Arthroscopic ACL Reconstruction with Bone Patellar Bone Graft using Anteromedial Technique

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Title

Arthroscopic Anterior Cruciate Ligament Reconstruction with Bone Patellar Tendon Bone Autograft Graft using Anteromedial Technique

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Abstract

There are approximately 200,000 anterior cruciate ligament (ACL) injuries per year in the United States and more than half will undergo ACL reconstruction. Diagnosis is made by physical exam supplemented by radiographs and an MRI scan. Successful ACL reconstruction returns most athletes back to pre injury activity, however, outcome is dependent on appropriate preoperative evaluation, surgical timing, surgical technique, graft choice and an effective postoperative physical therapy program. Specifically, graft choice, graft positioning, and fixation technique have been shown to play an important role in patient outcome. Surgeons must also be aware of concomitant meniscal tears and cartilage injury that should be addressed at the time of ACL reconstruction. In this case, we perform an anatomic ACL reconstruction with bone-patellar tendon-bone autograft using an anteromedial drilling technique and flexible reamers for a young college athlete. The anteromedial approach offers the advantage of reliably reproducing the native anatomy of the ACL on the femur footprint by drilling the femoral tunnel independently of the tibial tunnel. Furthermore, using a flexible reamer instead of a straight rigid reamer allows for a longer femoral tunnel and lower risk of posterior wall blowout or fracture.

Case Overview

Focused History

This is a 20-year-old college intermural athlete that injured his right knee while playing ultimate Frisbee. It was a non-contact injury, the patient landed on his right knee, felt a pivot and then heard a "pop". He had a large effusion after the injury. Patient was seen at the Emergency Department, placed in a brace and given crutches. Followed up with me in the office about 1 months after the initial injury. Patient had minimal pain but felt the knee "buckle" on him several times per week. He is very active and plays several club sports. After the injury, he is unable to go back to his preinjury activities.

Tips for History:

Obtain a medical history including the mechanism of injury, previous injuries, type of sport and activity level

- When and how did the injury occur? What was the mechanism?
- What symptoms do you currently experience? Is there pain or instability? What limitations in activity have occurred as a result of injury?
- What prior treatments has the patient tried (physical therapy, activity modification, medications)?

Physical Exam

On exam, this patient had moderate knee effusion and range of motion between 0 to 130 degrees. He had mild TTP over the lateral joint line. Slight opening of 5 degrees with valgus stress at 0 degrees but not at 30. Varus stress at 0 and 30 was stable and symmetrical. Lachman test is 2B with a positive pivot shift in clinic. External rotation dial in the prone position at 30 and 90 degrees was symmetrical. Neurovascular intact distally in the lower extremity.

- Visually inspect the knee for an effusion, ecchymosis, and the condition of the skin
- Carefully palpate the knee joint. Joint line tenderness may indicate a meniscus injury. Any defect in the extensor mechanisms or extensor lag may be indicative of an extensor mechanism injury.
- Evaluate active and passive knee range of motion. Any loss of passive extension may be due to a displaced bucket handle meniscus tear or arthrofibrosis. Loss of flexion may result from significant knee effusion.
- The knee should be stressed with a varus and valgus force at 0 and 30 degrees of flexion to detect collateral ligament injuries. Any instability at 0 degrees correlates with a collateral ligament injury with rupture of one or both cruiciate ligaments.
- Injuires to the posterior cruciate ligament and posterolateral corner should be tested for with the posterior drawer test and the external rotation dial test in the prone position, respectively.
- Patellar instability can also be assessed with apprehension testing (laterally directly force with the leg in 20 to 30 degrees of flexion. In this position, then patella is engaged in the trochlea groove).
- Tests for anterior cruciate ligament (ACL) rupture
    - The Lachman test is performed with the knee flexed 20 to 30 degrees with one hand stabilizing the femur. The other hand is then used to apply an anterior force on the tibia from a neutral starting position. Laxiety is compared to the contralateral side. The test can be graded according to the degree of anterior displacement. [1] Grade 1 is up to 5mm difference, Grade 2 is 5 to 10mm, and Grade 3 is >10mm of anterior translation. With anteriorly directly force, exam with endpoint is listed as A and without endpoint is B.

- The Pivot shift test can be used to assess the degree of rotational knee dysfunction. It is difficult to perform clinically, but is very sensitive during examination under anesthesia. [2,3] With the patient supine, the affected leg is slightly abducted to relax the iliotibial band. Then, an internal rotation and valgus force is applied while the examiner passively flexes the knee. In an ACL deficient knee, the tibia will subluxate anteriorly between 20 and 40 degrees of flexion. In an ACL deficient patient, a positive pivot shift is typically detected from 20 to 40 degrees of flexion, which is when the anterior subluxated tibia is reduced by the IT band.

Imaging

Initial imaging consists of a knee trauma series including anteroposterior, lateral and patellar views. The images are closely reviewed for bony avulsion fractures and any associated bony injuries. The Segond sign (small avulsion off the lateral tibial plateau) represents a lateral capsular avulsion which should raise suspicion for an ACL rupture. In select patients at risk for knee osteoarthritis, flexion weight-bearing films may be obtained. Knee MRI is the most sensitive and specific in diagnosing ACL injuries. Bone contusions of the lateral femoral condyle and posterior tibial plateau are the most common finding.[4] Injuries to the menisci, collateral ligaments and posterior cruciate ligament are also reliably detected on MRI. Knowledge of concomitant knee injuries is essential for preoperative planning.

Natural history

This patient developed recurrent feelings of knee instability and pain after his initial injury. The medial collateral ligament and menisci are often injured at the time of initial injury with lateral meniscus injuries more common acutely compared to medial meniscus injuries. Untreated ACL injuries may lead to further chondral and meniscal injuries. It is unclear if ACL reconstruction will reduce the incidence of arthritis.[5,6]

Options for treatment

Treatment options include physical thearapy starting with an emphasis on reestablishing full range of motion in both flexion and extension and controlling the effusion followed by quadriceps and hamstring strengthening and finally sport-specific rehabilitation. For high demand athletes and active patients with symptoms of instability, surgical ACL reconstruction is recommended. Both open and arthroscopic techniques exist with multiple graft choices including autograft (bone-patellar tendon-bone, quadrupled hamstring, quadriceps tendon) and allograft (SemiT, Achilles tendon, BTB, tibialis anterior or posterior).

Rationale for this procedure

An arthroscopic ACL reconstruction (compared to open) is associated with a shorter recovery and rehabilitation time with a decreased risk of infection. Partial menisectomy and meniscal repair can also be performed simultaneously. Cartilage lesions can also be addressed at the time of surgery. Autograft tissue is associated with a decreased rerupture rate in young athletes when compared to allograft tissue.[7] Bone patella tendon bone autograft have similar clinical outcomes comparing to hamstring autograft. However, recent clinic studies have shown decreased failure rate with BTB autograft and lower KT 1000 values (more stable graft). Furthermore, anteromedial approach for ACL reconstruction offers the advantage of reliably reproducing the native anatomy of the ACL on the femur footprint by drilling the femoral tunnel independently of the tibial tunnel (compared to

transtibial technique). Furthermore, using a flexible reamer instead of a straight rigid reamer allows for a longer femoral tunnel and lower risk of posterior wall blowout or fracture.

Special considerations *and Contraindications to ACL surgery*

Absolute contraindications to arthroscopic ACL reconstruction include any patient with an active knee infection or who is unfit for anesthesia. Relative contraindications include patients who are unlikely to follow post-operative rehabilitation protocols. Failure to comply with rehabilitation may result in arthrofibrosis and a poor outcome. Relative contraindications to patellar tendon harvest include patients who have preexisting anterior knee pain, jobs that require kneeling (Clergy, carpenters), jumping sport athletes, older patients, and those with narrow patellar tendons or patellar chondrosis.

BTB autograft harvest and drilling of the tibial tunnel can both be done with a single medially based vertical incision. However, the senior author prefer to center the first incision over the patella tendon for the BTB harvest and then make a second smaller incision over the tibial to drill the tibial tunnel.

With the flexible reamers, the femoral tunnel is drilled with the knee at 90 to 100 degrees of flexion. If a ridged straight reamer is used in the anteromedial portal for drilling, then the knee should be hyperflexed to >120 degrees to avoid posterior back wall blowout or fracture.

In the case of a femoral wall fracture, the graft can be tied over a screw and post as a bailout option.

The obliquity of the ACL graft should be recreated with the tibial tunnel. Using a starting position 1.5 to 2cm medial to the tibial tubercle will help recreate the obliquity of the native ACL.

Graft tunnel mismatch is frequently encountered in ACL reconstruction with BTB autograft. One trick to avoid the mismatch is to measure the size of the patella tendon and add 10 degrees, then set the tibia guide to that number. For example, in a tall patient, if the patella tendon measures at 55mm, add 10, which equals to 65 degrees. This is the setting for the tibial drill guide.

If mismatch occurs with the bone outside of the tunnel, several techniques can be used to address this:

1) Spining the graft up to 5 turns will shorten the patella tendon to help reduce the bone to the tibial tunnel.
2) Making a trough in the tibia and using a Richard's staple for fixation.
3) If the entire bone plug is outside the tibial tunnel, then the bone can be resected and a biocomposite, PEEK or metal soft tissue screw is used for tibial fixation.

It is essential to have the right angle setting on the tibial guide to avoid graft tunnel mismatch.

Grafting tension is done at 30 degrees of knee flexion with posterior directed force over the tibia (reverse drawer).

Interference Screw size: Femoral side, 10mm tunnel, screw is 3mm less or 7mm screw. A 25mm socket is typically drilled and length of screw is 20mm. Tibia side, always drill 0.5mm bigger than the femur to allow ease of graft passage (10.5mm tunnel), use a 8mm screw x 25mm in length.

Step By Step Technique

- Anesthesia
    - General endotrachial anesthesia (Sedation and Spinal is another option)
    - No femoral block for ACL reconstruction due to quadriceps inhibition in the postoperative period.
- Positioning
    - Patient is positioned supine on a regular operating room table with a post on the ipsilateral mid thigh.
    - Before beginning surgery, an examination under anesthesia is performed

- It is essential to evaluate ROM, Lachman test and Pivot Shift before starting surgery or graft harvest.
- A tourniquet is applied snugly as far proximal on the thigh as feasible
- After skin preparation and draping, a 5 to 7cm midline knee incision centered over the patellar tendon is marked with a skin marker (BTB can also be harvested with horizontal incision)
- The limb is exsanguinated and the tourniquet inflated to 250mmHG.

- Harvest of the patellar tendon
  - A 5 to 7 cm midline incision is made over the patellar tendon with a #15 scalpel
  - Dissection is carried down to the paratenon which is carefully reflected off the underlying tendon and preserved for repair (use a #15 scapule to dissect the paratenon)
  - Using a #10 scalpel, 10-mm central third patellar tendon is harvested extending from the patella to the tibial tuberosity
  - A 10x25-mm bone block is then taken from both the patella and the tibia using a micro oscillating saw taking care not to cut deeper than 15-mm so as to prevent an iatrogenic fracture.
  - Bone blocks are carefully removed with a curved osteotome.
  - The graft diameter is carefully measured on the back table and place in Bacitracin solution for 10 mins.
  - Bone block is shaped with a ronguer to fit through a 10mm tunnel for the femur and 10.5mm tunnel for the tibia. It is important that the bone plug goes through the 10mm sizer easily to allow passage of the graft. The plug is shaped to match a bullet for the femoral side to further allow turning of the graft to go into the femoral tunnel with ease.
- Placement of arthroscopy portals

- An anterolateral portal is established with the assistance of an 18 gauge spinal needle using an outside in technique. The portal is just above the meniscus and it is essential to check the trajectory of the needle and made sure it is directed to the footprint of the ACL on the femoral side.
- An anteromedial portal is then established with an #11 blade, capsulotomy is performed cutting from an inferior to superior direction.. It is positioned just above the medial meniscus to allow adequate visualization of the femoral ACL footprint.

- Diagnostic Arthroscopy
  - A thorough diagnostic arthroscopy is performed closely examining the patellofemoral, medial and lateral compartments.
  - Any meniscal pathology is addressed with either repair or partial menisectomy depending on the tear type and location
  - The torn ACL remnant is debrided with arthrocare device and shaver. A small notchplasty is done to allow improved visualization.
  - Alternatively, the senior author prefers the trans-notch portal through the patella tendon harvest site. This viewing portal allows excellent visualization of the ACL footprint for drilling.
- Femoral Tunnel
  - A small notchplasty is performed with a high-speed burr until adequate visualization of the femoral footprint is established. An aggressive notchplasty is not critical as long as the tunnel positions are easily identifiable and there is no graft impingement in full extension.

- The back wall of the femur is identified after debridement of the soft tissue. The anatomic position for ACL on the femoral side is located at the 10 to 10:30 position for a right knee (1 to 1:30 position for a left knee).
- A femoral tunnel over the top guide is used to help retain 1 to 2-mm of posterior wall following drilling. If drilling a 10-mm tunnel, a 6 or 7-mm offset guide should be used. The senior author prefers a 2mm backwall (7mm over the top guide)
- A #2 fiberwire is shuttled through the femoral tunnel to help assist in graft passage.
- The femoral tunnel is drilled through the anteromedial portal with the use of a flexible reamer (Stryker Versitomic Reamers) to the match the width and depth as the bone block (10-mm diameter and 25-mm depth in this case). The senior author prefer to make the bone plug 9.5mm in diameter and 23mm in length to allow ease of passage.

- Tibial Tunnel
  - Setting of the tibial guide is dependant on the length of the patella tendon. The rule is add 10 degrees to the patella tendon length. Typically, the tibial guide is set at 55 to 60 degrees.
  - A tibial tunnel drill guide is positioned such that the tunnel is located at the center of the native ACL footprint. This should also be adjacent to the slope of the medial eminence and along a line extended from the posterior border of the anterior horn of the lateral meniscus.
  - The obliquity of the ACL is restored when the guide pin is slightly on the medial tibial eminence.
  - The guide wire is placed and the tunnel drilled with a 10.5-mm diameter drill bit.
  - Soft tissue from both tunnels is cleared with the ArthroCare.
- Passing Graft

- Shuttle sutures are placed through both bone plugs and the graft is passed into the tibial tunnel and then to the femoral tunnel.
- A needle driver or grasper maybe used to help turn the graft on the femoral side if difficulty is encountered.

- Graft fixation
  - An interference screw is used to fixed the femoral side. The senior author prefer to use a 7mm x 20mm screw if the tunnel is drilled 10mm x 25mm in size.
  - Then the graft is tensioned by repetitively cycling the knee through a complete range of motion (20 cycles)
  - An interference screw is placed in the tibial tunnel after tensioning is complete. The senior author prefers to use a 8mm x 25mm screw if the tunnel is drilled to 10.5mm in diameter.
- Wound closure
  - The paratenon is carefully closed with buried #0 vicryl suture.
  - Skin is closed with running 3-0 monocryl with Steri-Strips.
  - A dry sterile dressing and ice therapy device is applied, and knee brace locked in extension are applied before leaving the operating room.
- Postoperative Protocol
  - Partial weight bearing in a hinged knee brace locked in extension for 4 weeks.
  - Brace is opened 0 to 90 from 4 week to 6 weeks and completely opened after 6 weeks.
  - Patient may transition to a smaller post operative knee brace at 8 weeks after surgery (Road runner ACL brace)
  - Post operative follow-up visits are normally scheduled at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year after surgery

- Range of motion and physical therapy are typically started 2 weeks post-operatively
- Patients may begin jogging at 3 to 4 months depending on progress and may resume sports between 6 months to 9months depending on the type of sport and also when full quadriceps strength returns.

Discussion

ACL reconstruction for ACL ruptures is associated with a high rate of return to sports performance and improved knee functional scores. [8] In patients who wish to return to sports, reconstructing the ACL has been shown to reduce the rate of further osteochondral and meniscal injury.[5,6]

Historically, femoral tunnel placement has been an issue of debate with many of published studies. Recent literature suggests that a lower lateral tunnel in the 10:30 or 1:30 position will more accurately recreate the position and function of the natural ACL, especially the rotational stability. This anatomic femoral tunnel position can be achieved with the use of an anteromedial portal and straight reamers, flexible reamers, and even the transtibial technique with hyperfelxion of the knee.[9] Historically, traditional transtibial ACL reconstruction techniques have been associated with improved anterior tibial translation, but with persistence of rotational instability and a positive pivot shift. [10,11] Biomechanically, double bundle ACL reconstruction where both the anteromedial and posterolateral bundles are reconstructed will most closely reproduce natural ACL function. However, Adachi et al failed to show any clinical difference between a single bundle and double bundle technique in a prospective randomized controlled trial of 108 patients [12] Until a clear clinical benefit for double bundle anatomic ACL reconstruction is demonstrated, we prefer a single bundle anatomic technique that is achieved by using a anteromedial portal and flexible reamers for femoral tunnel drilling.

Altentorn-Geli et al. compared the clinical outcome data of patients after ACL reconstruction using Transtibial (TT) vs anteromedial technique (AM). The authors reported significantly lower recovery

time from surgery, walking without cruthes, and return to normal life with the AM technique. In addition, patients after AM ACL reconstruction had significantly better knee stability (KT-1000, pivot-shift test, Lachman test, and IKDC scores) compared to the TT group. Koutras et al. also showed better Lysholm knee scores and performance with short-term follow-up (up to 6 months) in patients after AM ACL compared to TT technique. Furthermore, Mardani-Kivi et al. also reported significantly faster return to activity, better range of motion, and greater patient satisfaction in the AM ACL group. However, in this study, the Lachman testing or knee stability in the anterior to posterior direction was similar between both groups.

In addition, the use of a bone-patellar tendon-bone autograft construct which has been shown to have a decreased rate of reruputre in young active athletes compared to allograft.[7] We reserve allografts for older (>40 year of age), low demand patients or for revision cases where autograft choices may be limited. Patellar tendon grafts have less laxity (KT-1000) compared to hamstring grafts and also recent literature shows lower failure rate with BTB autograft, but they are associated with slightly higher rates of anterior knee pain.

Overall Outcomes after ACL reconstruction

Outcomes for ACL reconstruction are favorable with success rates of up to 95%. In a retrospective review of 97 patietns by Bach et al, 70% of patients had less than 3-mm on KT-1000 arthrometer testing. The same group also reported significant improvements in Teneger activity level, a mean Lysholm score of 87, and good to excellent modified Hospital for Special Surgery scores for 82% of patients.[13] A review of recent literature by Chalmers of studies with more than 10 years of follow-up compared cohorts of 685 patients treated nonoperatively and 1585 patients treated with ACL reconstruction. The operative group had significantly improved activity levels according to the Tegner score, fewer subsequent meniscal injuries, and significantly fewer additional knee operations.

However, they did not identify any difference in the Lysholm score, the IKDC score or the development of radiographially evident osteoarthritis. [14]

Future Research

With increasing numbers of young at risk athletes, future research is turning to injury prevention. Multiple recent studies have noted the ability of injury prevention or neuromuscular training to reduce the incidence of ACL ruptures. A cost-effectiveness study of ACL injury prevention programs for young athletes by Swart et. al demonstrated that universal neuromuscular training is the most cost effective method of ACL injury prevention.[15,16] Mather et al. using the MOON database showed that early ACL reconstruction was more effective in improved QALYs and lowering health care cost than rehabilitation plus optional delayed ACL reconstruction. The authors concluded that early ACL reconstruction should be the preferred treatment strategy from a societal health system perspective.

Patient follow-up information

At 4 months post-operatively, our patient has pain free range of motion from 0 to 130 degrees of knee flexion with a grade 1A Lachman test and no varus or valgus instability. Patient also had a negative pivot shift on clinical examination.

Equipment

1. AcuFex Anatomic ACL Instrumentation by Smith and Nephew, Andover, MA
2. Stryker Flexible ACL Versitomic drills
3. Stryker Metal Interference screws.

Disclosures

The author has no financial relationship with any of the companies mentioned in this article.

Statement of Consent

The patient referred to in this video article has given their informed consent to be filmed and is aware that information and images will be published on-line.

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