Anterior Cruciate Ligament Reconstruction With Bone—Patellar Tendon—Bone Autograft and a Medial Parapatellar Portal

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Abstract: Anterior cruciate ligament (ACL) reconstruction is one of the most extensively studied surgical procedures in orthopaedics. The importance of this ligament for knee function and stability has been widely studied. For athletes who participate in activities involving cutting, twisting, and running, surgical reconstruction of the ACL has become the standard of care. However, there is much debate regarding the techniques involved in ACL reconstruction, including graft choice, technique of drilling the femoral tunnel, and single- versus double-bundle reconstruction. In recent studies, ACL femoral tunnel drilling via a medial parapatellar or accessory anteromedial portal provides a more anatomic graft placement than transtibial femoral drilling. Long-term outcomes of these techniques have not been widely studied. This article details our technique for ACL reconstruction with bone—patellar tendon—bone autograft and a medial parapatellar portal.

Surgical intervention involves reconstruction of the anterior cruciate ligament (ACL) with bone—patellar tendon—bone (BPTB) autograft, hamstring autograft, quadriceps autograft, or allograft. The arthroscopic single incision ACL reconstruction with BPTB autograft remains the most widely used technique for primary ACL reconstruction.[1] When preparing the femoral tunnel, the transtibial (TT) technique is traditionally used over the 2-incision technique to avoid the use of a lateral incision, reduce operative time, and decrease morbidity. However, the TT technique places the ACL graft in a nonanatomic position with a more vertical orientation than the native ACL at its femoral insertion site.[2] Nonanatomic placement of the ACL graft can lead to abnormal graft tensioning with resulting loss of motion, recurrent instability, and ultimately graft failure.[3]

We describe our technique of primary ACL reconstruction with a BPTB autograft using the medial parapatellar or accessory anteromedial portal (AMP) to allow for anatomic placement of the ACL graft at its femoral insertion site independent of the tibial tunnel. This restores our graft to the native ACL dimension, orientation, and decreases abnormal stresses on the graft throughout the range of motion (ROM). We also present pearls/pitfalls and advantages/disadvantages of our technique in Tables 1 and 2.

Surgical Technique

Patient Positioning and Examination Under Anesthesia

The patient is placed in the supine position on the operating table. After the induction of anesthesia, an examination under anesthesia is performed on the operative knee, with comparison to the nonoperative side. A padded thigh tourniquet is placed proximally along with a lateral stress post.

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Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Maintain knee hyperflexion (110°-120°) during femoral tunnel reaming	Posterior wall blowout of femoral tunnel and damage to posterolateral structures
Perform initial femoral tunnel reaming of 3-5 mm	Posterior wall blowout of femoral tunnel and damage to posterolateral structures
Perform minimal notchplasty during anterior cruciate ligament (ACL) stump debridement	Unable to visualize lateral wall and posterior articular margin—nonanatomic placement of ACL graft
Extend knee with guide pin slightly extruded from tibial tunnel under direct arthroscopic visualization to assess risk of impingement—can eccentrically ream to fine-tune graft placement	Inadvertent graft impingement on intercondylar roof
Harvest no more than one-third width of native patellar tendon (i.e., need 30 mm tendon diameter for a 10-mm graft)	Can result in deficient graft (may need alternative graft—hamstring autograft *v* Achilles allograft) if too small or may affect extensor mechanism and cause anterior knee pain if more than one-third harvested
Orient sagittal saw cuts in an oblique manner to allow for easier harvest and lower risk of violating the articular surface of the patella	Can lead to a stress riser and iatrogenic fracture—especially on the patellar side
Place-different colored Fiber wire sutures ×2 in sequential order on both femoral and tibial bone plug	Unable to properly orient and pass graft if graft toggling or position shift occurs during passage—can selectively pull on lead suture to reorient graft for proper passage
Initially tension on femoral side with interference screw fixation followed by tibial-side tensioning in extension	Can result in loss of motion if tensioning tibial side in slight flexion
Place 18-gauge wire in most distal aspect of tibial bone plug	Unable to achieve supplemental fixation to tibial post in the event of fiber wire sutures cutting out or stripping during passage

Arthroscopy and Footprint Preparation

Diagnostic arthroscopy is performed using horizontal anterolateral and anteromedial portals at the level of the joint line just lateral and medial, respectively, to the patellar tendon. A sterile bump is placed underneath the knee and the arthroscope is placed into the intercondylar notch and the graft remnants debrided. A minimal notchplasty is performed to visualize the over-the-back position (Fig 1). Resident's ridge is flattened to provide access to the posterior articular margin. A small indentation is made with a high-speed shaver (Arthroscopic Shaver Blade 5.0 mm, barrel burr 6-flute, Formula Aggressive Plus Cutter 5 mm; both Stryker, Kalamazoo, MI) to identify where we believe the ACL graft should be placed.

Table 2. Advantages and Limitations/Risks

Advantages	Limitations/Risks
Independent placement of femoral tunnel with respect to the tibial tunnel	Blowout of posterior femoral wall of intercondylar notch
Creates an anatomic and obliquely oriented ACL graft	Inability to maintain joint visualization during knee hyperflexion
Ability to confer greater rotational, anteroposterior stability, and IKDC scores	Difficulty in passing the ACL graft and fixation instrumentation
Avoid additional lateral incision of distal femur	Femoral guide breakage

ACL, anterior cruciate ligament; IKDC, International Knee Documentation Committee.

Graft Harvest

The patellar tendon autograft is harvested using a longitudinal medially based incision from the distal pole of the patella to the tibial tuberosity with the knee flexed. Dissection is carried down to the paratenon, which is incised. Flaps are elevated both medially and laterally to visualize the edges of the tendon in order to measure the width. A double-blade knife (ACL Graft Knife 10 mm, 11 mm; DePuy Mitek, Raynham, MA) is used to harvest the central one-third tendon graft.

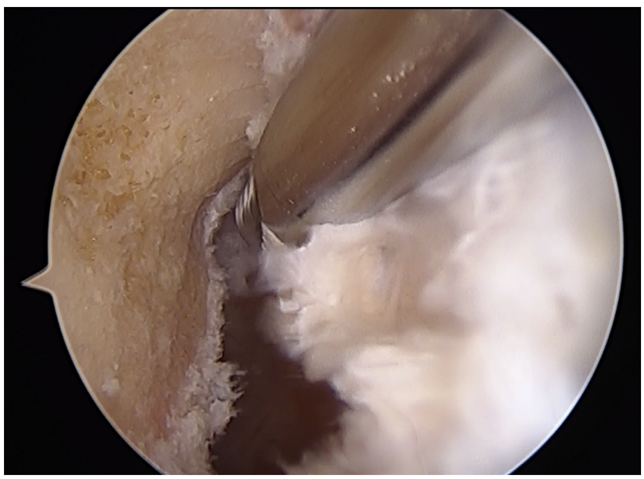

Fig 1. Arthroscopic view in a right knee from a standard anterolateral viewing portal showing the shaver instrumented through the anteromedial portal performing a minimal notchplasty to visualize the posterior articular margin of the femur.

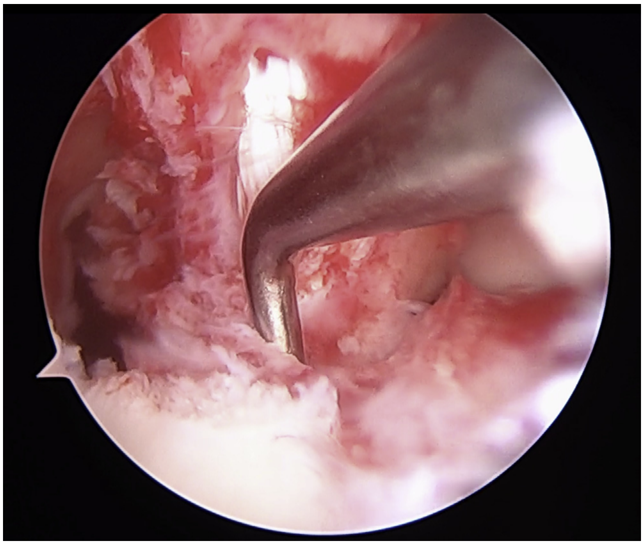

Fig 2. Arthroscopic view in a right knee from a standard anterolateral viewing portal. The custom tibial guide is inserted through the anteromedial portal. The tip of our guide is placed just anterior to the posterior cruciate ligament and the posterior drop-off of the tibial plateau and slightly lateral to the desired pin location in the anterior cruciate ligament footprint, as our guide places the pin approximately 10 mm anterior and slightly medial to the guide.

Using a mini-sagittal saw, the tibial bone block is harvested. The saw is angled slightly oblique on each side. An osteotome is used to free the bone block. The graft is dissected from the fat pad underneath. The patellar bone block is harvested cutting from distal to proximal and angling obliquely as the saw progresses proximally. The bone block is gently removed with an osteotome. A vertical medial parapatellar portal is made at the joint line 2 to 5 mm medial to the medial edge of the patellar tendon within the autograft harvest incision.

Tunnel Preparation

The tibial tunnel is placed approximately 10 mm anterior to the PCL using a custom-designed guide (Custom Tibial ACL Guide; Stryker) (Figs 2 and 3). A guide pin is placed and the knee is fully extended to ensure adequate clearance with the roof of the notch. The guide pin is impacted into the femur and reamed to the size of the tibial plug with an acorn reamer (Cannulated Acorn Reamer; Smith & Nephew Andover, MA), size dependent on the size of the bone block. The edges of the tunnel are chamfered with a rasp. A 7-mm femoral, over-the-back, offset guide (Acufex Classic Over the Back Femoral Guide; Smith & Nephew) is placed through the medial parapatellar portal and hooked over the back of the femur. The knee is hyperflexed to 120°. The direction of the guide is assessed to ensure that a guide pin will exit anterolaterally on the femur. The guide pin is placed and the appropriate-size acorn reamer used. Initial reaming is performed to a depth of 3 to 5 mm to double-check that no posterior wall blowout has occurred (Fig 4). The tunnel is then reamed to a depth 3 to 5 mm greater than the length of the lead plug (Fig 5). The anterior aspect of the femoral tunnel is chamfered with a rasp to ensure no sharp corner exists for the graft to abrade against.

Graft Passage and Fixation

A guide pin with sutures passed through an eyelet is placed through the medial parapatellar portal and sutures are subsequently passed from the femoral tunnel into the tibial tunnel. The graft is then loaded onto the sutures and traction on the lead suture pulls the graft into place. A probe is used to provide additional assistance in order to pass the lead plug. The knee is placed through an ROM and checked for impingement. Femoral fixation is performed in hyperflexion. A guidewire is placed on the anterior aspect of the tunnel via the medial parapatellar portal between the femoral tunnel and the plug. An 8-mm biocomposite interference screw (BioComposite Interference Screw; Arthrex, Naples, FL) is placed over the guidewire with a graft protector. The graft is assessed for fixation and placed through an ROM to ensure no impingement occurs. The graft is tensioned between 20 and 25 pounds through 18 to 20 cycles of 0° to 90° ROM. A second 9-mm biocomposite interference screw (Arthrex) is placed with the leg in extension on the medial side of the tibial tunnel as the graft has been rotated 90°. A

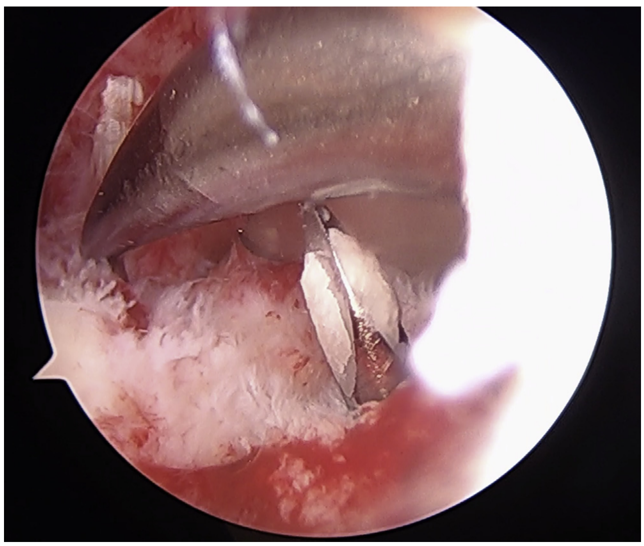

Fig 3. Arthroscopic view in a right knee from a standard anterolateral viewing portal. The custom tibial guide is inserted through the anteromedial portal. The guide is in our desired location just anterior to the posterior cruciate ligament and just medial to the location of the anterior cruciate ligament (ACL) footprint. The guide pin is shown entering anterior and medial to the guide in the desired location in the ACL footprint.

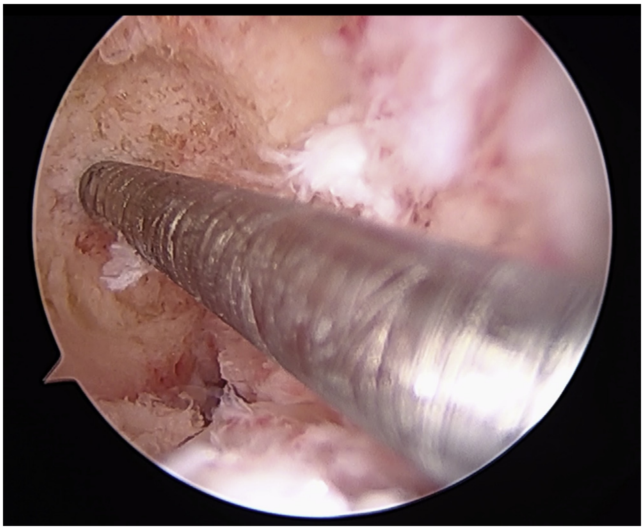

Fig 4. Arthroscopic view in a right knee viewing from the medial parapatellar portal. The femoral guide pin is in place on the femoral wall, having reamed 3-5 mm depth and the reamer removed showing an intact posterior wall without cortical breach.

tibial post is inserted distal to the tibial plug. The sutures from the tibial plug are wrapped around the post and tied down as a back-up form of suspensory fixation along with an 18-gauge wire if needed due to suture failure. Radiographs are taken intraoperatively to ensure accurate tunnel and screw placement.

Wound Closure

Excess bone from the graft harvest is placed in the patellar site. Using a No. 0 Vicryl suture, a purse-string-type closure is used to prevent graft dislodgement. The tendon remnant is loosely closed with a running No. 0 Vicryl suture. The paratenon is closed with a running No. 2-0 Vicryl. The dermal layer is closed with interrupted No. 2-0 Vicryl and the skin is closed with a running subcuticular No. 3-0 Monocryl. Skin glue is placed and the wounds are dressed with Telfa, Tegaderm, Webril, and an Ace bandage. A polar care ice machine is placed as well as a hinged-knee brace locked in extension.

Postoperative Rehabilitation

Rehabilitation in the postoperative period is divided into 7 phases. Phase 1 (postoperative days 1 and 2) aims to achieve full knee extension and anterior-posterior ROM of 0° to 90°. Patient is kept in a knee brace locked in full extension at all times with crutch ambulation. CPM is started at 0° to 45° and progressed 10° daily as tolerated and use of stationary bike is encouraged. Ankle pumps, heel slides, seated knee extension 90° to 45°, hamstring stretching/standing curls, and prone knee hang and flexion are implemented. Phase 2 (postoperative days 3 to 14) seeks to achieve 0° to 100° ROM with addition of weights and reps to the above-mentioned exercises. Phase 3 (weeks 2 to 4) seeks to achieve anterior ROM 0° to 120°, step onto 6-inch platform, and controlled squat on 2 legs. Mini squat 0° to 40°, closed-chain terminal knee extension with bands, calf raises, forward lunges, and hamstring curls are used. Phase 4 (weeks 4 to 10) seeks to achieve half squat on the operative limb, 1-minute single-leg balance, ROM 0° to 125°, and improved limb strength, endurance, and confidence. The knee brace is discontinued at 4 weeks if no quad lag is present during SLR. Single leg quarter squat, tiltboard balancing, 8-inch step up, pool running forward, lateral lunge, and stair stepper are all implemented during this phase. Phase 5 (weeks 10 to 12) seeks to perform 15 single-leg squats with good neuromuscular control and improved leg strength. Patient is allowed to run in place and progress from walk to a jog. Phase 6 (weeks 12 to 24) seeks to achieve running at half speed forwards and backwards, controlled landing of jumps on 1 or 2 legs with or without rotation, and sideways hopping. Plyometric exercises including single- and double-leg hopping, hop onto 6-inch stair, jump rope, sideways hopping, and rotational jumping onto trampoline are implemented. Phase 7 (6-month +) seeks to implement sport-specific training and allows for full speed running and cutting with 80% of strength retained in operative leg in flexion and extension versus the nonoperative limb.

Discussion

In the TT technique, the location of the femoral tunnel is dictated by the tibial tunnel and results in a

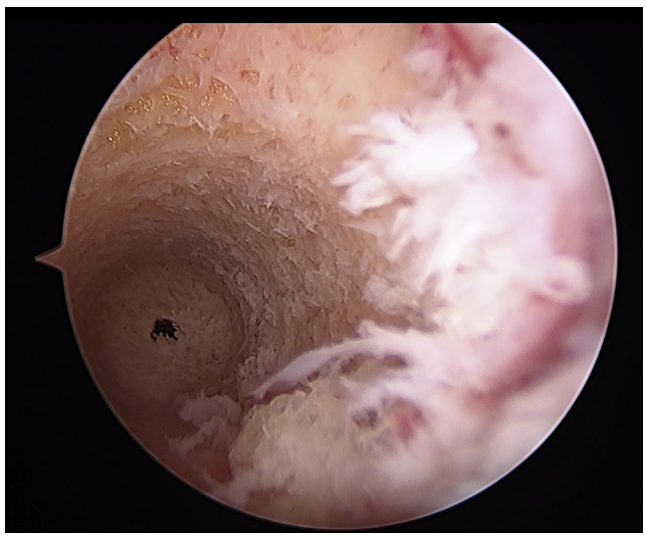

Fig 5. Arthroscopic view in a right knee viewing from the medial parapatellar portal. The femoral tunnel has been reamed to the desired length and is viewed to determine that the tunnel is intact without any posterior cortical breach or bone debris.

more vertically orientated, nonanatomic tunnel at the femoral insertion site. In contrast, the AMP technique places the graft in line with the anatomic ACL footprint independent of the tibial tunnel and more horizontal. The more anteriorly and vertically placed femoral tunnel using the TT technique results in decreased anteroposterior stability and increased internal rotation and a positive pivot shift.[4-6] In the coronal plane, the AMP technique allows more oblique orientation of the graft to better resist rotational loads.[7] These advantages can provide significantly greater anteroposterior and rotational stability, higher International Knee Documentation Committee scores, and a faster recovery time to return to sports than the TT technique using a BPTB autograft.[8,9] However, controversy still remains as some outcome studies and systematic reviews have shown no clinical differences and no difference in failure rates in short- to mid-term follow-up between TT and AMP techniques.[10,11]

In our technique (Video 1), a 7-mm over-the-back offset femoral guide is introduced through the AMP and placed over the posterior edge of the femur. The knee is flexed to 120° and the guide pin is assessed to ensure it exits anterolateral and not posteriorly through the femur. Initial reaming is performed to a depth of 3 to 5 mm to double-check our position to ensure that we have a 1 to 2 mm posterior wall to prevent posterior blowout. The tunnel is then reamed to a depth 3 to 5 mm greater that the length of the lead plug. The anterior aspect of the femoral tunnel is chamfered to ensure no sharp corner for the graft to abrade against. Our graft is passed and then secured with a bio-interference screws. This is a reliable and a reproducible technique that allows access to the anatomic femoral insertion site without conferring any significant increase in morbidity to the patient.

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