Integration of Hamstring Tendon Graft With Bone in Reconstruction of the Anterior Cruciate Ligament


Summary: Anterior cruciate ligament (ACL) reconstruction using four-strand hamstring graft with round-headed, cannulated, interference (RCI) screw fixation requires osteointegration of the tendon graft. This report describes the histology at the bone-tendon junction of two specimens retrieved from patients undergoing revision surgery after traumatic mid-substance ACL graft rupture at 6 and 10 weeks after initial reconstruction. Revision was performed at 12 and 15 weeks. Integration of the graft was evident by observation of collagen fiber continuity between bone and tendon. This histology plus the low incidence of early graft failure suggest that free tendon autograft attached to bone by RCI screw allows adequate osteointegration between 6 and 15 weeks after surgery. Key Words: Anterior cruciate ligament—Hamstring tendon graft—Histology—Bone-tendon junction.

Hamstring tendon (HT) autograft through bone tunnels in the femur and tibia is a common method for anterior cruciate ligament (ACL) reconstruction. The technique requires osteointegration of the tendon graft after initial fixation by interference screws.

Little is known about the HT graft-bone interface in humans. Histology at the site of graft and interference screw has not been reported. Understanding of the integration process is important for improving graft fixation methods and for planning postoperative rehabilitation. This report describes the histology at the bone-tendon junction of two specimens retrieved from patients undergoing revision surgery for mid-substance graft rupture.

METHOD

The arthroscopic reconstruction technique used a four-strand HT graft of semitendinosus and gracilis secured in tibial and femoral bone tunnels by a titanium interference fit screw with a round head and soft thread to avoid graft laceration (Smith & Nephew/Donjoy, San Diego, CA). Awls matched to the graft diameter shaped the tunnels to ensure a tight fit. The awl overreamed the articular end of the femoral tunnel by 2 mm to countersink the screw head. Early movement was allowed without bracing.

At the time of sampling, rupture was known to have occurred in 12 of 960 patients performed over the 2-year period 1994 to 1995. At revision surgery, all showed mid-substance failure of synovialized graft with intact femoral and tibial insertions. Ten revisions used HT graft from the other leg placed into the original bone tunnels (the authors’ preferred method). The remaining two patients suffered traumatic rupture at 6 and 10 weeks after reconstruction and underwent revision at 12 and 15 weeks, respectively, using an ipsilateral bone—patellar tendon—bone graft. This technique allowed biopsy of the tibial graft-bone interface by coring a tunnel 9 mm in diameter and 45 mm in length after removal of the interference screw (Fig 1).

The specimen was cut longitudinally and subjected to histological examination. Techniques included H&E.
FIG 1. Core biopsy of tibial tunnel using 9-mm trephine after removal of the interference screw.

and Masson trichrome staining with polarization microscopy to examine the continuity of collagen. Immunoperoxidase staining for smooth muscle actin by an avidin biotin method was used to assess myofibroblastic proliferation as part of the process of graft substitution.

RESULTS

Macroscopically, a band of fibrotendinous tissue blending with bony tissue was noted in both cases. Microscopically the graft was acellular centrally; peripherally, prominent fibroblastic and myoblastic proliferation was noted in the immunoperoxidase stained slides. In much of the specimen, this tissue merged directly with new woven bone around the graft, which in turn merged with the original surrounding normal lamellar bone. Collagen fibers in the new bone were in direct continuity with those in the graft, consistent with well-developed graft integration. This was shown using H&E (Fig 2) and the Masson trichrome stain (Fig 3).

DISCUSSION

These cases illustrate integration of the HT ACL autograft by showing collagen fiber continuity between bone and tendon. This resembled Sharpey’s fibers and the tendon bone junction at 12 weeks of healing in goats.

Direct contact between graft and bone in a tight tunnel is achieved by interference screw fixation. Such contact is important both for temporary secure fixation and for integration. Whiston and Walmsley observed a cuff of tissue containing fibroblasts and collagen.

FIG 2. Integration of graft with bone at 12 weeks. H&E stain at low power (original magnification ×20) showing dense acellular graft centrally (C), with fibroblastic proliferation peripherally (P) merging with a zone of woven bone (W) and surrounding original lamellar bone (L).
FIG 3. Integration of graft with bone at 12 weeks. Masson trichrome stain at high power (original magnification ×200) showing collagen continuity between the peripheral fibroblastic proliferation (P) and woven bone (W) at the graft bone interface. L represents original lamellar bone.

weeks after tendon autograft transplantation into a tibial tunnel in the rabbit. The activity of the bone marrow reticular tissue from which the fibroblasts were derived was most prominent at the areas of direct contact in what was otherwise a loosely fitting graft. Also in the rabbit, Forward and Cowan4 described ingrowth of callus among collagen fibres of securely implanted tendon. The collagen fibres were buried in new bone matrix at four weeks. In the dog, Rodeo et al.5 used a snug fit tendon in a tibial tunnel secured with stainless steel sutures allowing postoperative exercise ad libitum. Substantial collagen bone connections were established by 12 weeks including alignment of the fibers in the direction of tendon pull.

The site of graft failure implies that the strength of the bone-tendon junction, supported by the interference screw, at 6 and 10 weeks after surgery was adequate for rehabilitation forces below the threshold for provocation of midsubstance rupture in the case of these particular grafts. On biomechanical testing in the dog, Rodeo et al.5 noted failure by tendon pullout from the tunnel at up to 8 weeks after surgery. By 12 weeks, all pullout tests resulted in graft slippage from the clamp or graft rupture, implying that the tunnel-graft interface was no longer the weakest link. The possibility remains that these two cases of rupture may have occurred at unusually low loads in abnormally weak or damaged graft substances. However, the low rate of early graft failure overall would contribute to the suggestion that the construct is adequate for early rehabilitation forces.

Both the clinical and histological findings in these two cases supported by prior animal studies may influence choice of reconstructive procedure and postoperative rehabilitation. They suggest that free tendon autograft attached to bone by RCI screw allows adequate osteointegration between 12 and 15 weeks after surgery.

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REFERENCES