Hybrid Graft Anterior Cruciate Ligament Reconstruction: A Predictable Graft for Knee Stabilization

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abstract

Trauma to the anterior cruciate ligament (ACL) is a season-ending injury and involves months of activity modification and rehabilitation. The annual incidence of ACL tears in the United States is approximately 200,000, which allows for a broad range of individualized treatment options. Various surgical techniques, including transtibial and independent tunnel drilling, allograft and autograft tissue, and various implants, have been described in the literature. This article describes the indications and technique for a hybrid soft tissue graft for ACL reconstruction. Autologous grafts eliminate the risk of disease transmission and have recently been shown to have a lower rerupture rate, particularly in younger, active patients; however, the harvesting of autologous hamstring grafts carries a risk of donor-site morbidity, iatrogenic injury of the graft, and inadequate graft size. In contrast to a traditional autologous soft tissue graft, the hybrid graft allows for graft size customization for a desired reconstruction, especially in cases where autograft hamstrings may be iatrogenically damaged or of inadequate size when harvested. The goal of a hybrid graft ACL reconstruction is to provide a favorable-sized graft with clinical outcomes comparable with autologous soft tissue grafts. In contrast to a traditional autologous soft tissue graft, this technique provides another option in the event of unforeseen deficiencies or complications associated with harvesting and preparation of the autologous gracilis and semitendinosus soft tissue graft. [Orthopedics. 2015; 38(6):e473-e476.]
Trauma to the anterior cruciate ligament (ACL) is a season-ending injury and involves months of activity modification and rehabilitation. For an active patient, surgical stabilization is recommended to return the athlete back to his or her sport. \(^1\) \(^3\) In the United States, the annual incidence of ACL tears is approximately 200,000. \(^4\) Although surgical techniques and implants vary and autograft patellar tendon has historically been considered the gold standard for graft selection, soft tissue ACL reconstruction has become increasingly popular. \(^1\) \(^5\) For many surgeons, autograft hamstrings are considered a new gold standard.

Allograft tendons may be the graft of choice for some surgeons due to the decreased risk of donor-site morbidity and operative time. \(^5\) Although soft tissue allografts have shown excellent outcomes, more recent evidence indicates a higher graft failure rate in addition to increased surgical cost for the allograft tissue. \(^2\) Therefore, many surgeons who have primarily used soft tissue allograft have favored the use of autologous gracilis and semitendinosis tendons as a primary graft when reconstructing the ACL. Autologous hamstring grafts provide a strong framework for ingrowth of host tissue and collagen fibers. \(^2\) Patient consent for ACL reconstruction requires patient education about graft choice risks, benefits, and alternatives. \(^6\) \(^8\) Soft tissue allografts, such as the tibialis anterior, allow for customization of graft size and reduce operative time while eliminating harvest-site morbidity; however, they are subject to graft rejection, slower incorporation, potential for disease transmission, and higher failure rates, especially in young, active patients. \(^7\) \(^10\)

Treme et al \(^5\) determined that risk factors for a quadrupled hamstring graft measuring less than 7 mm in diameter are weight less than 50 kg, height less than 140 cm, thigh circumference less than 37 cm, and body mass index (BMI) less than 18 kg/m\(^2\). According to Conte et al, \(^11\) grafts less than 8 mm in diameter are a risk factor for poor patient outcomes, with an increase in rate of failure, particularly in patients younger than 20 years. Smaller hamstring autograft size is also a key predictor of poorer Knee Injury and Osteoarthritis Outcome Score (KOOS) sport and recreation function 2 years after ACL reconstruction. \(^9\) \(^12\) This indicates the importance of the hybrid graft, which allows customization of the graft size to attempt to improve patient outcomes.

When the operative plan calls for autograft hamstrings, the size of the autograft tissue may not be sufficient for ACL reconstruction; in short or thin patients, the graft may be damaged during harvesting, which may preclude its use. \(^9\) \(^10\) \(^13\) Soft tissue graft hybridization provides a graft for reconstruction with the benefits of both an autologous tissue core and a customizable graft size for the individual patient by augmenting with allograft soft tissue (Table 1). Tracy et al \(^13\) demonstrated that the biomechanical properties of a soft tissue hybrid tibialis-semitendinosus allograft are not statistically different from the traditional single-loop tibialis allograft. The main limitations of the traditional autograft may result in a long-term reduction in the strength and speed of the hamstring muscles at high flexion angles. \(^3\) \(^14\) In both planned primary ACL reconstruction or revision surgery and in alternative backup reconstruction when autologous tissue is inadequate or damaged during harvest, hybrid soft tissue provides a reliable and predictable ACL graft and should be considered when counseling patients for surgery.

**Hybrid Graft Surgical Technique**

Following a diagnostic arthroscopy confirming an ACL tear, harvesting of autograft gracilis and semitendinosis hamstring tendons is performed with a standard incision over the pes anserine with dissection carried down to the sartorial fascia (Table 2). While preserving the medial collateral ligament (MCL), the distal...
ends of the semitendinosus and gracilis tendons are released from their distal attachment, isolated from the backside of the fascia, and whipstitched with a heavy, nonabsorbable suture. The tendons are separated from the fascia, and each is individually harvested from the myotenion complex using a tendon-stripping device (Figure 1).

Under sterile conditions, the muscle is stripped off the tendon, and the opposing ends are whipstitched. Tendon bands and fat are debrided off the harvested tendons. On completion, the tendons are quadruple stranded and the circumference is measured using the sizing guides (Figure 2). If the harvested tendons are smaller than the recommended 8 mm in diameter or iatrogenically damaged, the current authors’ preferred operative plan is to stabilize the knee with a hybrid graft reconstruction where the autograft hamstring is augmented with allograft soft tissue tendon.

A soft tissue allograft, such as a tibialis or gracilis tendon, is thawed in a sterile normal saline/1-g vancomycin solution. The required amount of allograft tendon that will be needed for the desired graft hybridization is measured. This amount is sharply incised using a #10 scalpel and removed from the remaining tendon. Each end of the cut tendon is whipstitched with heavy, nonabsorbable suture. The prepared allograft is then combined with the autograft core. The hybrid autograft hamstring and tibialis allograft circumference is measured. With the hybrid graft meeting the desired size, it is then placed on the surgeon’s choice implant device in preparation for implantation (Figure 3).

**DISCUSSION**

Those who participate in high-level activities or sports are considered high risk for episodes of instability following ACL injury. As such, ACL reconstruction should be strongly considered to minimize the risk of instability and additional damage to the knee. A patient scheduled to undergo ACL soft tissue graft reconstruction is a candidate for the hybrid graft technique, particularly if he or she has the risk factors for inadequate autograft hamstring described by Treme et al or if iatrogenic injury to the harvested autograft tissue occurs requiring augmentation.

The hybrid graft should be considered as a primary or alternative graft choice when the patient is young and physically active or if the harvested autograft is of

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<th align="left">Table 2</th>
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<tr>
<td align="left"><strong>Tips</strong></td>
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<td align="left">• The graft is loaded on a femoral aperture fixation device for implantation.</td>
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<td align="left">• The graft tails are shuttled from the anteromedial portal and out through the tibial tunnel where the graft is tensioned and the knee is cycled and the graft secured with an interference screw.</td>
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<td align="left"><strong>Pearls</strong></td>
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<td align="left">• A single surgical technique using independent tunnel drilling and a common anterior cruciate ligament (ACL) implant graft aperture fixation system was used for all reconstructions.</td>
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<td align="left"><strong>Pitfalls</strong></td>
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<td align="left">• Autograft gracilis and semitendinosis hamstring tendons need to be harvested in the standard fashion using a closed-ended tendon stripper, cleaned of muscle, and whipstitched with a nonabsorbable suture at each end.</td>
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<tr>
<td align="left"><strong>Indications</strong></td>
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<td align="left">• Autologous tissue is inadequate or damaged during harvest.</td>
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<td align="left"><strong>Contraindications</strong></td>
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<td align="left">• The use of autografts in ACL reconstruction should still be considered the gold standard; graft hybridization using autograft in conjunction with soft tissue allograft should be considered as an alternative. Hybrid grafts prove beneficial in achieving desired graft size and knee stabilization when autograft size proves insufficient.</td>
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<td align="left"><strong>Risks</strong></td>
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<td align="left">• Similar to the risks assumed from autologous ACL reconstructions.</td>
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**Figure 1:** The autograft gracilis tendon (top), autograft semitendinosis tendon (middle), and allograft tendon (bottom) are harvested and placed on the preparation table. At this time, the allograft has not been incised to create the desired size when augmented with the autograft tissue for the hybrid graft.

**Figure 2:** Under sterile conditions, the muscle is stripped off the tendon, and the opposing ends are whipstitched with heavy, nonabsorbable suture. The required amount of allograft tissue needed for the desired graft hybridization is measured and incised using a #10 scalpel.

**Figure 3:** The graft is loaded and folded to increase the tensile strength. The graft is then run through the graft sizing block to determine the size of the graft.
inadequate size. There are several potential benefits to the use of a hybrid graft, primarily that the size of the graft tissues can be well controlled, especially in cases where the autologous tissue may be suboptimal in terms of size. The preferred size of the quadruple-stranded gracilis and semitendinosus tendons may be difficult to determine before harvesting.\textsuperscript{15} Using a traditional autograft may also result in a long-term reduction in the strength and speed of the hamstring muscles at high flexion angles.\textsuperscript{3,14} In many patients, graft harvest does not result in a clinical disability or diminished sport performance; however, the ability to maintain fully functional hamstrings may benefit certain patients. A hybrid graft allows the surgeon to customize the size of the graft for reconstruction by augmenting autograft hamstring with soft tissue allograft. In addition, for an operative plan to hybridize the graft, it also allows for the harvesting of only one of the patient’s hamstring tendons, reduces morbidity, and permits the surgeon to customize the graft with allograft while maintaining an autograft core. The current authors recommend the use of a hybrid graft as an alternative graft choice for ACL reconstruction.

CONCLUSION

Autograft hamstring use in ACL reconstruction has become increasingly popular in recent years, offering similar patient outcomes when compared with the traditional gold standard bone–patellar tendon–bone. Autograft gracilis and semitendinosus tendons provide an ideal graft to stabilize the knee; however, if graft size or iatrogenic injury to the hamstring tendons during harvesting presents an intraoperative dilemma to achieve adequate autograft tissue for ACL reconstruction, one solution is graft hybridization to achieve the desired graft size and knee stability. The authors’ preferred method of reconstructing the ACL is the gold standard autograft hamstring, while educating patients on surgery with a possible hybrid graft. Further studies evaluating the clinical functional outcomes comparing soft tissue hamstring autograft, allograft, and hybrid graft for reconstruction of the ACL ligament are needed.

REFERENCES