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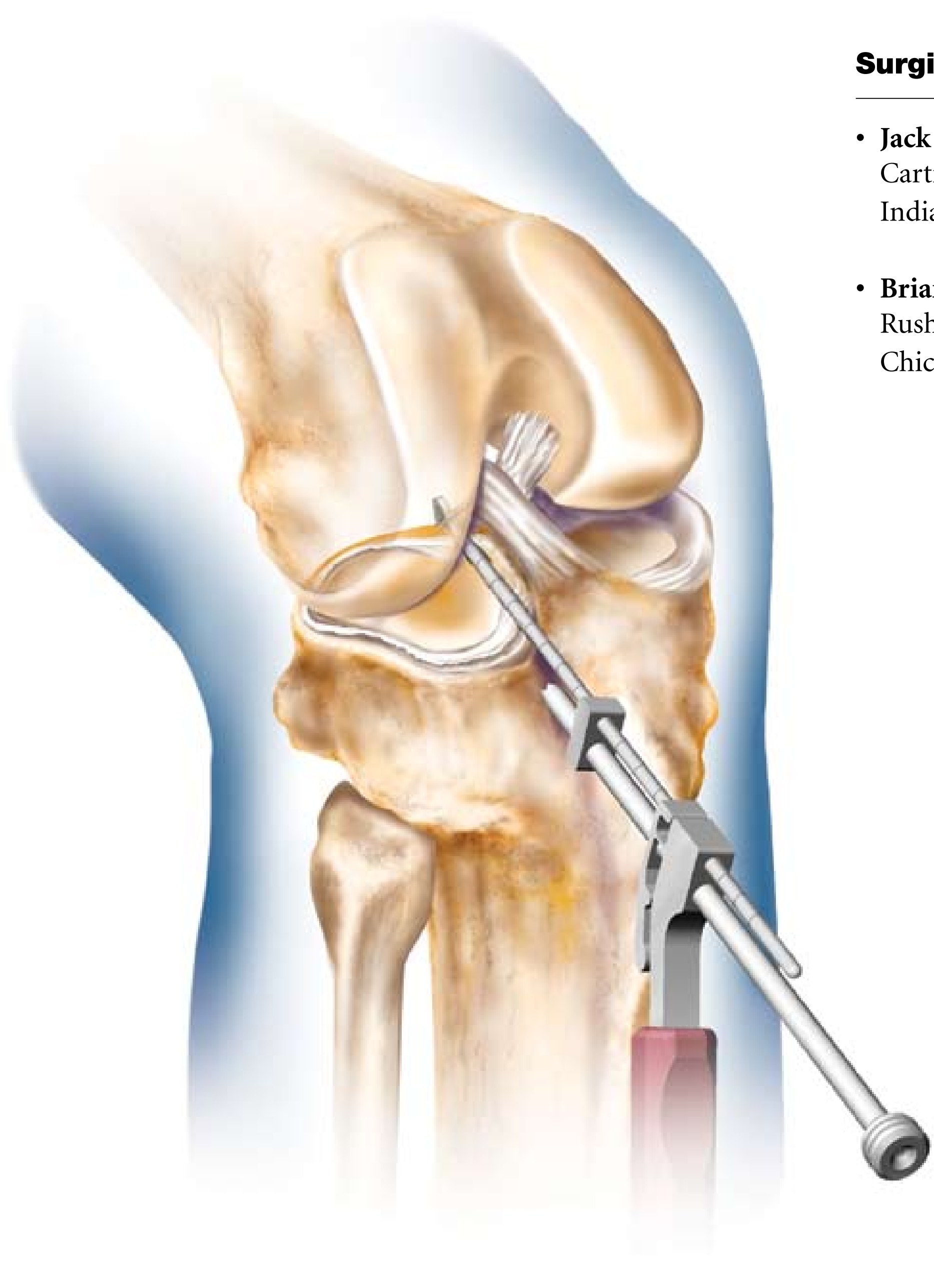
Joint Preservation

Slot Instruments
For Meniscal Transplantation



Surgical Technique

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Introduction

Meniscus transplantation is an accepted treatment option for patients experiencing symptoms secondary to the absence of one or both menisci.[1-5] Basic science provides evidence for the importance of maintaining the bony insertion sites of the anterior and posterior horns. These studies suggest that soft tissue fixation alone is sub-optimal for restoration of the tibiofemoral load sharing function of the meniscus.[8-10] Thus, depending upon surgeon preference, the meniscus allografts are prepared so that techniques utilizing a bone bridge or bone plugs can be performed. This surgical technique describes a bone bridge technique used in conjunction with the Stryker Slot Instruments for meniscal transplantation. The Slot Instruments are designed to improve the efficiency, reproducibility, and quality of allograft meniscus transplantation for either medial or lateral allograft transplantation. It maintains the relationship of the anterior and posterior meniscal horns and eliminates the need for transosseous tunnels, which complicate the procedure.

Note 1. Indications

Meniscus transplantation performed in knees with tibiofemoral arthrosis of Grade III or IV is associated with less favorable results in animal studies.[12] When indicated, concomitant cartilage restoration procedures should be performed at the time of meniscus transplantation (i.e., osteochondral grafting, autologous chondrocyte implantation).

Similarly, significant limb malalignment and ligament insufficiency should be corrected either prior to or concomitant with meniscus transplantation.[13,14] Attention to the location of osteotomy cuts or ligament tunnels is critical to determine the appropriate position of the slot prepared in the tibia to receive the meniscus bone block (see Section 3 for recommendations on the order of multiple procedures).

Note 2. Meniscus Sizing

Meniscus allografts are side and compartment specific. Pre-operatively, precise measurements must be obtained from A/P and Lateral radiographs with magnification markers placed on the skin at the level of the proximal tibia, to obtain a correctly sized allograft. If peri-operatively, in the judgment of the surgeon, the graft is severely under or over-sized, or if the surgeon is presented with the incorrect meniscus altogether (i.e. a medial meniscus rather than a lateral meniscus or left vs. right meniscus), the meniscus should not be used. Small size mis-matches are handled with only minor modifications and are likely to have minimal effects on anatomic restoration. The techniques for managing size mis-match are beyond the scope of this standard surgical technique.

Surgical Preparation

1. Position

Depending upon surgeon preference, the limb may be placed in a standard leg holder or maintained in the unsupported supine position. The posteromedial and/or posterolateral corners of the joint must be freely accessible to permit unencumbered inside-out meniscus suturing techniques.

2. Exposure

Arthroscopic: Except for the steps required to create the tibial bone slot and to insert the meniscus, it is common for meniscus transplantation to be performed arthroscopically through standard arthroscopic portals. It is necessary, however, to create a mini arthrotomy in line with the anterior and posterior horns of the involved meniscus to permit accurate "in-line" guide placement during slot formation and for introduction of the meniscus. Depending upon surgeon preference, the mini-arthrotomy may be immediately adjacent to the patellar tendon or through a split made within the patellar tendon.

Open: An ipsilateral parapatellar arthrotomy allows adequate exposure for allograft meniscus transplantation when performed open or during the performance of concomitant cartilage restoration procedures.

When full exposure of both condyles is necessary, it may be easier to perform a tibial tubercle osteotomy with proximal reflection of the extensor mechanism.

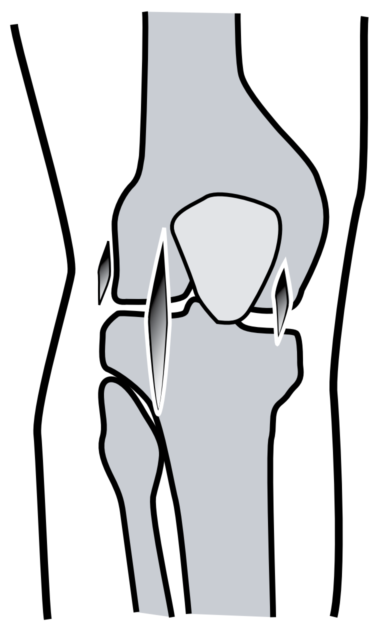

Fig. 1

3. Concomitant Procedures

High Tibial Osteotomy: Usually, the meniscus transplant technique is completed first including the bone and soft tissue fixation since this can involve high forces to "open the joint." If the surgeon desires to perform the osteotomy first, rigid osteotomy fixation is required to tolerate the meniscus repair technique, and extreme caution must be used to avoid fracturing through the slot into the osteotomy site.

ACL Reconstruction: First, arthroscopically perform all soft-tissue portions of the meniscus transplant technique. ACL tibial and femoral tunnel reaming is performed prior to meniscus slot placement. Placing the tibial ACL tunnel as close to the mid-line as possible without compromising the anatomical position of the ligament will decrease interference between the tunnel and a medial meniscus slot. The meniscus bone bridge is trimmed at the site of intersection with the ACL tunnel. This facilitates ACL graft passage. Depending upon surgeon preference, consideration for hamstring ACL graft reconstruction may also facilitate graft passage. When using a patellar tendon graft, the bone bridge of the meniscal allograft is temporarily elevated to allow passage of the bone and is then reduced as the tendon portion occupies a much smaller volume of the tunnel compared to the bone block.

Distal Realignment: All steps of the meniscus transplant are performed first, followed by the tibial tubercle osteotomy and other required soft tissue procedures as determined by the surgeon (i.e., lateral release, medial patellofemoral ligament reconstruction). Performing the tibial tubercle osteotomy as distal as possible will prevent inadvertent encroachment on the meniscus slot.

Autologous Chondrocyte Implantation or Osteochondral Grafting: It is typically easier and safer for the chondral procedure to be performed after all steps of the meniscus transplant are completed to avoid inadvertent damage to the articular cartilage graft during instrumentation or suture placement.

Slot Instruments Surgical Technique

1. Establishing Anatomic Slot Placement

Anatomic placement of the slot in line with the center of the native meniscus insertion points is critical. Identify the remnant anterior and posterior attachments of the native meniscus. Use an electrocautery or electrothermal device to mark a line that connects the center of the anterior and posterior attachment sites.

The horn attachments are usually discrete and readily identifiable structures. A notable exception to this is the anterior horn of the medial meniscus which has a more variable insertion near the anterior-most aspect of the tibial plateau. The true attachment site is deep to the traversing soft tissue of the intermeniscal ligament.

Fig. 2

Prior to slot creation, it is critical to identify and protect the cruciate ligaments and their attachments.

To allow better visualization of the posterior meniscal horns and improve instrument placement, it is helpful to perform a minimal notchplasty of the ipsilateral femoral condyle adjacent and inferior to the respective cruciate ligament early in the procedure.

2. Establishing a Reference Slot

Using the line established between the meniscus insertion sites in Step 1, a 4 mm un-hooded burr is used to create a superficial (from anterior to posterior) reference slot. Since the tibial plateau typically contains rises and undulations, the reference slot will have varying depths especially at the spine region, where the depth may be actually deeper than the average of 4mm. At approximately 4mm deep anterior and posterior to the spine, the superficial reference slot allows the depth gauge (4mm in diameter) to sit flush with the adjacent articular cartilage of the plateau and parallel to the slope of the plateau articular cartilage.

Note: Remove only the tibial spine present along this line to facilitate creation of a straight anterior to posterior slot in the plane of the tibial slope. A level and smooth slot is confirmed by fully seating the depth gauge in the reference slot.

Fig. 3

3. Drill Guide Placement

Place the depth gauge in the reference slot under direct visualization so that the tip is firmly engaged against the posterior cortex by gently pulling back on the depth gauge. The etched lines on the depth gauge can be used to determine the complete A/P length of the tibial plateau.

Fig. 4

Maintain the depth gauge tip against the posterior tibial cortex and advance the drill guide over the depth gauge until the distal end of the drill guide is firmly seated against the anterior tibia. The depth gauge will slide in the drill guide when the trigger is depressed. Release the trigger to lock the gauge in place. The depth gauge should remain fully seated in the reference slot.

Placing the depth gauge parallel to the slope of the tibial plateau positions the final slot in the proper anatomic orientation. The spike of the drill guide tip will maintain positioning during drilling.

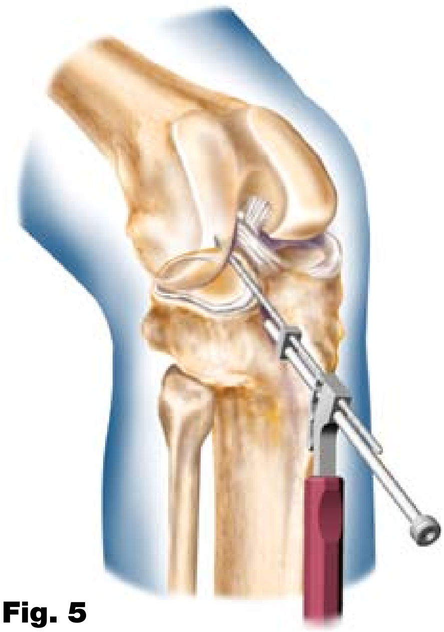

Fig. 5

Obtaining Depth

1. Guide Pin and Reaming

First verify the tibial A/P dimension either by the depth gauge laser marks relative to the proximal most bracket of the drill guide (A) or the second set of laser marks measured relative to the drill guide tip (B) (Fig. 6a). Both markings should read the same as they pertain to the distance from the distal tip of the drill guide as it rests against the anterior tibia to the hook at the end of the depth gauge. Laser marks on the guide pin allow the surgeon to chuck the pin to the desired distance, as measured from the depth gauge laser mark. The surgeon may choose to ream to a depth of 3-5mm less than the depth of the tibia plateau (as measured with depth gauge) to preserve the posterior cortex of the tibia.

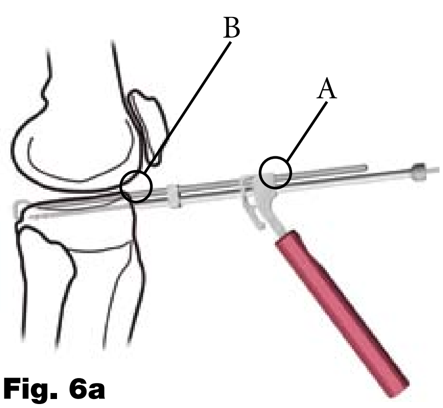

Fig. 6a

Drill the 3.2mm guide pin through the drill guide hole located inferior to the depth gauge hole while maintaining the drill guide pin parallel to the slope of the tibial plateau (Fig. 6b). The drill guide will provide a hard stop at the desired distance as the drill chuck contacts the proximal end of the drill guide.

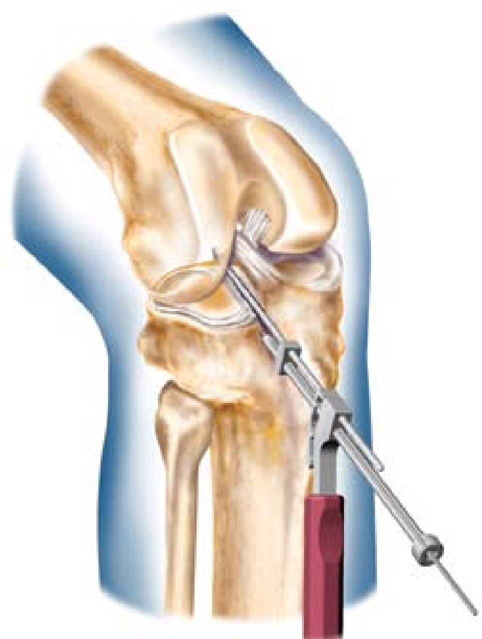

Fig. 6b

After guide pin placement, un-chuck and remove the drill guide and depth gauge, leaving the drill pin in place. Set the drill collar on the 8mm drill bit to the same depth as the drill pin (3-5mm short of the posterior cortex of the tibia plateau). To set the drill collar, depress the circle laser marks on either side of the collar and slide to the desired distance. The grooves in the drill bit allow the surgeon to lock the collar into place. Ream over the guide pin to the desired distance (Fig. 7a and Fig. 7b).

Fig. 7a

Fig. 7b

2. Slot Preparation

Remove the drill bit and guide pin and insert the 8mm box cutter by placing the bullet nose of the cutter into the drilled hole. Gently impact the cutter with a mallet to advance the cutter into the tunnel to remove residual bone around the tunnel and between the tunnel and the reference slot (Fig. 8a). The box cutter creates a slot 8mm in width by 10mm in depth. The tines of the box cutter should be visualized anthroscopically as they are advanced through the articular surface.

Use the 7 and 8mm sizer/rasp in succession to smooth the final slot (Fig. 8b). The 8mm rasp also serves as a proxy for the allograft bone block and allows the sized bone bridge to slide smoothly into the slot. Once the 8mm rasp sits flush with the tibial plateau, your slot is completed.

In some cases, an arthroscopic burr or a straight rongeur may be used to further debride the residual bone from the posterior section of the final slot.

Fig. 8a

Fig. 8b

3. Meniscal Allograft Bone Bridge Preparation

Depending on surgeon preference, this technique allows for either an 8mm bone block to press fit into the 8mm slot or undersizing the meniscus bone bridge width by 1mm (i.e. 7mm bone bridge into a 8mm final slot).

Identify Meniscus Attachments: Dynamically identify both horns of the meniscus by moving the meniscus back and forth about the attachment sites like a bucket handle (Fig. 9a).

Fig. 9a

Debride the accessory attachments (including the "intermeniscal ligament") leaving only the true attachments (usually 5-6mm in width). Unlike the other horn attachments, the anterior horn of the medial meniscus usually extends to the anterior-most extent of the tibial plateau for attachment. In rare cases in which the anterior attachment is 7 to 9mm wide, leave the bone bridge beneath the anterior horn 7 to 9mm wide and trim the remainder of the bridge to the planned 7 or 8mm width. Then, prior to insertion, enlarge the anterior-most aspect of the recipient slot with the 7 or 8mm rasp to accept this widened area.

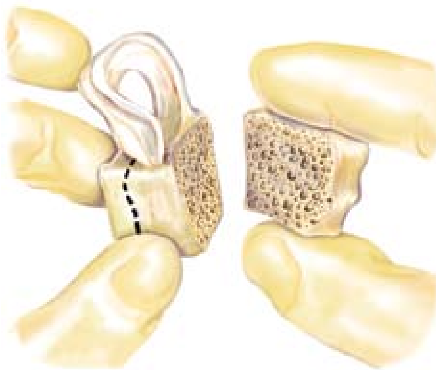

Fig. 9b

Fig. 9c

Bone Bridge Width: Use a marking pen to trace the straight lines connecting the planned cuts on the medial and lateral side of the bone bridge (Fig. 9b). Cut the bone bridge to a width of 7mm or 8mm, or as dictated by the width of the soft tissue attachment (Fig. 9C). The walls of the graft sizer workspace are 8mm and 7mm high, respectively. To fine tune the meniscus width, the surgeon may lay the bone block flush against the wall with the height corresponding the desired width cut. The surgeon may then create the desired bone bridge width by "painting" the bone block with the saw (Fig. 9d). (Note: The bone block of the unprepared meniscus allograft is often skew to the line connecting the horn attachments. Do not let the shape of the unprepared bone block influence your lines of cut when determining the final bone block width.)

Fig. 9d

Bone Bridge Height: Cut the bone bridge to a height of 10mm. Measure the height from the attachment sites, not from the tibial spine, which may be several millimeters higher than the horns. The laser mark and cutting groove in the graft sizer workspace aides in this cut. The distance between the laser mark and the cutting groove is 10mm. Therefore, position the meniscus so that the laser mark runs through the horn attachment sites and then run the saw through the cutting groove to attain the desired 10mm height cut. (Note: the "dead" cartilage covering the spine area of the bone bridge may be removed to allow better visualization during insertion and to help prevent inadvertent bony impingement on the ipsilateral femoral condyle.)

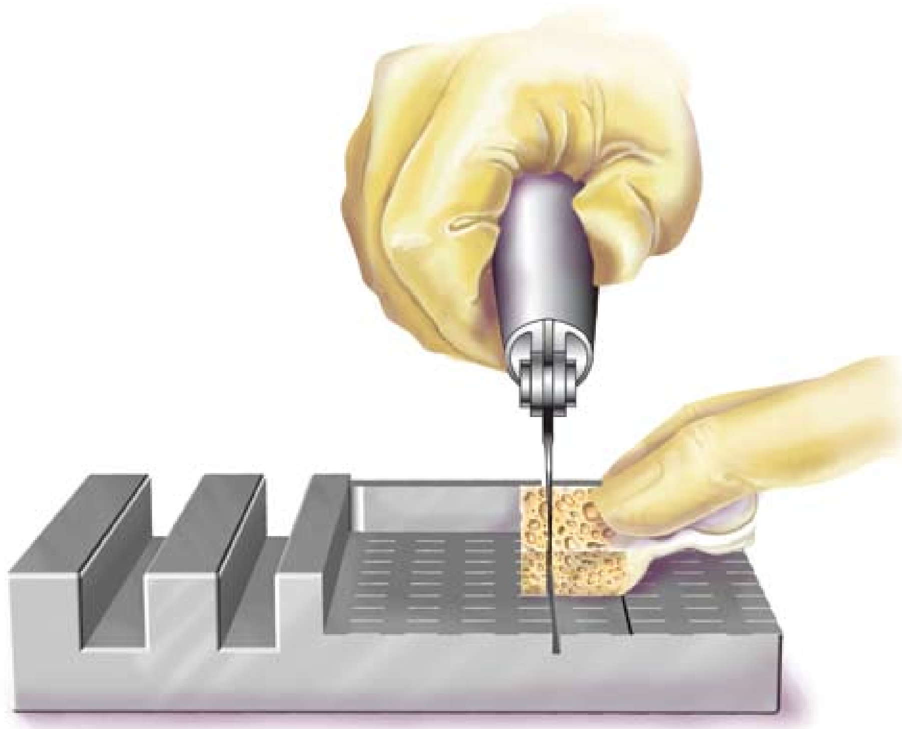

Fig. 10

Bone Bridge Length: Remove any bone that extends beyond the posterior horn attachment (Fig. 11). Bone extending beyond the anterior horn attachment is left intact to provide graft integrity during insertion. This may be trimmed following bone bridge insertion.

Place the bone bridge in the bone bridge sizer channels to allow it to slide smoothly into the final slot (8mm wide and 10mm deep). If a looser fit is desired, then use the 7mm channel to test the graft fit in the tibia. If a press fit is desired, then use the 8mm channel.

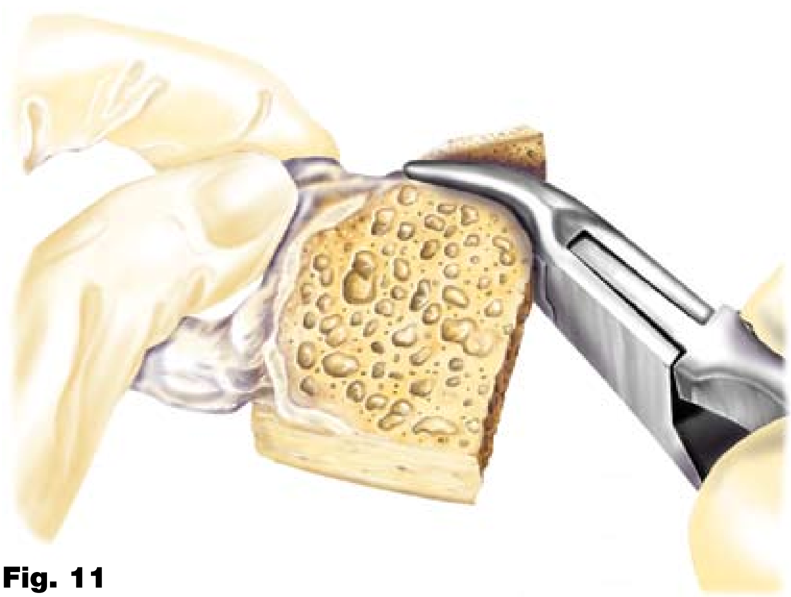

Fig. 11

4. Meniscus Insertion

Place a vertical mattress traction suture using #0 PDS through the junction of the posterior and middle third of the meniscus. Using a single barrel cannula, advance a long nitinol suture passing pin through a properly positioned cannula from the contralateral portal through the capsule at the corresponding attachment site of the posterior and middle third of the meniscus and exit the accessory posteromedial or posterolateral incision. The proximal end of the nitinol pin is then withdrawn from the contralateral portal and into the arthrotomy site to help facilitate passage of the meniscus into the knee. Place the traction sutures from the meniscus through the loop on the proximal end of the nitinol pin and withdraw the pin and sutures from the accessory incision. In cases where the suture is not anatomically placed within the capsule relative to the meniscus, it can be subsequently removed rather than used for final meniscus suturing.

5. Meniscus Insertion and Fixation

Insert the meniscus through the arthrotomy, taking care to accurately align it with the recipient slot while gently pulling on the traction suture. The assistant manually opens the joint by applying a varus (lateral meniscus) or valgus (medial meniscus) stress to the knee. Confirm the proper size and position of the meniscus by cycling the knee through its range of motion. Carefully match the meniscus position to the femoral condyle and tibial plateau.

Depending on surgeon preference and the fit of the bone bridge in the final slot, three choices exist to secure the bone bridge within the recipient tibial slot:

Interference Screw: If the bone bridge fits loosely in the slot and greater fixation is desired, then the surgeon may use a Stryker 7mm by 23mm HA/PLLA screw. Place the screw central to the graft (medial side of the graft if inserting a lateral meniscus (Fig. 12a)). Tapping is recommended.

Bone Pin: If the bone bridge fits more snug in the slot and additional interference fit is still desired, then the surgeon may use a 3.2mm by 45mm allograft cortical bone pin. The drill guide is also designed to introduce the bone pin.

Place the guide at the junction of the bone bridge and the tibial slot, 5mm from the base of the slot and central to the graft. Chuck the drill pin to between 5mm and 10mm and drill a pilot hole. Remove the drill pin while leaving the drill guide in place. Insert the bone pin in the same hole as used for the drill pin in the drill guide and dispense the pin with the tamp (Fig. 12b). Insert the pin only as far as the back wall of the slot. Use a rongeur or bone cutter to cut any portion of the bone pin protruding from the slot.

Fig. 12a

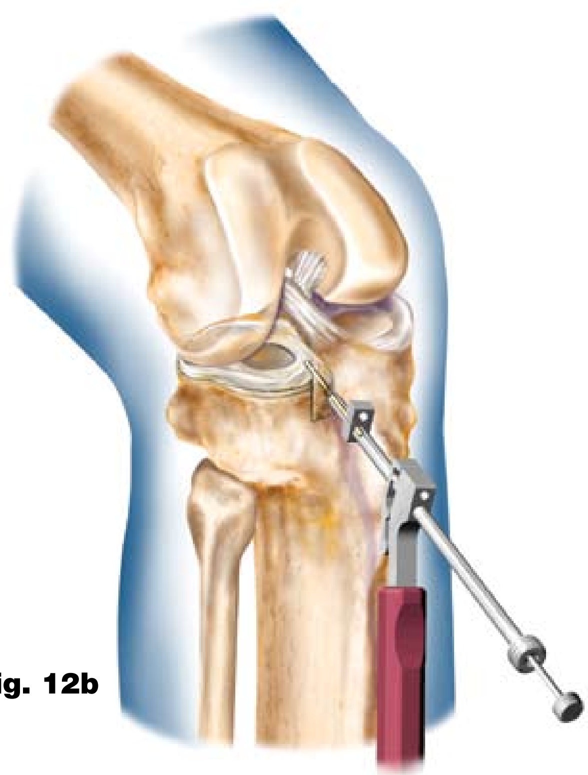

Fig. 12b

Press fit: If the surgeon feels as though the graft fits adequately in the slot without additional fixation, then proceed to meniscus suturing (Fig. 12c).

(Note: As another alternative, transosseus sutures can be used for fixation of the bone bridge in the slot.)

6. Meniscus Suturing

Finally, repair the meniscus with vertical mattress sutures using an inside-out technique or as per surgeon preference.

Fig. 12c

Medial Bone Bridge in Slot Meniscal Allograft Transplantation

Medial meniscal allograft transplantation (MAT) is most commonly performed using bone plugs in tunnels. The rationale for this technique is based on two factors: The first is that plug in tunnel technique is technically feasible medially as compared to the lateral meniscus. That is, the bone plug in tunnel technique when attempted for lateral MAT leads to tunnel convergence. The thin bone wall separating the tunnels often would collapse creating difficulty with accurate positioning of the plugs which is essential in proper meniscal horn positioning. Thus, the use of a bone bridge for the lateral meniscus was a logical development based on this close proximity of the two horn attachments (Fig. 13).

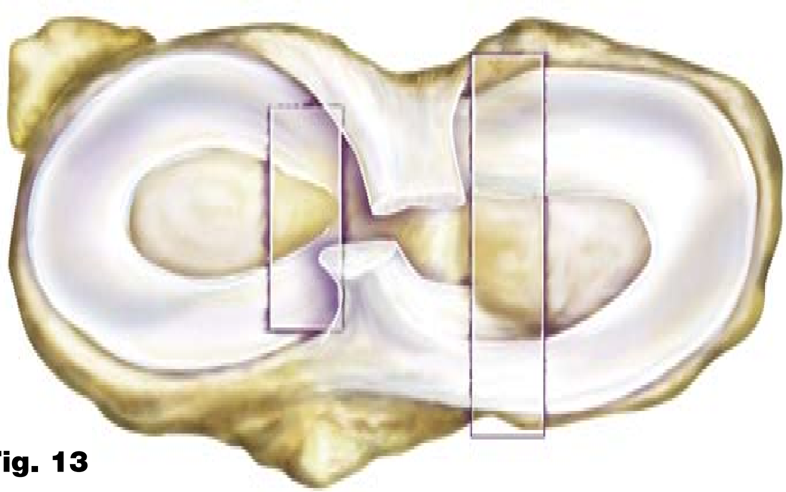

Fig. 13

The second factor influencing use of the plug/tunnel technique for the medial MAT was the concern for the loss of the medial tibial spine/medial femoral condyle interaction/force transfer. This second theoretical factor is very difficult to evaluate from a pure biomechanical standpoint because of the technical difficulties in measuring spine/condyle loading with the current "force transducers" available (e.g., Tekscan, Fuji film).

Acknowledging the theoretical implications of loss of medial tibial spine/medial femoral condyle contact/stress transfer, it is important to review the current recommended plug in tunnel techniques. These techniques stress the importance of adequate visualization of the posterior horn attachment and adequate room to orient the plug into the posterior tunnel. However, anatomy precludes optimal visualization and room for plug insertion in most patients. In addition, as the medial meniscus attaches extra-articularly on the posterior tibial slope along and adjacent to the PCL (posterior cruciate ligament), to properly visualize this attachment, the plug in tunnel technique suggests both a "minor" resection of the medial tibial spine and a "minor" posterior notchplasty of the medial femoral condyle (Fig. 14).

Fig. 14

This technique is designed to provide the needed visualization of the posterior horn attachment and room for plug orientation, but it also serves to biomechanically remove any force transfer between the medial spine and the medial femoral condyle. Thus, at this point in MAT, there does not appear to be a compelling evidence to preclude the use of a bone bridge for medial MAT.

There are potential advantages of any bone bridge technique over a plug in tunnel technique. First, critical review of some plug in tunnel MAT post-operative radiographs will reveal many that violate the region of the posterior tibial plateau typically covered by articular cartilage. While this small area probably does minimal harm to the tibial plateau articular cartilage, it does place the posterior horn medial and anterior to the true anatomic posterior horn attachment site. Published biomechanical studies stress the potential deleterious effect of non-anatomic posterior horn position.

Second, the anterior horn attachment tunnel (for plug in tunnel technique) is selected by the surgeon based on "where the anterior horn fits with appropriate tension". It is extremely difficult for a surgeon to select both tension and position. Thus, most anterior horn tunnels are actually medial to the native fixation site. Not only has this tunnel technique required the surgeon to select the attachment sites, but any errors are additive (posterior horn plus anterior horn). With a bone bridge, additive errors should be avoided as the relationships of the horns is dictated by the donor attachment sites. True medial meniscal posterior horn attachment (extra-articular and adjacent to the PCL) is dictated by the slot accepting the bridge. Finally, the anterior horn attachment site is selected by the anatomy of the donor (size matched to the patient), and the anatomy of the host (as the slot is in line with the host horn attachments) not the surgeon.

That is, if the properly sized MAT has been selected, then the match in the joint is near anatomic. As the slot mimics the anterior/posterior (A/P) course of the natural meniscus, the medial lateral position of the meniscal horns is anatomic and the only variable remaining is the correct AP position of the bone bridge in the slot. The overall goal of MAT is to duplicate the contact area distribution of the medial femoral condyle (MFC) onto the medial tibial plateau. To optimize the contact area, the MFC must fully capture the meniscus. As the 7mm bone bridge easily moves in the 8mm slot, cycling the knee near extension (there is minimal A/P motion of the medial meniscus from 0 to 60 degrees of flexion), allows the patient's anatomy (MFC capturing the MAT) to select the final A/P position of the MAT bone bridge in slot. At that point the MAT is fixed in a manner previously described for the lateral MAT technique. Clinically this technique has been in use since 1999 with results and complications similar to other reported techniques.

Box Cutter Pearls and Pitfalls

Fig. 15

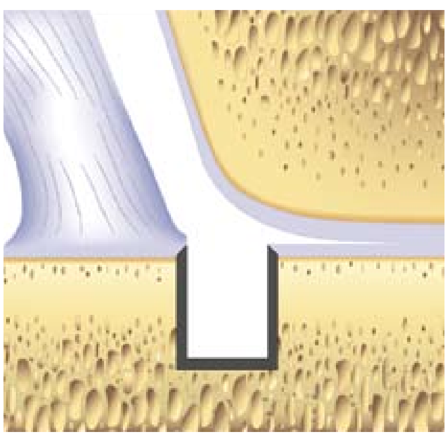

Fig. 16a Optimal Slot Depth

Optimal blade placement allows a smooth cut of the walls and roof of the slot without damage to the medial femoral condyle.

As with most instrumentation systems, the slot technique is a surgeon assist, not surgeon independent technique. If the blades of the box cutter are not optimal, then the surgeon should take actions as follows:

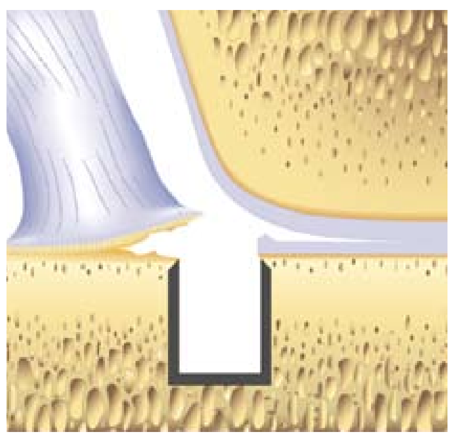

Fig. 16b "Low" Slot

Recognition that the blind tunnel is too low will prevent "snow plowing" of the subchondral bone with possible elevation fracture of the ACL footprint. Recognition allows the surgeon to manually position the box cutter at the appropriate level.

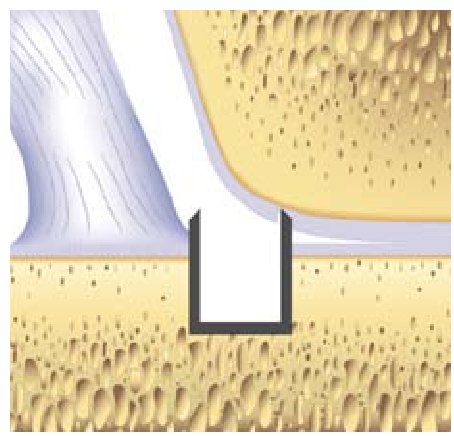

Fig. 16c "High" Slot

The surgeon should directly monitor the progress of the box cutter blades. If they are too high, they can be directed distally manually by the surgeon to prevent injury to the medial femoral condyle.

Instruments are available for purchase or single-use from Stryker Joint Preservation:

Slot Instruments (Single Use)
R2000-004-050

Slot Instruments (Sale)
2000-004-050

Additional instruments and materials recommended for procedure:

Small oscillating saw

Meniscal repair set and mensical sutures

Suture passing nitinol needle

Straight bite rongueurs (5mm or smaller)

4mm Stryker Formula
unhooded round burr
375-940-200

7mm x 23mm Stryker Biosteon
(HA/PLLA) Wedge Interference Screw
234-010-161

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