Chapter 18

Meniscus Transplantation

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INTRODUCTION

Any significant loss of meniscal function through injury or menisectomy alters the biomechanical and biological environment of the normal knee, eventually resulting in pain, recurrent swelling, and effusions. Overt secondary osteoarthritis is often the endpoint.[1,2] Recognition of these consequences has led to a strong commitment within the orthopedic community to meniscal-sparing interventions. However, there are cases in which meniscal preservation is not possible. In carefully selected patients, meniscal allografts can restore near-normal knee anatomy and biomechanics, providing excellent pain relief and improved function.[3,4]

Several techniques exist for allograft meniscus transplantation including bone-plug and bone-bridge techniques, the latter comprising variants such as the keyhole, dove-tail, and bridge-in-slot techniques. We prefer the latter because of its simplicity and secure bony fixation; the ability to more easily perform concomitant procedures, such as osteotomy and ligament reconstruction; and the advantages of maintaining the relationship of the native anterior and posterior horns of the meniscus.[5]

PREOPERATIVE EVALUATION

History and Physical Examination

It is essential to elicit a thorough history including the causative mechanism, associated injuries, and prior treatments. Recent operative reports and arthroscopy images can be helpful to rule out diffuse arthritic changes that would constitute a contraindication for meniscal transplantation.

Patients frequently report a history of knee injury, with subsequent surgical treatment for meniscal repair or menisectomy. Commonly, a period of symptomatic improvment ensues before gradual development of ipsilateral joint-line pain and activity-related swelling. On examination, range of motion (ROM) is usually preserved, joint effusion is present depending on recent physical activity, and, occasionally, palpation will reveal joint line or femoral condyle tenderness. Associated pathology, such as malalignment and ligamentous instability, should be noticed, because it would have to be addressed in a staged or concurrent fashion.

Imaging

We routinely obtain weight-bearing anteroposterior (AP) and posteroanterior (PA) 45-degree flexion radiographs, nonweight bearing 45-degree-flexion lateral view, axial view of the patellofemoral joint, and a long-leg mechanical axis view to evaluate malalignment.

Magnetic resonance imaging (MRI) with or without intra-articular or intravenous contrast is helpful to assess the extent of menisectomy, degree of subchondral edema in the involved compartment, and the presence of other articular comorbidities, such as ligamentous or chondral injury.

Indications and Contraindications

The ideal candidate has a history of prior total or subtotal menisectomy with persistent pain localized to the involved compartment, intact articular surfaces (Grade I or II), normal alignment, and a stable joint. Associated pathologic findings, such as malalignment, chondral defects, or ligamentous instability, are not absolute contraindications in an otherwise appropriate candidate because they can be addressed in either staged or concomitant procedures.

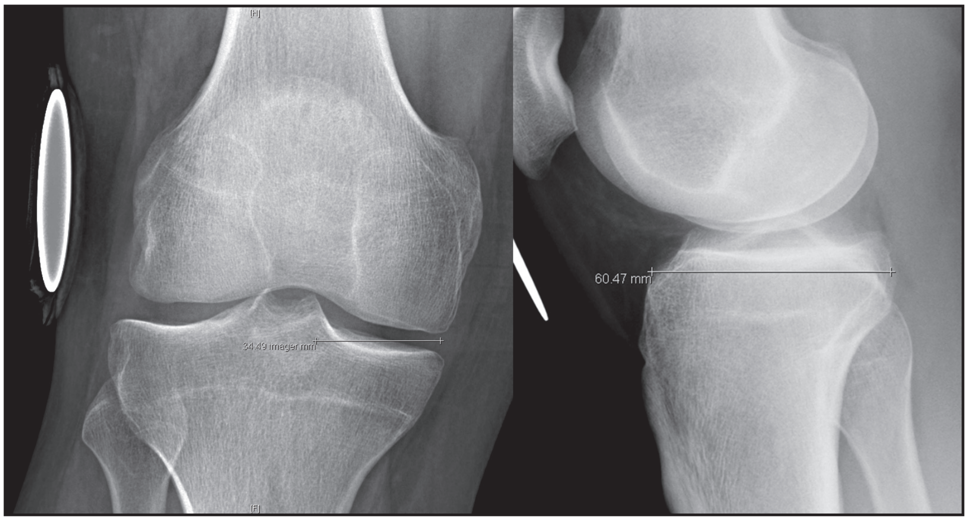

Figure 18-1. Graft sizing on anteroposterior and lateral radiographs.

In addition to uncorrected comorbidities (malalignment, ligament deficiency, uncorrected localized chondral damage in the involved compartment), contraindications are diffuse arthritic changes and joint space narrowing, especially when associated with femoral condyle/tibial flattening, history of inflammatory arthritis, or marked obesity.

Full-thickness chondral defects have traditionally been considered a contraindication to meniscal transplantation. Several recent reports have demonstrated results of concurrent meniscal transplantation and cartilage repair that are similar to isolated meniscal transplantation.[6] Therefore, we currently do not consider localized chondral defects as a contraindication, but rather as a correctable comorbidity similar to malalignment or ligamentous instability.

Surgical Planning

Concomitant Procedures

Significant limb malalignment, ligamentous instability, or discrete chondral defects can be addressed in a staged fashion or concomitant with meniscus transplantation.

Allograft Sizing

Meniscal allografts are size, side, and compartment specific. Preoperative measurements are obtained from AP and lateral radiographs with magnification markers placed on the skin at the level of the joint line. After accounting for radiographic magnification, meniscal width is measured on the AP radiograph from the edge of the ipsilateral tibial spine to the edge of the tibial plateau. Meniscal length is calculated by multiplying the depth of the tibial plateau (as measured on lateral radiographs) by 0.8 for medial and 0.7 for lateral meniscal grafts (Figure 18-1).

Meniscal Graft Processing and Preservation

Meniscal allografts are harvested using sterile surgical technique, usually within 24 hours of donor asystole. Unlike fresh osteochondral allografts, graft viability in meniscal transplants does not seem to substantially influence the outcome; thus, the most commonly implanted grafts are either fresh-frozen or cryopreserved. Lyophilized grafts have been largely abandoned due to worse results. The risk of disease transmission is minimized through rigid donor screening, graft culturing, and polymerase chain reaction testing for human immunodeficiency virus (HIV). Several tissue banks are evaluating secondary sterilization techniques to further improve upon the safety of meniscal allograft tissue.

SURGICAL TECHNIQUE

Special Instrumentation

A meniscal allograft workstation is usually provided by the organization that supplied the allograft. Several proprietary instrumentation kits are available, including the dove tail, key-hole, and bridge-in-slot techniques. Knowledge of the instrumentation is required, and the surgeon should familiarize him- or herself in advance with the specific technique planned, ideally through a cadaver lab. Furthermore, meniscal repair equipment such as zone-specific cannulas and double-armed needles are needed for the meniscocapsular repair.

Positioning

Based on surgeon, anesthesiologist, and patient preference, the procedure can be performed under general, spinal or regional anesthesia, or a combination thereof. The patient is positioned supine on a standard OR table, with a thigh tourniquet, and the extremity is placed in a standard leg holder allowing full knee flexion or hyperflexion. The posteromedial or posterolateral corner must be freely accessible to perform inside-out meniscus suturing.

Figure 18-2. Reference slot prepared with a bur.

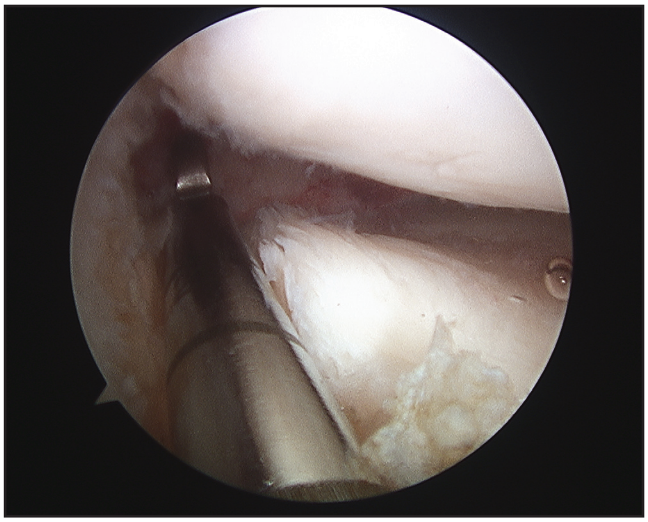

Figure 18-3. Guide probe lying in the superficial reference slot.

Surgical Anatomy

Useful surgical landmarks include the patella, patellar tendon, tibial plateau, and fibular head. Structures most at risk during the procedure include the peroneal nerve and lateral collateral ligament during the posterolateral approach. The posteromedial approach risks injury to the saphenous nerve, potentially resulting in a painful neuroma. Lastly, needle passage during the meniscocapsular repair can injure the posterior neurovascular bundle.

Technical Steps

Examination under anesthesia should evaluate range of motion and ligamentous stability. Diagnostic arthroscopy is useful to evaluate for other intra-articular pathology, such as loose bodies, ligamentous deficiency, or chondral defects.

The initial steps for medial and lateral meniscus transplantation are identical: the meniscal remnant is debrided to a 1- to 2-mm peripheral rim without perforation of the joint capsule until punctate bleeding occurs. The most anterior aspect of the meniscus can be excised later under direct visualization using a No. 11 scalpel blade placed through the mini-arthrotomy. The anterior and posterior horn insertion sites should be maintained because they are helpful markers during slot preparation. A limited notchplasty along the most inferior and posterior aspect of the ipsilateral femoral condyle allows improved visualization of the posterior horn and facilitates graft passage. If a medial meniscal transplant is planned, the most medial fibers of the tibial ACL insertion are released, exposing the medial tibial spine.

A mini-arthrotomy is now performed in line with the anterior and posterior horn insertion sites of the involved meniscus. This allows correct orientation of the slot and introduction of the graft. Depending on the surgeon's preference, the arthrotomy can be performed either directly *adjacent to* or *through* the patellar tendon in line with its fibers. An ipsilateral, either posteromedial or posterolateral, approach is required for meniscal repair. The incision should extend approximately one-third above and two-thirds below the joint line and allow adequate exposure to protect the neurovascular structures during passage of the inside-out sutures. The ipsilateral gastrocnemius muscle-tendon junction is elevated off of the posterior capsule, and a meniscal retractor is placed anterior to it. Elevation of either the iliotibial band or sartorius fascia anteriorly allows for suture tying beneath these structures to minimize the chances of capturing the knee due to soft-tissue tethering.

Preparation of the tibial slot follows the normal anatomy of the meniscus attachment sites. Using electrocautery, the centers of the anterior and posterior horn attachment sites are connected with a line, and cartilage and soft tissue along this line is debrided with the electrothermal device. Using this line as a guide, a 4-mm bur is used to create a superficial reference slot in the tibial plateau (Figure 18-2). Its height and width will equal the dimensions of the bur, and its alignment in the sagittal plane should parallel the slope of the tibial plateau. Slot dimensions should be confirmed by placing a hooked depth gauge in the reference slot, which also measures the AP length of the tibial plateau (Figure 18-3). Using a drill guide referencing off the hooked probe, a guide pin is drilled into the proximal tibia, just distal and parallel to the reference slot. The pin is advanced to, but not through, the posterior cortex, being mindful to avoid overpenetration, which could injure the posterior neurovascular bundle. The pin is subsequently overreamed with an 8-mm cannulated drill bit, again taking care to maintain the posterior cortex. A box cutter is then used to create a slot 8-mm wide by 10-mm deep (Figure 18-4), which is smoothed and refined with a rasp to ensure that the bone bridge will slide smoothly into the slot.

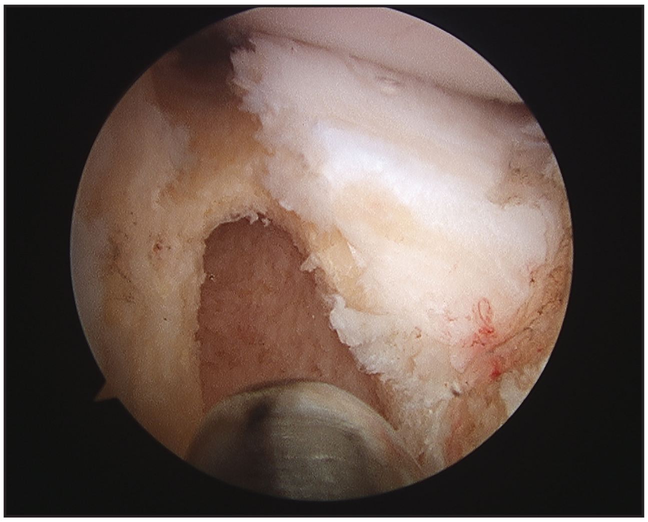

Figure 18-4. Tibial slot: the posterior aspect of the slot still demonstrates the superficial reference slot with the reamed tunnel underneath. A box-cutter and rongeur are used to remove the remaining bone in-between, followed by a rasp to smooth the walls.

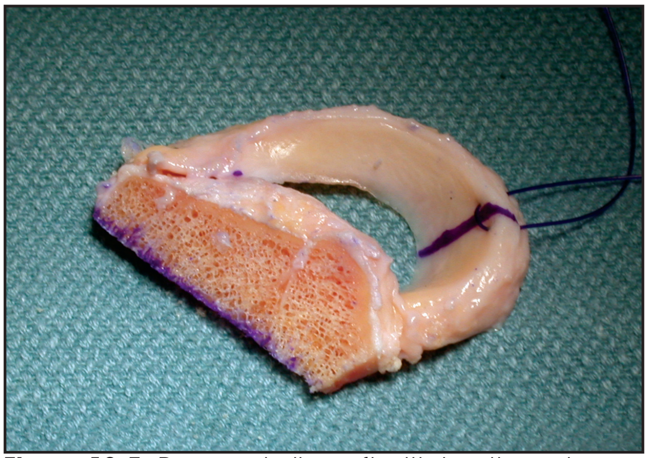

Figure 18-5. Prepared allograft with traction suture.

The meniscal graft can be prepared at this point, or, ideally, it has been prepared previously during anesthesia induction to save surgical time. The described technique utilizes a single bone bridge to secure the graft to the tibial plateau. The bone bridge is intentionally undersized by 1 mm to facilitate graft passage and thus reduces the risk of inadvertent bridge fracture if forceful insertion were required. The attachment sites of the meniscus are identified on the bone block, and the accessory attachments are debrided. Only the true attachment sites should remain, usually 5 to 6 mm wide. The bone bridge is then cut to a width of 7 mm and a height of 1 cm. Also, any bone extending beyond the posterior horn attachment site is removed, while bone anterior to the anterior horn attachment site should be preserved to maintain graft integrity during insertion. A vertical mattress traction suture is placed at the junction of the posterior and middle third of the meniscus using a number 0 PDS suture (Figure 18-5).

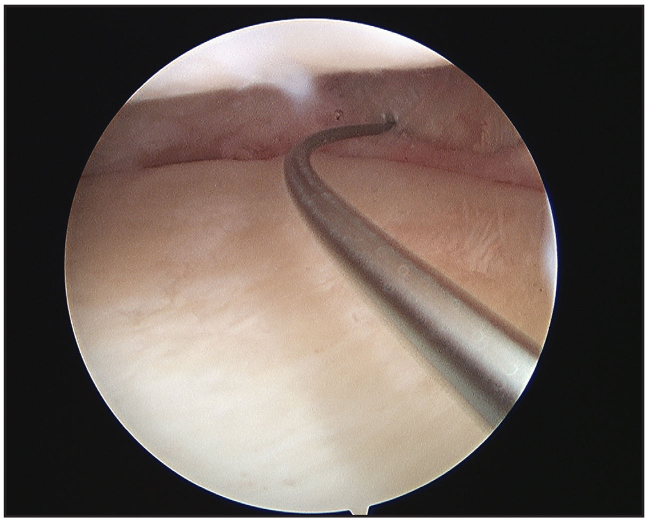

Figure 18-6. Nitinol wire in place.

Occasionally, the anterior horn attachment can be larger: up to 9 mm wide. If the anterior horn attachment site is wider than the intended width of the bone bridge, the attachment should be left intact, and the width of the bone bridge should be increased accordingly in the area of the anterior horn insertion only; the remainder of the bone bridge should be trimmed to 7 mm as intended. To accommodate the increased width, the corresponding area of the recipient slot should be widened accordingly.

Viewing through the ipsilateral portal, a zone-specific meniscal repair cannula is placed through the contralateral portal and directed toward the intended position of the junction of the posterior and middle third of the meniscus (Figure 18-6). A long flexible nitinol suture-passing pin is placed through the capsule to exit the accessory posteromedial or posterolateral incision. The proximal end of the nitinol pin is then withdrawn from the anterior arthrotomy site; the allograft traction sutures are passed through the loop of the nitinol pin, and the pin and sutures are withdrawn through the accessory incision. With the aid of the traction sutures, the meniscal allograft is pulled into the joint through the anterior arthrotomy while the bone bridge is advanced into the tibial slot and the meniscus is manually reduced under the condyle with a finger placed through the arthrotomy. Appropriate valgus or varus stress opens the ipsilateral compartment and aids in graft introduction and reduction under the condyle (Figure 18-7). Once the meniscus is reduced, the knee is cycled to properly seat the graft, and the bone bridge is secured within the tibial slot with a bioabsorbable cortical interference screw. Finally, the graft is attached to the capsule with standard inside-out vertical mattress sutures placed equally on the superior and inferior meniscal surface. This fixation can be supplemented with appropriate all-inside fixation devices placed most posteriorly and outside-in suture placement placed most anteriorly.

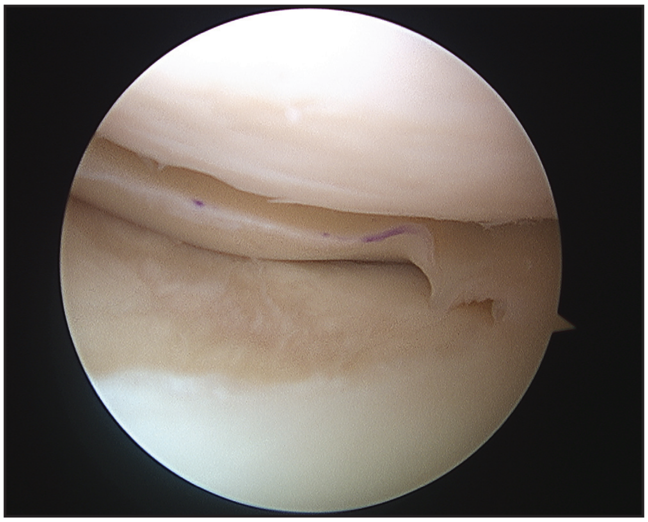

Figure 18-7. The reduced meniscal allograft in place.

Figure 18-8. Postoperative radiographs.

Standard closure follows, and the patient is placed in a hinged knee brace, initially locked in full extension. Radiographs are obtained at the 2 week follow-up appointment (Figure 18-8).

Concurrent Procedures

ACL Reconstruction and Medial Meniscus Allograft Transplantation

For combined medial meniscal transplantation and ACL reconstruction, we use a modification of the bridge-in-slot technique that utilizes two smaller bone blocks rather than one long bridge. This allows the ACL graft to pass between the two blocks, while one longer bridge occasionally was pushed up out of the slot by the ACL graft passing underneath. The technique is similar to the bone-plug technique described for medial meniscal transplantation; however, the slot facilitates passage of the posterior bone block.

- Use a soft tissue graft (hamstring autograft or achilles tendon, tibialis anterior or hamstring allograft).
- Drill tibial tunnel for ACL.
- Drill femoral tunnel for ACL.
- Prepare meniscal slot as usual.
- Pass and fix femoral side of ACL graft.
- Divide the bone block, removing the central third between the meniscal horn attachments, resulting in two separate bone blocks.
- Using the ACL tibial aiming guide, drill two transtibial tunnels that exit inside the slot at the original meniscal horn attachment sites, anteriorly and posteriorly. The guide pins are over-reamed with the smallest tibial reamer.
- Pass a nonresorbable suture each around the anterior and posterior meniscal horns.
- Using a suture passer, shuttle these sutures through the respective tibial tunnels.
- Pass meniscus and reduce soft tissue and bony components.
- Tie the sutures over a bony bridge on the tibia, securing the two bone blocks.
- Fix tibial side of ACL graft.
- Repair meniscus.

Concurrent High Tibial Osteotomy and Meniscus Allograft Transplantation

- Perform all aspects of meniscus transplantation first.
- Perform opening wedge osteotomy such that line of osteotomy passes at least 1.5 cm below bottom of tibial slot.
- Be very careful and patient when wedging open the osteotomy, because the crack can propagate proximally into the meniscal slot, rather than laterally towards the fibular head.

POSTOPERATIVE ISSUES

Rehabilitation Protocol

- Weeks 0 to 2: Partial weight bearing in a hinged knee brace locked in. ROM only while nonweight bearing and limited to 0 to 90 degrees of flexion.
- Weeks 3 to 8: Weight bearing as tolerated and free nonweight bearing flexion beyond 90 degrees.
- Weeks 9+: Full weight bearing and ROM.
- In-line running after 16 weeks.

TABLE 18-1

Clinical Results of Meniscal Allograft Transplantation

Author	*Follow-Up*	*Outcome*
Milachowski et al[7]	14 month mean	19 of 22 (86%) successful
Garrett[8]	2 to 7 years	35 of 43 (81%) successful
Noyes et al[9]	30 month mean (range, 22 to 58 months)	56 of 96 (58%) failed
van Arkel and de Boer[10]	2 to 5 years	20 of 23 (87%) successful
Cameron and Saha[2]	31 month mean (range, 12 to 66 months)	58 of 63 (92%) successful
Goble et al[11]	2 year minimum	17 of 18 (94%) successful
Carter[12]	48 month mean	45 of 51 (88%) successful
Rodeo[13]	2 year minimum	22 of 33 (67%) successful 14 of 16 (88%) with bone fixation 8 of 17 (47%) without bone fixation
Rath et al[14]	5.4 year mean (range, 2 to 8 years)	14 of 22 (64%) successful
Verdonk et al[15]	7.2 year mean (range, 0.5 to 14.5 years)	10 of 61 (16%) lateral transplants failed 11 of 39 (28%) medial transplants failed
Cole et al[4]	33.5 month mean (range, 24 to 57 months)	41 of 45 (91%) successful, 85% of successful transplants would have surgery again

- Return to full activities after 6 months, once strength has returned to greater than 80% of the contralateral leg. Return to cutting sports, such as soccer or squash, is discouraged due to the increased risk of injury even to a native meniscus.

Complications

Complications are similar to those of meniscal repair, consisting of infection, arthrofibrosis, incomplete healing of the meniscocapsular repair, and saphenous or peroneal nerve injury. The transplanted meniscus is at higher risk for reinjury, and meniscal tears can occur, which are treated similar to native meniscal injuries.

Results

Following meniscal allograft transplantation, good-to-excellent results are achieved in nearly 85% of cases, and patients demonstrate a measurable decrease in pain and increase in activity level (Table 18-1). The risk of graft failure appears greatest with irradiated or lyophilized grafts, grade III to IV osteoarthritic changes that are not repaired, soft tissue fixation, and uncorrected malalignment or instability.

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