# Meniscal Allografts of the Knee

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## Contents



**Abstract**

Meniscal allograft transplantation has emerged as a useful treatment for carefully selected patients. Almost all studies, from short- to long-term (>10 years of follow-up), report patient satisfaction and improvement in pain and function.

Objectively, physical examination findings are improved in the majority of patients. Radiologically, joint space narrowing is only significantly progressive at long-term follow-up. On magnetic resonance imaging (MRI), shrinkage is seen after some years, but more with lyophilized allografts. Histologically, incomplete re-population of the graft is noticed. Second-look arthroscopy usually shows good healing of the capsule. In a recent long-term study, progression of cartilage degeneration according to MRI and radiological criteria was halted in a number of patients, indicating a chondroprotective effect.

However, there still is a lack of consensus on how the success of a meniscal transplantation should be evaluated, which makes it difficult to compare study outcomes. In our opinion, radiographic measurement of joint space narrowing and changes in meniscal allograft MR signal are the best assessment tools, but the use of a good clinical evaluation system, such as the International Knee Documentation Committee (IKDC) and the Hospital for Special Surgery (HSS) scoring system, remains essential.

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Contra-indications • Knee • Medial meniscus, lateral meniscus • Meniscal allografts: indications • Rehabilitation • Technique-arthroscopic • Technique-open

## Indications

According to current recommendations, meniscal allograft transplantation is indicated in three specific clinical settings:

1. Young patients with a history of meniscectomy who have pain localized to the meniscus-deficient compartment, a stable knee joint, no mal-alignment and articular cartilage with only minor evidence of degenerative changes (no more than grade 3 according to the International Cartilage Repair Society (ICRS) classification system (Table 1) are considered ideal candidates for this procedure. Some studies [1–6] have shown that meniscal allografts can survive in an osteoarthritic joint (Outerbridge grade 3–4), with significant improvement in pain and function. Because of the more rapid deterioration in the lateral compartment [7], a relatively common indication for meniscal transplantation is a symptomatic, meniscus-deficient, lateral compartment.
2. Anterior cruciate ligament (ACL)-deficient patients who have had previous medial meniscectomy with concomitant ACL reconstruction and who might benefit from the increased stability afforded by a functional medial meniscus. It is the authors' conviction that an ACL graft is significantly protected by the meniscus allograft as much as the meniscus is protected by an ACL graft.
3. In an effort to avert early joint degeneration, some also consider young, athletic patients who have had total meniscectomy as candidates for meniscal transplantation prior to onset of symptoms [8]. However, the results obtained so far still preclude a return to high-impact sports.

**Table 1** International cartilage repair society cartilage lesion evaluation system

| | |
|---|---|
| Grade 0 | Normal |
| Grade 1 | Superficial lesions, softening, fissures or cracks |
| Grade 2 | Lesions, erosion or ulceration of less than 50 % |
| Grade 3 | Partial-thickness defect of more than 50 %, but less than 100 % |
| Grade 4 | Ulceration and bone exposure |

## Contra-Indications

Advanced chondral degeneration is considered a contra-indication to meniscal allograft transplantation, although some studies suggest that cartilage degeneration is not a significant risk factor for failure [9]. In general, greater than grade 3 articular cartilage lesions, according to the ICRS classification system, should be of limited surface area and localized. Localized chondral defects may be treated concomitantly, as meniscus transplantation and cartilage repair or restoration may benefit each other in terms of healing and outcome [10]. Chondrocyte transplantation or osteochondral grafting procedures should be performed after completion of the meniscal transplantation in order to prevent accidental damage to the patch or graft during meniscal allograft insertion [11]. Radiographic evidence of significant osteophyte formation or femoral condyle flattening is associated with inferior post-operative results because these structural modifications alter the morphology of the femoral condyle [12]. Generally, patients over age 50 have excessive cartilage lesions and are sub-optimal candidates. Axial mal-alignment tends to exert abnormal pressure on the allograft leading to loosening, degeneration and failure of the graft [12]. A corrective osteotomy should be considered in patients with more than two degrees of deviation toward the involved compartment, as compared with the mechanical axis of the contralateral limb.

Varus or valgus deformity may be managed with either staged or concomitant high tibial or distal femoral osteotomy [11]. However, as in any situation in which procedures are combined, it is unclear which aspect of the procedure is implicated in symptom resolution, such as relief of pain [12]. Other contra-indications to meniscal transplantation are obesity, skeletal immaturity, instability of the knee joint (which may be addressed in conjunction with transplantation), synovial disease, inflammatory arthritis and previous joint infection and obvious squaring of the femoral condyle.

## Technique for Meniscal Transplantation

### Pre-Operative Considerations

In contrast to the use of deep-frozen allografts, a strict time schedule from harvest to transplantation is mandatory for viable allografts. The transplantation of viable meniscal allografts implies the availability of viable donor tissues, cultured in vitro immediately following harvest. Sizing of the graft is critical for correct implantation. For deep-frozen allografts the mediolateral and anteroposterior length of the tibial plateau of the receptor are measured on a calibrated X-ray and transferred to the tissue bank. Since viable meniscal allografting is more limited in size-options due to the fact that there is only one donor and a limited number of recipients, the most appropriate recipient is chosen based on corresponding donor-recipient height and weight criteria. Once a patient is deemed to be a candidate for this type of procedure, 30–50 ml. of autologous serum is prepared and frozen at −21 °C. The waiting time for a viable meniscal allograft averages 2 months – ranging from 14 days to 6 months – at our institution. Once an appropriately- sized meniscal allograft is harvested, the patient is notified and an operation is planned within the next 14 days.

## Surgical Technique

### Introduction

The purpose of this technical chapter is to present medial and lateral meniscal allograft transplantation (1) as an open procedure or (2) as an arthroscopically- assisted procedure. Both techniques use primarily soft tissue fixation of the allograft to the native meniscal rim. Additional trans-osseus fixation of the anterior and posterior horn is used in the arthroscopic technique, while a tag on the anterior horn is used in the open procedure for soft tissue-bone fixation.

### Anaesthesia and Surgical Preparation

These items are identical for the open and arthroscopic procedure.

The choice of anaesthesia is made in consultation between the surgeon, the anaesthetist and the patient and depends on the patient's age, co-morbidity and history with regard to previous anaesthesia. General anaesthesia is preferred.

The patient is then positioned supine on the operating table. A lateral leg-holder is positioned at the height of the tourniquet with the leg positioned in 90° of flexion. A foot holder is used to hold the leg in 90 ° and 110 ° of flexion as needed. Previous skin incisions are marked. The limb is exsanguinated and the tourniquet is inflated. The limb is then prepared with chlorhexidine gluconate-alcohol solution (Hibitane, Regent Medical Overseas Limited, Manchester, UK) and draped at the mid-thigh level.

### Allograft Preparation for the Open Procedure

As previously described elsewhere, the allograft is positioned and fixed on a specially designed cork board with three 25 gauge needles [13]. With a scalpel, the residual synovial tissue is dissected from the allograft meniscus at the meniscosynovial junction level and discarded.

The upper side of the allograft is marked with a methylene blue skin marker.

Horizontal 2/0 polydioxanone surgical sutures (PDS II mounted on a double small needle, Ethicon, Somerville, NJ, USA) or 2/0

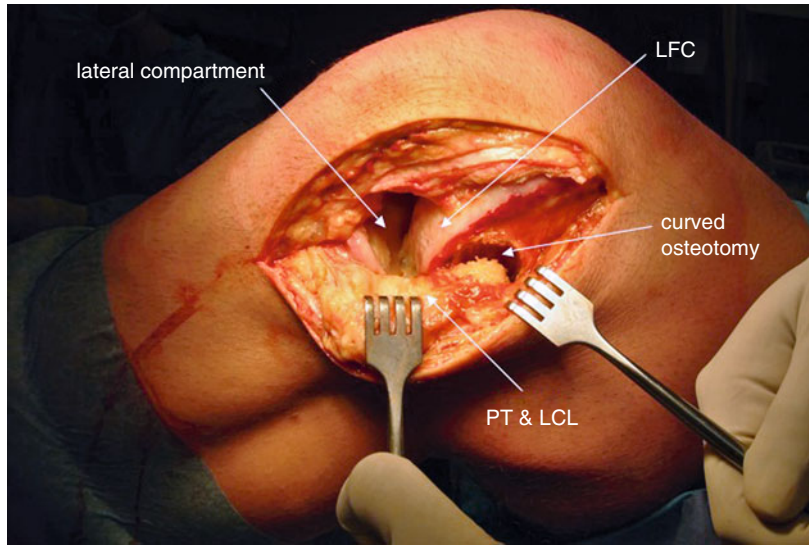


**Fig. 1** Open meniscal allograft transplantation. To further open the lateral compartment, the LCL and PT are detached with a curved osteotomy on the femoral side

non-absorbable polypropylene sutures (Prolene mounted on a double small needle, Ethicon, Somerville, NJ, USA) are placed every 3–5 mm. through the posterior horn, the body and the anterior horn of the allograft and fixed onto a specially designed suture holder (holder A). The senior surgeon (RV) prefers the use of 2/0 Prolene sutures for the posterior horn since this suture material comes with slightly smaller needles and therefore allows easier surgical handling in the more narrow posterior joint space. The sutures are fixed onto the suture holder in sequence from posteriorly to anteriorly. Generally 6–8 sutures are needed to cover the complete allograft.

## Open Meniscal Allograft Transplantation

A medial or lateral parapatellar incision of approximately 8 cm. is made with the knee in 90 ° of flexion to gain access to the involved compartment of the knee joint. The joint capsule is then opened and the anterior horn of the meniscus remnant is transected.

For the lateral procedure, the iliotibial band is released subperiostally from its distal attachment. To further open up the lateral compartment, the insertion of the lateral collateral ligament (LCL) and popliteus tendon (PT) are detached with a curved osteotomy on the femoral side (Fig. 1). The centre of the osteotomy bone block is first pre-drilled with a 2.7 mm. drill. This facilitates subsequent re-fixation with a screw and washer. The osteotomy is done in a clockwise direction from the 8 o'clock position to the 4 o'clock position and is approximately 1.5 cm. deep and conically shaped. The bone block is gently folded out using a bone clamp and then the osteotomy is completed inferiorly from the 4 o'clock to the 8 o'clock position using the osteotome. The lateral joint space can now be opened up easily 1–2 cm. by placing the knee in the figure-of-4 position in 70–90° of flexion with the index foot positioned across the contralateral limb.

For the medial procedure, the medial collateral ligament is detached on the femoral side with an osteotome [14]. A flake osteotomy (0.5–1 cm. in thickness) is done with a straight osteotome at the level of the medial femoral epicondyle. The soft tissues posterior to the medial collateral ligament are left in continuity. By gently placing the knee in a valgus position, the medial compartment can now be opened up in a controlled fashion.

The meniscus remnant is trimmed preferably to a stable meniscal rim with a scalpel

anteriorly and with arthroscopic instruments posteriorly. Most often, the insertion of the posterior horn is still intact and in continuity with the tibial plateau. The insertion of the posterior horn is also trimmed to fit the allograft. The meniscal rim deserves surgical attention, as it serves as a strong envelope encapsulating the medial or lateral compartment of the knee.

The meniscal remnant level is then marked with a small mosquito clamp anteriorly as landmark for the correct level of subsequent fixation of the allograft. Next, the previously prepared viable meniscal allograft is introduced into the knee compartment. The sutures are taken from the holder in the correct sequence from posteriorly to anteriorly and driven through the meniscal rim one by one in an all-inside fashion from inferiorly to superiorly and transferred to a second suture holder (holder B), again in a sequence from posteriorly to anteriorly. The lateral allograft is also sutured to the popliteus tendon. We have found on follow-up arthroscopies that the popliteal hiatus will re-create itself naturally. The insertion of the anterior horn of the meniscus is not yet sutured at this stage of the operation. Once the sequence of suture transfer from holder A through the meniscal rim (and popliteal tendon) to holder B is completed, the allograft is introduced into the compartment by gently pulling on each suture in a sequence from posteriorly to anteriorly. Generally, this procedure has to be performed progressively to establish a secure fit of the allograft to the meniscal rim. The suture knots are then securely tied and cut. A fine-tipped suture driver and knot pusher are frequently required to securely tighten the posterior sutures. The knee is now positioned again in a normal 90 ° flexed position. The bone block of the collateral ligament and popliteus tendon is re-positioned and fixed using a 35 or 40 mm. 2.9 AO cancellous screw with a spiked washer. The anterior horn of the allograft is then fixed to the tibia using an anchor (GII, Depuy Mitek, Raynham, Massachussetts, USA). The Hoffa fat pad and knee capsule are closed using interrupted Vicryl 1/0 (Ethicon, Somerville, NJ, USA) cross stitches after haemostasis.

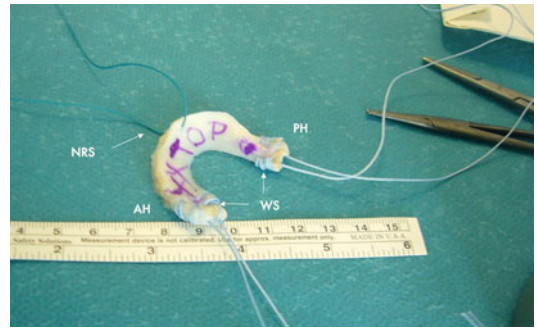


**Fig. 2** Prepared lateral meniscal allograft for arthroscopic meniscal transplantation. Whipstiches (*WS*) on inner and outer rim of anterior (*AH*) and posterior horn (*PH*). A vertical non-resorbable suture (*NRS*) is placed on the posterolateral corner, just anterior to the PT hiatus

## Allograft Preparation for the Arthroscopic Procedure

The allograft is positioned and fixed on a specially designed cork board with three 25 gauge needles. With a scalpel, the residual synovial tissue is dissected from the allograft meniscus at the meniscosynovial junction level and discarded.

The upper side of the allograft is marked with a methylene blue skin marker.

Non-resorbable high-strength (Fibre wire, Arthrex, Naples, USA) sutures are placed in the anterior and posterior horn of the allograft. Generally, 3 whipstitches are placed on the inner and outer rim of the horn of the allograft. An additional vertical non-resorbable suture (Ethibond 2/0, Somerville, NJ, USA) is placed at the posteromedial or posterolateral corner of the medial or lateral allograft, respectively. For the lateral allograft, the posterolateral suture is positioned just anteriorly to the popliteus tendon hiatus as this will serve as a landmark during arthroscopy (Fig. 2).

### Arthroscopically-Assisted Lateral Meniscal Allograft Transplantation

The classic anteromedial and anterolateral portals are made. An additional anteromedial portal is positioned very medially to gain easy instrumental access for the debridement and resection of the anterior portion of the native lateral meniscus. Using shaver and punch the remnant meniscus is debrided to the level of the meniscal rim.

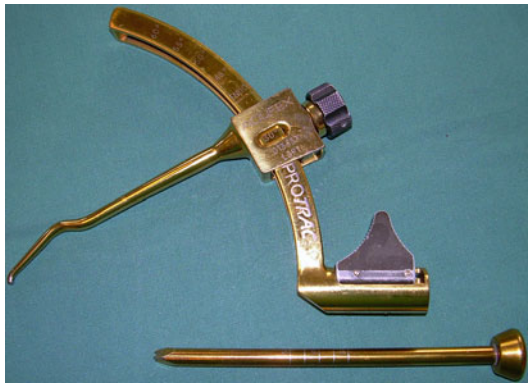


**Fig. 3** Modified ACL aiming device, with low profile tip. This device is positioned at the anatomical posterior horn of the lateral meniscus, just posterior to the ACL

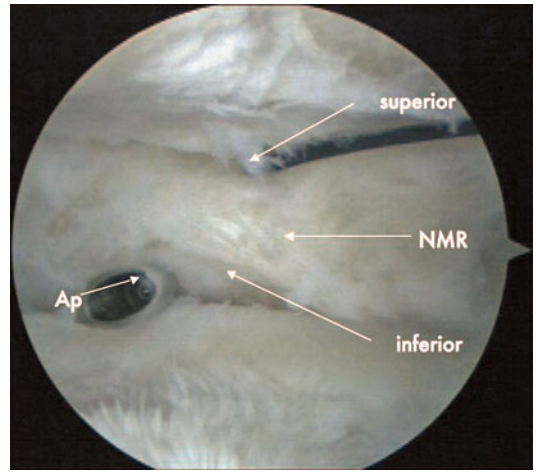


**Fig. 4** A suture passer (Acupass ®Ap) is introduced twice from outside-in, just anterior to the LCL and the PT, superior and inferior to the native meniscal rim (NMR)

A modified ACL aiming device, with a low profile tip, is inserted through the medial portal and positioned at the anatomical posterior horn of the lateral meniscus just posterior to the ACL (Fig. 3). A guide pin is drilled first and subsequently overdrilled by a 4.5 mm. cannulated drill. A double-loop metal wire is introduced through the tunnel from outside-in and picked up intra-articularly with an arthroscopical grasper and pulled out through the lateral portal. Subsequently, a suture passer (Acupass, Smith and Nephew, Memphis, Tennessee, USA) is introduced twice from outside-in just anterior to the lateral collateral ligament and the popliteus tendon into the joint: one just below and the second above the native meniscal rim (Fig. 4). The looped wires are picked up and pulled out again through the lateral portal. Next, the posterior horn pull suture and the posterolateral pull suture are pulled through using the double-looped metal wire and the double-looped suture pass wire. The prepared lateral allograft is subsequently introduced into the lateral compartment throughout an enlarged lateral portal by pulling progressively on the posterolateral pull suture and the posterior horn pull suture. Care should be taken that the graft does not flip upon introduction and that pull wires do not intertwine. Risk for intertwining wires is greatly reduced by using a double- loop metal wire for the posterior horn.

The posterior horn is now positioned correctly. Its position can be slightly modified more towards the posterolateral corner or more towards the posterior horn by pulling more on the posterolateral or posterior horn traction wire. One or two all-inside meniscal fixation devices (Fastfix, Smith and Nephew, Memphis, Tennessee, USA) are used to fix the allograft to the meniscal rim. Fixation should be started in the posterolateral corner. Subsequently inside out horizontal Ethibond 2/0 sutures are used for fixing the body of the allograft. The anterior horn is fixed using outside-in PDS or Ethibond 2/0 sutures.

Prior to making the suture knots, the anterior horn is introduced into the knee joint and the anatomical insertion site is identified and prepared is a same manner as for the posterior tunnel. If necessary, its position can be slightly adapted to the graft position. Similar to the procedure for the posterior horn, the anterior tunnel is prepared and the traction suture is pulled through.

First, the meniscal inside-out sutures are knotted. Subsequently, the anterior and posterior horn traction sutures are knotted to each other over a bone bridge on the anteromedial side of the tibia. This procedure reduces the possibly stretched capsule and native meniscal rim tied to the meniscal allograft, by pulling on the

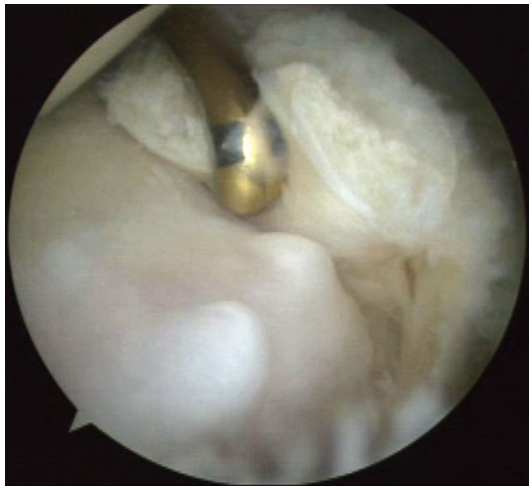

**Fig. 5** Arthroscopical view of the posteromedial portal used in arthroscopically-assisted medial meniscal allograft transplantation. The custom ACL guide in introduced through the intercondylar notch on the anatomical posterior horn insertion of the native medial meniscus

anterior and posterior horn by a transosseus suture fixation.

### Arthroscopically-Assisted Medial Meniscal Allograft Transplantation

A similar procedure as for the lateral allograft transplantation is performed for the medial allograft transplantation. However, some steps are different and will be highlighted in this section.

Additional to the classic anteromedial and anterolateral portal, a posteromedial portal should be used to identify the original posterior horn attachments of the native meniscus (Fig. 5). Using the same drill guide, the transosseus tunnels can be prepared. These tunnels should be prepared starting on the anterolateral side of the tibia. This direction is more in line with the forces on the traction sutures.

A posteromedial traction suture is used, as with the lateral allograft. On the medial side, however, we lack a clear anatomical landmark such as the popliteal hiatus on the lateral side.

The anterior horn of the native medial meniscus may in some cases be very anterior on the tibial plateau resulting in a very short transosseus anterior tunnel.

***Special note on soft tissue versus bone block fixation*** [15–19].

*Biomechanical cadaver studies have shown the superiority of a bony fixation over a soft tissue fixation technique, although a recent cadaver study showed comparable results. Bony fixation however, has also been shown to be associated with increased risk for cartilage lesions if implanted incorrectly and an increased immunological potential due to the presence of allogeneic bone. It is the authors' experience that perfect allograft size matching is essential if bony fixation is to be used. A mal-positioned bone block or plugs can inflict damage on the overlying cartilage. Too small a graft will result in a need to overtension the inside-out sutures and possible failure of the soft tissue fixation. Therefore, limited oversizing of the graft is commonly advocated using bone plugs or blocks. Separate bone plugs have the potential advantage that the implantation can be somewhat more variable compared to a single bone block. In addition, on the lateral side a straight bone block sometimes induces the need to sacrifice some posterolateral fibres of the ACL.*

*Today, clinical and/or radiological differences have not been shown between soft tissue or bone block fixation.*

## Rehabilitation

Rehabilitation is initially focused on providing mobility to the joint without endangering ingrowth and healing of the graft. Therefore, 3 weeks of non-weight-bearing are prescribed followed by 3 weeks of partial weight-bearing (50 % of body weight). Progression to full weight-bearing is allowed from week 6 on to week 10 post-operatively. The use of a knee brace is not strictly necessary and depends on the morphology and profile of the patient. For the same reasons, range of motion is limited during the first 2 weeks from 0 to 30, to increase by 30° each 2 weeks.

Isometric muscle toning and co-contraction exercises are prescribed from day 1 post-surgery on. Straight leg raising however, is prohibited

during the first 3 weeks. Proprioception training is started after week 3.

Swimming is allowed after week 6, biking after week 12 and running is progressively promoted starting at week 20.

## Conclusions

In conclusion, ample evidence has been presented to support meniscus allograft transplantation in meniscectomized painful knees, with observance of the proper indications. Significant relief of pain and improvement in function have been achieved in a high percentage of patients. These improvements appear to be long-lasting in 70 % of patients. Based on plain radiology and MRI, a sub-set of patients does not show further cartilage degeneration, indicating a potential chondro-protective effect. The lack of a conservatively-treated control group is considered a fundamental flaw in the reported studies, making it difficult to establish the true chondro-protective effect of this type of treatment. Based on the presented results, meniscus allograft transplantation should no longer be considered experimental surgery for the meniscectomized painful knee.

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