BONE PLUG TECHNIQUE FOR MENISCAL TRANSPLANTATION

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The goal of meniscal transplantation is to restore meniscus structure and function in symptomatic individuals post-meniscectomy. Biomechanical studies have shown that anatomic bony fixation of the horns is required to restore normal knee contact mechanics. The purpose of this chapter is to describe the operative technique and results using bone plugs for medial meniscal allograft transplantation.

KEY WORDS: meniscal allograft, meniscal transplantation, bone plug, meniscectomy, medial meniscus

There are a variety of techniques currently in use for allograft meniscus transplantation. It is suggested by several studies that maintaining bone fixation of the anterior and posterior horns during meniscal transplantation is necessary to regain near normal knee contact pressures.[1,2] While bone bridge techniques can be used for medial and lateral allograft meniscus transplantation, there are alternatives including techniques that utilize bone plugs fashioned and inserted in tibial tunnels for fixation. The advantages of this technique are largely recognized during medial meniscus transplantation and include minimizing the risk for compromising the tibial insertion site of the anterior cruciate ligament as well as more easily allowing concomitant high tibial osteotomies which may otherwise encroach on a tibial slot. The indications for allograft meniscus transplantation, graft selection principles, and considerations for preoperative planning are thoroughly discussed in the previous chapter in this issue ("Bone Bridge in Slot Technique" by Cole and co-workers). Thus, this article will specifically discuss the surgical technique using bone plugs for allograft meniscus transplantation.

SURGICAL TECHNIQUE

SETUP

The patient is positioned supine on the operating room table with 10 to 15° of lumbar flexion placed in the table. The nonoperative extremity is padded and positioned in a well leg holder. The operative extremity has a tourniquet placed about the proximal thigh and is placed in a C-shaped leg holder. The foot of the bed is flexed to 90° allowing circumferential access to the knee for meniscal repair and possibly, concomitant procedures (Fig 1).

ARTHROSCOPY

Arthroscopy is initiated through standard portal placement. Diagnostic arthroscopy is performed removal of the remnant meniscus is initiated with arthroscopic baskets and a 3.5 mm shaver. The meniscus should be resected to a vascular edge, typically just to the meniscal-synovial junction, but not through the synovial lining. One to two mm of meniscal capsular rim is usually left when complete (Fig 2). A No.11 blade is often necessary to remove the anterior horn facilitated by the arthroscopic shaver and hand instruments. Additional remnants can be removed when the mini-arthrotomy is made for allograft implantation.

A standard meniscus repair exposure positioned in line with the respective femoral epicondyle situated one-third above the joint line and two-thirds below the joint line is required to protect the neurovascular structures during inside-out meniscus repair. A Henning retractor (Linvatec, Largo, FL) is placed through this incision within the interval between the posterior capsule and ipsilateral gastrocnemious tendon will aid in directing the needles away from neurovascular structures.

PREPARATION OF THE MENISCUS

The meniscus is thoroughly thawed in normal saline. The soft tissue capsular remnants and excess tissue surrounding the meniscal insertion sites are sharply excised. The meniscus allograft is prepared by using a coring reamer system (Arthrex, Inc., Naples, FL). The posterior horn is prepared first. A 2.5 mm twist drill is used to create a drill hole angled at about 60° relative to the posterior horn insertion and centered within the foot print of the insertion site. Next, a collared pin is placed through the drill hole with the collar abutting the bone. Pin placement is confirmed by moving the meniscus back and forth like a handle to expose both surfaces at the insertion site. Optimally, the pin should be completely buried within soft tissue so as to capture the maximal amount of insertion

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Fig 1. Clinical photograph of proper patient positioning allowing circumferential access to the operative knee (see text for further details).

site with the bone core to minimize the potential for soft tissue avulsion from bone (Fig 3). Next, an 8-mm coring reamer is passed over the collared pin and a bone plug with the intact meniscus insertion is fashioned. The plug is trimmed to a length of 8 mm with a rongeur. The steps are repeated for the anterior horn. The only difference is that a 9- or 10-mm coring reamer is used at an angle of about 90° relative to the insertion site of the anterior horn.

A No. 2 nonabsorbable traction suture [ie, Fiberwire (Arthrex, Inc., Naples, FL)]is first passed in a figure-of-eight fashion through the soft tissue insertion and the ends are passed through the center of the bone using a Keith needle (Fig 4). A No. 0 or 1 monofilament suture is then placed at the junction of the middle and posterior one-third of the meniscus to aid in reduction of the prepared meniscus (Fig 5).

PREPARATION OF BONE TUNNELS

Attention is returned to the intraarticular arthroscopy. An anterior cruciate ligament (ACL) guide is used to determine the location of each tunnel. Debriding the interval between the medial aspect of the posterior cruciate ligament (PCL) femoral origin and the bony portions of the medial femoral condyle facilitates passage of the posterior bone plug. The posterior tunnel is created with the guide set at 60° and the guide tip positioned to deliver a 2.4 mm guide pin into the middle of the posterior remnant attachment while holding the guide perpendicular to the slope of the tibial plateau. The origin of the tunnel is on the anteromedial aspect of the tibia, between the tibial crest and posterior border of the tibia. An 8 or 9 mm ACL tibial reamer is then drilled over the guide pin taking care not to inadvertently advance the guide pin (Fig 6). A shaver is used to debride the tunnel entrance of residual meniscus insertion site and cartilage debris. A rasp is used to smooth the tunnel edges.

INSERTION OF MENISCUS

Extending the inferomedial portal distally and excising a small portion of the fat pad allows sufficient access to the joint to remove remaining meniscal tissue, introduce and seat the meniscus in the posterior tunnel, and to reduce the meniscus to the periphery. The mini-arthrotomy also allows arthroscopic and direct visualization for meniscal repair and creates access to drill the anterior horn blind bone tunnel socket. The first step is proper reduction of the meniscal allograft. A single barrel zone-specific cannula is placed through the inferolateral portal and is used to advance a Nitenol suture passing pin (Arthrex, Inc.) that exits the posteromedial knee capsule at the attachment site

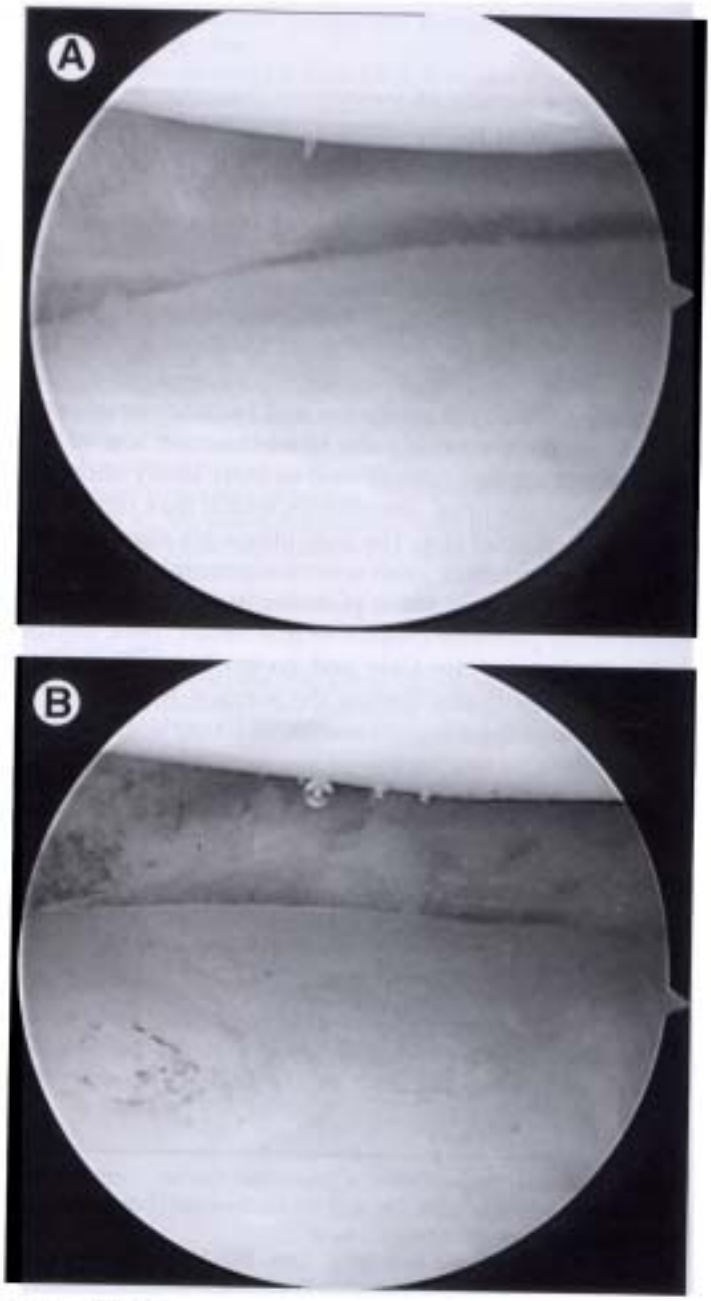

Fig 2. (A) Arthroscopic view of a patient's medial compartment following subtotal meniscectomy with minimal arthritic change. (B) Arthroscopic view demonstrating appropriate debridement of the residual meniscus to the periphery.

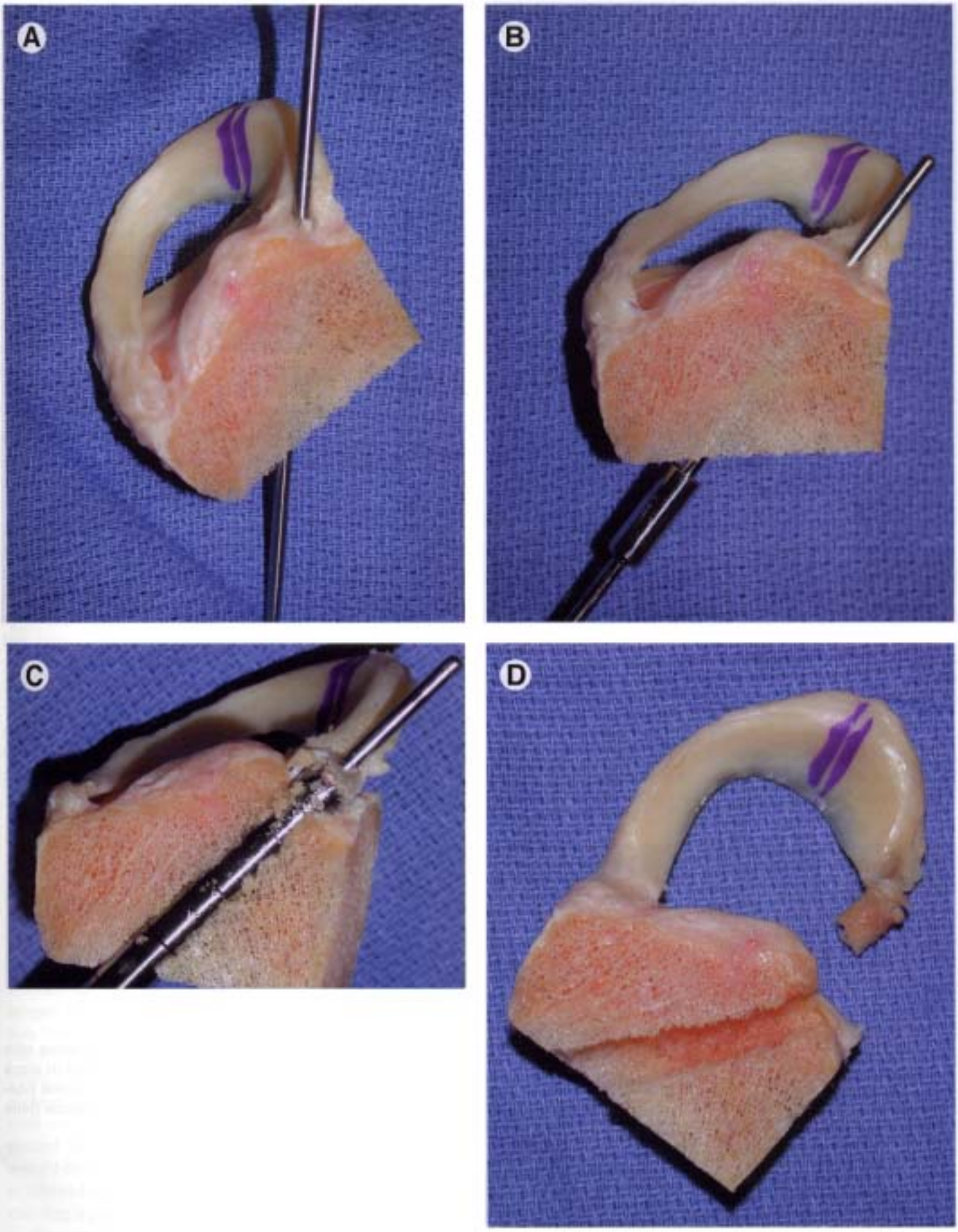

Fig 3. Meniscal preparation. (A) A 2.5-mm twist drill at 60° to the posterior horn insertion site. (B) Collared pin in place. (C) A 8-mm cannulated coring reamer capturing the majority of the meniscal insertion site. (D) Final 8-mm × 8-mm posterior horn bone plug meniscal construct.

Fig 4. Bone-plug traction suture is placed using a No.2 nonabsorbable suture in a figure-of-eight pattern at the base of the soft tissue insertion followed by passing the suture ends simultaneously through the center of the bone plug using a Keith needle.

of the posterior and middle third of the meniscus. The proximal end of the Nitenol pin is retrieved under direct visualization from the medial mini-arthrotomy. The No. 0 or 1 monofilament traction sutures in the allograft meniscus is passed through the loop of the Nitenol pin, and the sutures are withdrawn through the medial accessory meniscal repair incision.

A suture passer is advanced into the entrance of the tibial tunnel and retrieved through the arthrotomy. The No. 2 nonabsorbable suture passing through the posterior horn bone plug is shuttled retrograde through the arthrotomy so as to exit the tibial tunnel on the anteromedial surface of the tibia (Fig 7).

The meniscus is advanced into the knee with gentle simultaneous traction on the monofilament suture and the bone plug traction suture typically with the knee in about 30° of flexion with a firm valgus load to facilitate reduction. A blunt tipped probe or index finger will help seat the meniscus and push the posterior bone plug toward its bone tunnel. Once the majority of the meniscus is in the joint, the arthroscope is used to verify the final position of the implant (Fig 8).

The meniscus is repaired using inside-out techniques with 7 to 10 vertical mattress sutures of No.2 to 0 nonabsorbable suture. Sutures are placed on both sides of the meniscus. Once the meniscus is secured, the anterior horn socket is established by creating a blind 1-cm tunnel using a 9 to 10 mm reamer. The bone plug is seated by passing a heavy gauge needle trans-osseously through the bottom of the tunnel to shuttle the anterior horn sutures through the anterior tibial cortex to reduce and secure the anterior bone plug (Fig 9). These sutures can be tied over soft tissue. In addition, the posterior horn sutures should be tied independent of the anterior horn sutures using a small ligament button (Fig 10). When finally securing the meniscus, sutures should be tied beneath the sartorius fascia with the knee in extension so as to prevent capturing the knee and inadvertently creating a flexion contracture (Fig 11).

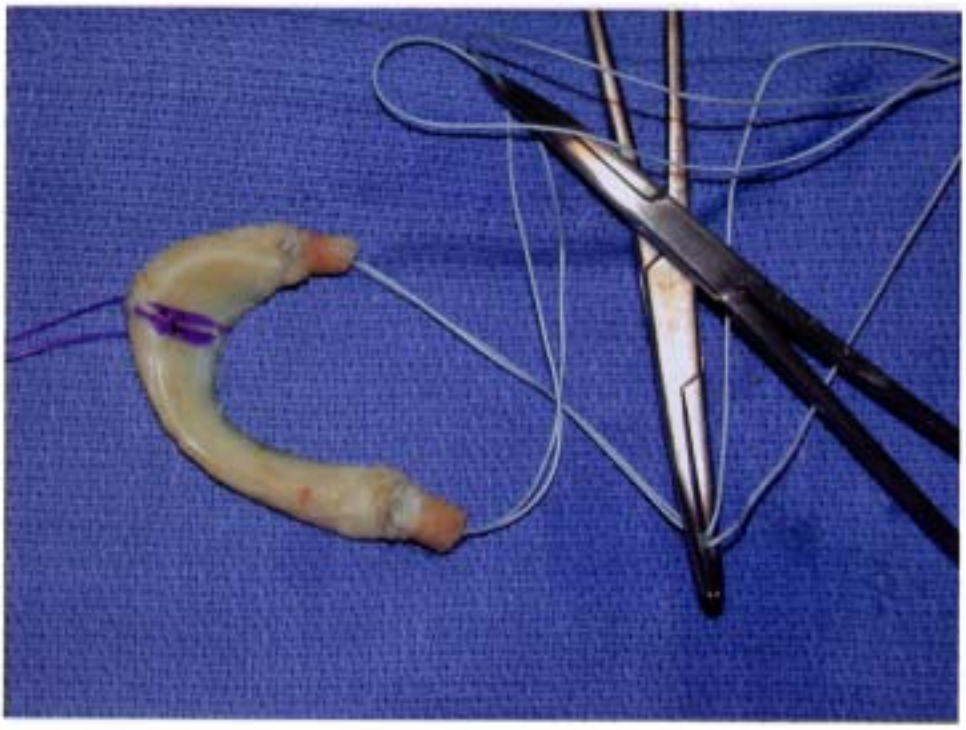

Fig 5. Fully prepared meniscus with monofilament traction suture in place at the junction of the middle and posterior one-third of the meniscus (blue mark).

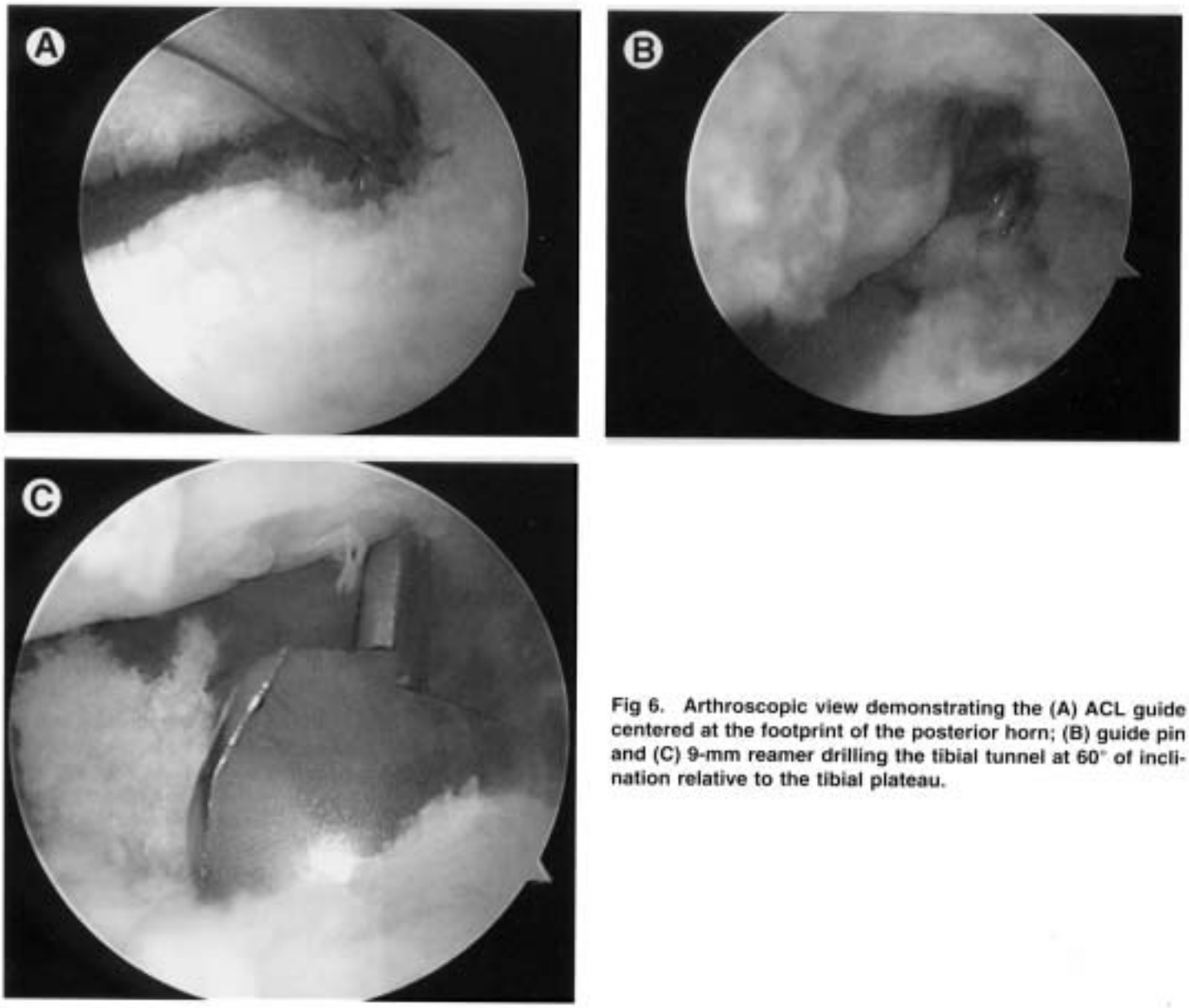

Fig 6. Arthroscopic view demonstrating the (A) ACL guide centered at the footprint of the posterior horn; (B) guide pin and (C) 9-mm reamer drilling the tibial tunnel at 60° of inclination relative to the tibial plateau.

Rehabilitation

The postoperative rehabilitation is covered thoroughly in the Bridge in Slot Technique chapter by Cole and co-workers in this issue. Briefly, the patient is placed in a hinged knee immobilizer and is allowed immediate motion from 0 to 90°. We do not routinely use a continuous passive motion machine, unless the procedure is combined with a cartilage restoration technique. Patients are allowed to progress from partial to full weight-bearing with crutches over the first four postoperative weeks. To protect the meniscus repair, flexion beyond 90° with weight-bearing is limited. At 4 weeks, full range of motion is allowed and gentle strengthening is performed. In-line running is permitted at 12 weeks and return to full activity is allowed at 4 to 6 months, provided lower extremity strength is at least 80 to 85% of the nonoperated leg. Patients are cautioned regarding the inherent risks in returning to highly competitive sports that involve cutting and pivoting.

RESULTS

While there are several studies investigating the results of meniscal allograft transplantation, there are only a few that focus on a single technique such as bone plug fixation. Stolsteimer and co-workers[3] reported on 23 meniscal transplants with bone plug fixation. The most significant finding was a reduction in pain after implantation. Rath and co-workers[4] in 2001 studied 18 patients with bone plug fixation and found a decrease in pain with a significant improvement in function, although function still remained limited.

The senior author (BJC) has performed 86 transplants between September, 1997 and September, 2002. Twenty-three of these were medial meniscal allografts using the double bone plug technique with a minimum follow-up of 24 months. Self-reported visual analog pain responses (range, 0 to 10) were reduced from 6.0 to 3.6 ($P < 0.05$) and patients reported a nearly 90% satisfaction rate with the procedure. Only two patients failed, both of which oc-

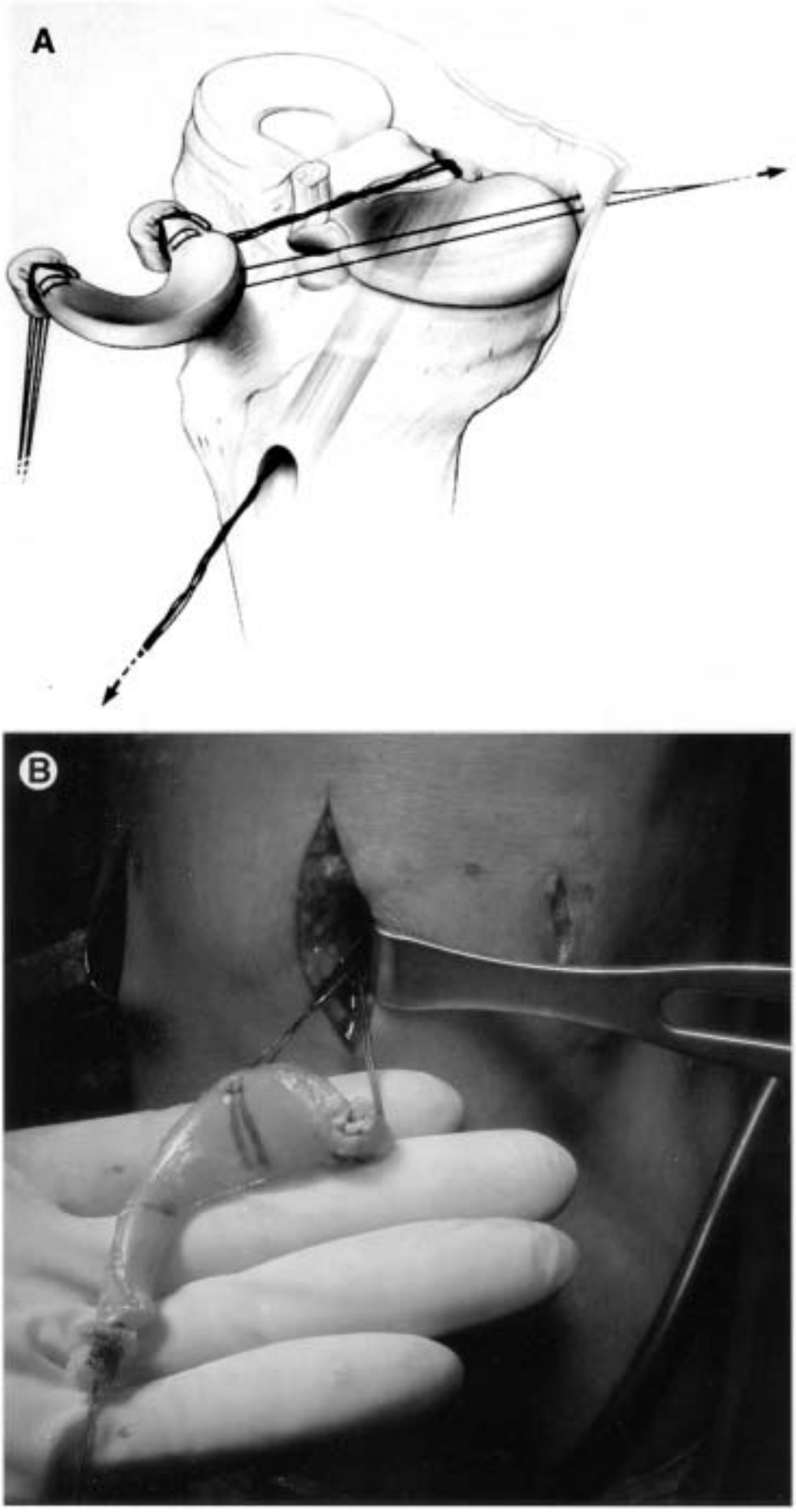

Fig 7. (A) Schematic of fully prepared meniscus before introduction into the knee. (B) Clinical photograph of the medial meniscus just before introduction, but following traction suture placement and suture passage through the tibial tunnel.

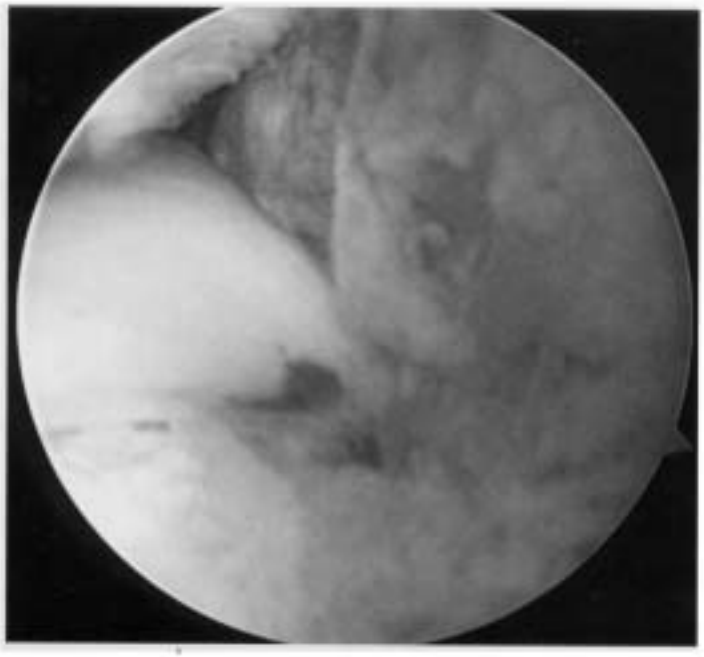

Fig 8. Arthroscopic view of the posterior bone plug fully seated within its tibial tunnel.

Fig 9. After drilling of the blind socket for the anterior horn bone plug, a suture shuttle is placed by passing a heavy gauge needle and suture trans-osseously through the base of the socket to be used to shuttle the bone plug traction sutures through so as to exit the anteromedial tibia.

Fig 10. Example of a plastic suture button used to transfix the posterior horn tractions sutures to the anteromedial tibia.

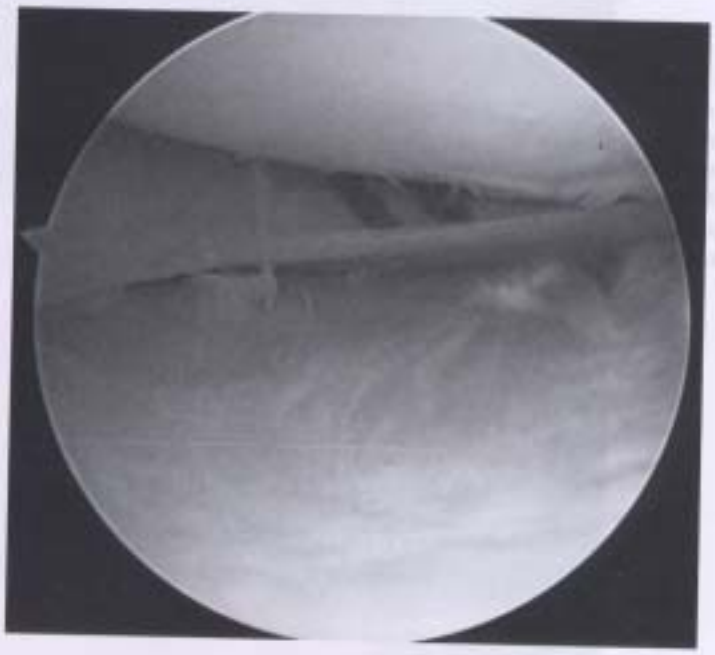

Fig 11. Final arthroscopic appearance of fully sutured medial meniscus transplant in the same patient shown in Fig 2.

curred during the first 12 postoperative months. Only one required revision to knee arthroplasty. There were no complications related to the specific technique used.

DISCUSSION

Studies have clearly shown the bone fixation of meniscal allografts[1,2,5] is essential to restore near normal contact forces which is one goal of meniscal transplantation. While the ability of meniscal allografts to delay or prevent the progression of arthritis remains unknown, the growing experience with this procedure clearly indicates that they are effective in reducing symptoms and improving function in patients who become symptomatic following meniscectomy as long as the appropriate indications are adhered to. Results are generally poor in patients with advanced arthrosis and this remains the primary contraindication to this procedure. The procedure is technically challenging and the indications are relatively uncommon as most patients initially do well after meniscectomy.

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