All-Arthroscopic Tibial Inlay Double-Bundle Posterior Cruciate Ligament Reconstruction

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Introduction

Posterior cruciate ligament (PCL) injuries are relatively rare; however, their treatment remains a challenging problem for the managing orthopedic surgeon. Not all clinical outcomes following PCL rupture are uniformly poor; however, recent studies suggest that the kinematics of the PCL-deficient knee is significantly altered from the intact state [1, 2]. In a similar fashion to the anterior cruciate ligament–deficient knee, PCL deficiency redistributes the forces across the knee joint [1, 2]. The results of which are an increase in pressure in the medial and patellofemoral compartments which may lead to premature and severe arthrosis [2, 3]. Reconstruction of the PCL restores the affected knee to a stability state more similar to the intact knee and it is now accepted that patients with PCL laxity greater than 10 mm compared to the contralateral side have improved outcomes with PCL reconstruction (PCL-R) [4–8].

There are multiple surgical techniques and graft choices for PCL-R with no "gold standard." The purpose of this chapter is to discuss the clinical presentation of PCL injury, the diagnostic approach, and the surgical treatment of PCL rupture. Furthermore, the technical aspect is focused on the double-bundle arthroscopic inlay surgical technique as this is currently the senior author's preferred technique for PCL-R. Pearls and pitfalls of the surgical technique are highlighted during the technical description. Following the technical aspects, a literature review drives a discussion of the advantages of the double-bundle arthroscopic inlay PCL-R and provides evidence as to why this is our advocated and chosen surgical technique for reconstruction of the PCL.

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Preoperative Considerations

History

In the case of an acute injury, there is often a history of a direct trauma to the pretibial aspect of the lower extremity or a hyperextension injury to the affected knee. An effusion or swelling is often present with an acute PCL injury; however, the lack thereof does not rule out a PCL injury. A knee dislocation often results in injury to the PCL, which is likely associated with concomitant ligamentous or soft tissue injuries. In the case of severe knee trauma, 95 % of patients with a PCL injury have associated ligamentous injuries. The most common associated injury is disruption of the posterolateral knee structures (approximately 60 %) [9]. High-energy traumas may result in capsular damage and extravasation of the joint effusion, thus the absence of an effusion should not lessen the examiner's suspicion for ligamentous injury. Patients with chronic PCL injuries may complain of pain and instability with activity without additional or associated signs or symptoms.

Physical Examination

It is crucial to fully evaluate and appreciate the extent of the soft tissue and ligamentous injury to the knee. PCL injury may be associated with a knee dislocation that spontaneously reduces prior to presentation. A thorough physical examination of the entire affected lower extremity is appropriate. Remember to assess the presumed intact structures and consistently compare to the contralateral knee.

The first component of the physical examination should be an assessment of the neurovascular status of the affected limb. This is of particular importance if there is suspicion for or history of knee dislocation. Once the neurovascular competence of the injured limb is established, inspection and palpation for a knee effusion is conducted. This is followed by an examination of knee, hip, and ankle range of motion.

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With regard to the knee, it should be passively taken through a range of motion and, if the patient is capable, passive range of motion should be compared to active range of motion. With the knee flexed, the relationship of the tibial plateau and femoral condyles as well as the natural tibial step-off can be assessed. In 90° of flexion, the Godfrey test is used to assess for a posterior sag sign (Fig. 11.1). The dynamic posterior drawer test is also performed in 90° of flexion and can evaluate the magnitude of posterior tibial translation. In cases of traumatic PCL injuries, a concomitant posterolateral corner (PLC) injury is present as well. This injury pattern can be assessed with the constellation of a reverse pivot test, a dial test, a posterolateral drawer test, and a varus stress testing at both 30° and 90° of flexion.

Radiography

The initial diagnostic imaging study should be plain radiographs (anteroposterior and lateral) of the knee. These initial radiographs are helpful in that they can rule out a fracture or an unreduced knee in the acute setting. Plain radiographs can be used to assess the medial or patellofemoral compartments for arthrosis in patients who present with a suspected chronic PCL deficiency. Long-leg standing films should be obtained if any fixed or dynamic instability is suspected or if there is evidence of extra-articular deformity. Posterior tibial subluxation may be evaluated on standard lateral radiographs; however, if there is any doubt bilateral stress (weighted) radiographs should be performed (Fig. 11.2).

Other Imaging Modalities

Although not regularly utilized in our current diagnostic algorithm, the extent of degenerative changes in the chronically PCL-deficient knee can be assessed with a bone scan.

Fig. 11.1 Intraoperative physical exam finding of the PCL-deficient knee; a posterior sag of the right tibia in 90° of flexion

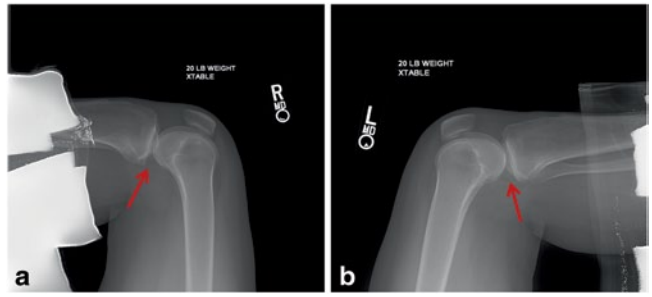

Fig. 11.2 Stress radiographs of the bilateral knees. The normal anatomic position of the tibia in relation to the femur (*arrow*) in a ligamentously intact knee (**a**). Posterior tibial subluxation in relation to the femur (*arrow*) is present in a PCL-deficient knee (**b**)

More commonly, a magnetic resonance imaging (MRI) study is an essential part of the work up of a PCL injury. The MRI serves to confirm the suspected PCL rupture but more importantly provides an assessment of associated ligamentous injuries such as those to the PLC that will affect the preoperative plan, the surgical technique, and ultimately the clinical outcome (Fig. 11.3).

Indications and Contraindications

Patients who sustain acute isolated grade I or II PCL injuries should be treated with nonoperative, protected weight bearing, and progressive rehabilitation. The grade I or II injuries that do not respond well to nonoperative measures and go on to have persistent or recurrent instability may be treated surgically. Grade III isolated PCL tears should be treated with surgical reconstruction, although not all authors agree on the existence of an isolated grade III PCL injury [10–12]. The majority of acute PCL ruptures occur as part of a larger constellation of knee injury, either a multiligamentous knee injury or a knee dislocation. In either case, surgical intervention is advocated for the majority of patients, especially those

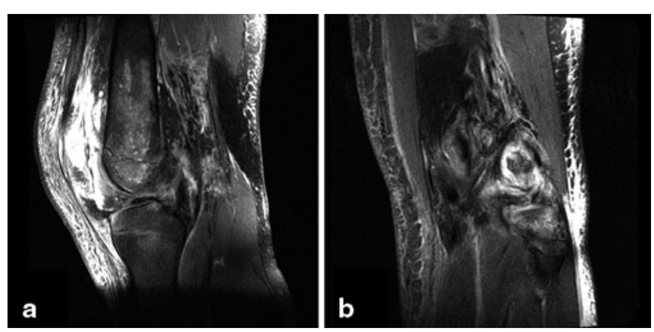

Fig. 11.3 Magnetic resonance imaging of a patient who sustained an acute complete tear of the PCL off the femur (**a**) and a patient with a concomitant PLC injury in the presence of an acute PCL tear (**b**).

patients who are young and active. The timing of intervention remains controversial; however, the literature supports either early or late reconstruction depending on the severity of injury (isolated PCL vs. multiligamentous injury), the surgeon's preference, and the patient's activity level [6, 12–18]. In the presence of an acute bony avulsion, early reconstruction is generally advocated.

There are a number of instances in which an acute PCL-R is contraindicated. In the setting of a traumatic open knee injury or in the presence of a neurovascular injury requiring repair or reconstruction, the PCL-R should be deferred into the late period to allow for resolution of the open injury or nervous insult. Relative contraindications to PCL-R include the presence of a chronic, fixed posteriorly subluxated deformity of the tibia and the PCL-deficient knee in which significant arthrosis is present. In both of the aforementioned scenarios, for the best clinical outcome, the senior author recommends a biplane osteotomy rather than a soft tissue reconstruction.

Surgical Technique

Overview

Once the decision has been made to proceed to the operating room for PCL-R, there are a number of surgical variables to consider, including graft material, number of graft bundles, and surgical technique (transtibial vs. open inlay vs. arthroscopic inlay). First to address the issue of number of graft bundles, recent biomechanical studies and a systematic review of the literature concluded that while there are no clinical studies to suggest an advantage of double-bundle grafts, there are distinct biomechanical advantages to the double-bundle PCL-R [19–21]. Thus, the senior author (JKS) has transitioned to the use of double-bundle grafts in primary PCL-R and when possible in revision PCL-R. The evolution of PCL-R surgical technique has been such that the all-arthroscopic tibial inlay technique has combined the advantages of both the transtibial and open inlay techniques while obviating the disadvantages of each technique [22–24]. For these reasons, the double-bundle arthroscopic inlay technique is our preferred technique for PCL-R and will be presented here.

Anesthesia and Positioning

Preoperative femoral and sciatic nerve catheters may be placed in the preoperative holding area for postoperative pain management. The catheters should not be dosed until a postoperative neurovascular assessment is complete in the recovery room. Following catheter placement, the patient is then transported to the operating room and placed supine on a radiolucent table. The radiolucent table is paramount as fluoroscopic confirmation of tunnel position and orientation will be necessary throughout the case. The patient should undergo general anesthesia and endotracheal intubation, but it is important to communicate with the anesthesia team that no long-acting paralytics should be given to ensure all neurologic stimulation induces a response. Once the patient is anesthetized and intubated, a comprehensive exam under anesthesia is performed to assess the integrity of all ligamentous and soft tissue structures of the knee. The results of the examination under anesthesia often aid in dictating the surgical plan. Once the exam is complete, the patient's nonoperative extremity bony prominences are well padded and a sandbag bump is taped to the bed. The bulk of the surgical work is performed between 45° and 90° of flexion and to facilitate these flexion angles, the sandbag is taped to the ipsilateral side of the table roughly at the level of the contralateral heel cord (Fig. 11.4). Additionally, doing the majority of the surgical procedure in flexion is a safety measure as flexion ensures the contents of the popliteal fossa fall away from the posterior tibia to allow for safe arthroscopic dissection of the tibial footprint. Although rarely inflated, a well-padded tourniquet is applied to the ipsilateral proximal thigh. The main advantage to working without the tourniquet is the early detection of a vascular injury if one was to occur. Lastly, when positioning, a flip-down lateral post is placed at the level of the tourniquet and set in a high position to act as a buttress for levering of the leg if a valgus force is necessary for medial compartment work.

Fig. 11.4 Surgical positioning for the arthroscopic inlay procedure. A sandbag or bump is secured to the radiolucent table to allow the operative knee to be ranged in the flexion arc of 45–90° (*red star*). A lateral post is attached to the table at the level of the thigh tourniquet to act as a fulcrum when placing a valgus force on the knee (*red arrow*). The contralateral leg is well padded and a sequential compression device is placed for deep venous thrombus prophylaxis (*black star*)

Portal Placement

Slight adjustments are made to the standard arthroscopic portal locations for the all-arthroscopic tibial inlay double-bundle PCL-R. A standard anterolateral (AL) portal is made, but the anteromedial (AM) portal is altered. The AM portal must be established in closer proximity to the patellar tendon for increased access to the posteromedial joint space. Later in the procedure, at the time of graft passage, the AM portal is extended into a 2-cm parapatellar arthrotomy to facilitate graft passage. The location of the posteromedial working portal is also crucial to prevent surgical struggle and should thus be established under direct visualization. An 18-gauge spinal needle is used to access the posteromedial aspect of the joint on a line between the posteromedial edge of the tibia and the femoral condyle. The posteromedial working portal is first utilized to clear the tibial footprint of the PCL and as such the ideal portal placement is approximately 1 cm cranial to the posteromedial joint line.

Once the three initial portals are created, a thorough diagnostic arthroscopic exam is conducted. The exam should include an evaluation of the integrity of all ligaments, menisci, and chondral surfaces. Injuries to the posteromedial and posterolateral corners are evaluated with increased opening of the medial and lateral compartments respectively under conditions of valgus and varus stress. In either case, a missed corner injury will place undue stress on the PCL-R and lead to increased risk of clinical failure.

Tibial Socket

The tibial socket is created prior to the femoral tunnels. First, a PCL guide pin (Arthrex Inc., Naples, FL, USA) is drilled from the anterior tibial surface into and through the tibial PCL footprint. This step is done with the assistance of fluoroscopy and under direct arthroscopic visualization. The target for insertion of the guide pin is within the footprint and 7 mm distal to the proximal pole of the tibial footprint. The corresponding 3.5-mm cannulated drill is used to overdrill the guide pin and once again the position is confirmed arthroscopically (Fig. 11.5a). Care is taken to avoid altering the tunnel trajectory by changing hand position while drilling and, more importantly, care is taken to avoid plunging into the posterior structures of the knee. Two safety mechanisms are employed to avoid plunging: the first is that the reaming position can be confirmed fluoroscopically or with direct arthroscopic visualization. The second is that the newest iteration of the drill guide has a built-in 13-mm footplate that protects against plunging (Arthrex Inc.). If another drilling system is employed, a straight curette may be placed on top of the guide pin, entering the joint via the AM portal. Once the tunnel is reamed, the tibial socket is ready to be created with the FlipCutter (Arthrex Inc.). The drill and guide pin are removed and replaced by the FlipCutter (Arthrex Inc.), which is advanced through the tibial tunnel until it is visualized intra-articularly with the arthroscope (Fig. 11.5b). Once the working end of the FlipCutter is within the joint, the blade is engaged by "flipping" it into a perpendicular position. The blade is activated and a 13-mm diameter tibial socket to a depth of 10–12 mm is then drilled in a retrograde fashion (Fig. 11.6). The FlipCutter blade is then advanced into the joint and "flipped" back into the upright positioned to enable the device to be withdrawn.

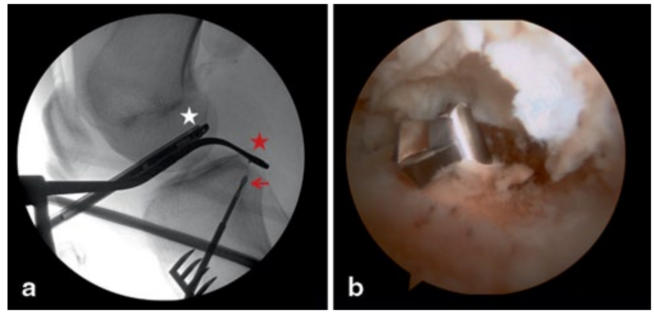

Fig. 11.5 Creation of the tibial socket. Fluoroscopic image demonstrating the PCL guide system (*red star*) and the cannulated drilling of the tibial socket (*red arrow*) (**a**). This step is done under fluoroscopic and direct arthroscopic visualization (*white star*). Arthroscopic view confirming successful insertion and position of the FlipCutter at the tibial footprint of the PCL (**b**)

Graft Preparation

In cases of isolated PCL-R autograft, tendon–bone constructs may be considered; however, the majority of operative PCL injuries include additional soft tissue/ligamentous injuries requiring reconstruction, thus allograft is preferred. The current graft of choice is the Achilles tendon allograft with calcaneal bone block. With this technique, there is no clinical outcome study we are aware of to suggest a superiority

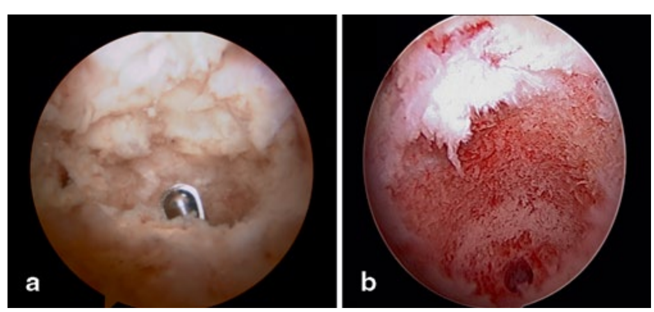

Fig. 11.6 Arthroscopic images of the completed tibial socket reamed by the FlipCutter. Anterior to posterior arthroscopic image with shaver-clearing debride from tibial socket (**a**). Arthroscopic view of the tibial socket; diameter 13 mm, depth 10–12 mm (**b**)

of allograft or autograft; however, the Achilles tendon–bone allograft is a natural graft choice as the anatomic raphe between the superficial and deep fibers facilitates the creation of two bundles (Fig. 11.7a). Sharp dissection is used to develop the interval between deep and superficial Achilles fibers, in line with the longitudinal fibers of the graft to a distance of approximately 1 cm proximal of the calcaneal bone block. The newly created graft bundles are oriented in the anterior-to-posterior orientation with the larger bundle (8–11 mm) for the anterolateral bundle (ALB) and the smaller bundle (6–9 mm) for the posteromedial bundle (PMB). Each bundle of the bifid graft is reinforced with a No. 2 braided, nonabsorbable whipstitch (Fig. 11.7b).

Attention is then turned to trimming and shaping the calcaneal bone plug for a press fit into the tibial socket. The stability of the all-arthroscopic tibial inlay PCL-R technique relies heavily on the press-fit design of the graft [25]. The proper press fit for a 13-mm socket is a cylindrical 12-mm bone plug, which can be either created with the aid of a coring reamer or hand whittled with a rongeur. The coring reamer is the most expedient and accurate method; however, there is a learning curve associated with this technique. Once the outer diameter of the bone plug is established, a central tunnel is created within the bone plug and over-reamed to a diameter of 3.5 mm with a cannulated drill system. The 1 cm of tendon left in continuity is then whipstitched with a No. 2 braided nonabsorbable suture and the free ends of this stitch are passed through the center tunnel of the bone plug from the cortical to cancellous side of the bone plug (Fig. 11.8). The free limbs passing through the bone block aid in guiding the bone plug into position. Once the bone block is seated and the graft is tensioned, the free limbs are tied over a post or button to augment tibial fixation. Recently, we have transitioned to the use of cortical button fixation which we have tested biomechanically in the laboratory and found to be equivalent in strength to post fixation. In addition to equivalent strength and stiffness, the cortical button has ease of use and improved visualization to seat the bone plug fluoroscopically.

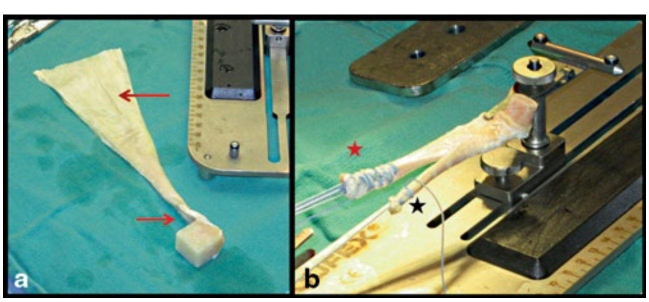

Fig. 11.7 Preparation of the soft tissue segment of the tendon–bone graft. The natural raphe of the Achilles tendon allograft is appreciated (*red arrows*) before sharply dissecting the graft into two limbs (**a**). Each limb is whipstitched and tubularized with a No. 2 braided, nonabsorbable suture; ALB (*red star*) and PMB (*black star*) (**b**)

Fig. 11.8 Preparation of the bone segment of the tendon–bone graft. After sculpting the cubed bone block into a cylinder, the central calcaneal aperture is created with the use of a 3.5-mm drill system. The graft is finalized by passing a No. 2 braided, nonabsorbable suture through the remaining 1 cm of intact tendon at the bone plug end of the graft. The free limbs are then shuttled through the bone plug to aid in guiding the bone plug into the tibial socket and ultimately assisting with fixation

Femoral Tunnel

The femoral tunnels may be created inside out or outside in; however, for accuracy of placement we prefer the outside-in technique. A skin incision is made anteromedially overlying the vastus medialis obliquus (VMO) at the level of the medial epicondyle extending in line and anterior to the intermuscular septum. Once the fascia is incised, the VMO is elevated with a Cobb and retracted with a deaver or deaver-like retractor over the anterior femur. The periosteum is then exposed to clearly identify the starting position for the tunnels and ensure accurate tunnel position. The ideal tunnel for the ALB places the anterior edge of the ALB 1–2 mm off the articular margin of the medial femoral condyle at the 11:30 (left) or 12:30 (right) clock position. To create this tunnel, the guide pin is placed approximately 5 mm posterior to the articular margin (Fig. 11.9). For the PMB, the guide pin is placed 7 mm off the articular margin at the 9:00 (left) or 3:00 (right) position. The edge of the drilled tunnel should

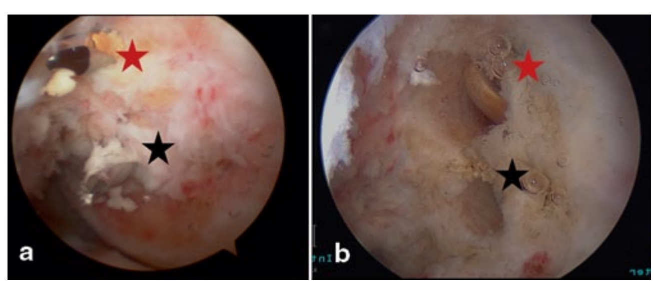

Fig. 11.9 Arthroscopic confirmation of anatomic position of the femoral tunnels. The respective guide pins located in the center of the ALB (*red star*) and PMB footprints (*black star*) (**a**). The guide pins are overdrilled and two tunnels are created with a distinct bone bridge to prevent bone bridge collapse and tunnel convergence (**b**)

lie approximately 3 mm off the articular margin (Fig. 11.9). The technical challenge in femoral tunnel drilling is avoidance of tunnel convergence which will ultimately result in bone bridge collapse and loss of the potential benefits of a double-bundle reconstruction.

Graft Passage/Tibial Fixation

As mentioned previously, the AM portal is often extended 1–2 cm to ease the passage of the graft. The graft and sutures must be cleanly passed through the arthrotomy and fat pad avoiding incarceration of the graft or entanglement of the sutures in the fat pad. The calcaneal bone plug is seated into the tibial socket and the position is confirmed fluoroscopically prior to any fixation (Fig. 11.10). The press-fit security is assessed arthroscopically by probing the interface and once the stability of the construct is deemed adequate, the tibial side of the graft is fixed to the anterior tibial cortex with the cortical button construct. We have recently employed the TightRope as the tibial cortical fixation technique (Arthrex, Inc.).

Femoral Fixation

Once the tibial side of the graft is secure, the femoral-sided suture limbs are retrieved through their respective bone tunnels with a looped 18-gauge wire. Before fixing the AL and PM bundles, the knee and graft are cycled to eliminate laxity in the construct. In a similar fashion to the double-bundle ACL reconstruction, in which the two bundles are preferentially fixed at different flexion angles to recapitulate the native ligament tension in each bundle separately, there is discussion that the two bundles of the PCL-R should also be differentially fixed [26, 27]. However, until these data emerge in the literature, we are currently tensioning both bundles at 90° of flexion [28]. The tensioned bundles are fixed with bioabsorbable interference screws and the fixation is then backed up with postfixation. The graft tension is tested with a probe and visualized arthroscopically (Fig. 11.11).

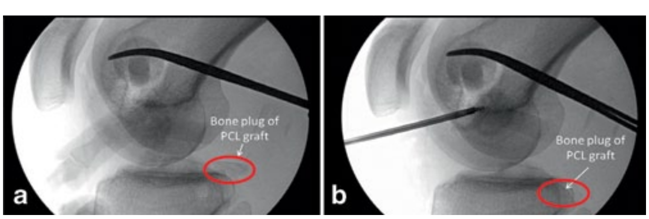

Fig. 11.10 Fluoroscopic confirmation of a well-positioned tibial bone plug (**a**). Once tension is placed on the suture limbs, the seating of the bone plug in the tibial socket is confirmed (**b**) (Adapted from [42])

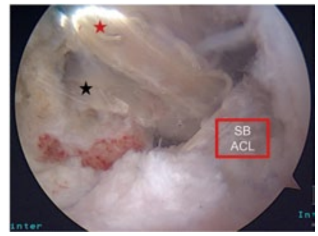

Fig. 11.11 The arthroscopic appearance of a completed double-bundle arthroscopic tibial inlay PCL reconstruction with appropriate graft tension; ALB (*red star*) and PMB (*black star*) are distinct graft bundles. A concomitant single-bundle ACL reconstruction (SB ACL) was also performed in this patient

Postoperative Considerations

Rehabilitation

The overall objective of rehabilitation is to protect the reconstructed knee in the early postoperative period, and then gradually increase gains in motion and strength over time. There are a number of rehabilitation protocols in the literature with demonstrated good to excellent results for both the isolated PCL-R and the multiligament reconstructed knee [6, 29, 30]. A full description of each protocol is outside the scope of this chapter, and will be reviewed later in the text; however, the following is an overview of the preferred rehabilitation protocol.

Cryotherapy and a hinged knee brace locked in full extension are placed on the operative limb at the conclusion of the case. Controlled range of motion exercises and partial weight bearing with the operative extremity locked in extension are permissible in the immediate postoperative period. If chondroplasty, meniscal repair, or fracture fixation is performed at the time of PCL-R, a period of nonweight bearing will occur prior to advancing to partial weight bearing. In the early postoperative period, isometric quadriceps exercises are permitted and electrical muscle stimulation may be used to enhance quadriceps recruitment [31]. Prone passive knee flexion, quadriceps strengthening sets, and patellar mobilization exercises are expected in a progressive and graduated fashion over the 1st postoperative month. Weight bearing as tolerated with an assisted device begins at 2–4 weeks given the extent of injury and typically graduates to weight bearing as tolerated without an assisted device after 6 weeks. The stationary bike is incorporated as part of the exercise regimen in the 2nd postoperative month and in the 3rd postoperative month full flexion should be achieved. Full range of motion closed chain exercises are added in the 4th postoperative month and athletes are returned to straight-line running at 6 months. Between 6 and 9 months, sport-specific activities are initiated in a stepwise fashion. Most athletes return to full sports activities between 9 and 12 months. Currently, there are a number of criteria used to return athletes to full participation, including absence of effusion, satisfactory clinical examination, quadriceps and hamstring strength at or above 90% of the contralateral leg, one-leg hop and vertical jump at or above 90% of the contralateral leg, full-speed run, shuttle run, and figure-of-eight running without a limp, and ability to perform squat and rise without difficulty [12, 32].

Complications

Although complications associated with PCL-R are rare events, they do occur, in part, due to the proximity of the ligament to vital neurovascular structures. As with any surgical procedure, complications may be divided into preoperative, intraoperative, and postoperative events. The major preoperative complication encounter is neuropraxia secondary to poor or improper positioning of the contralateral leg or bilateral arms. Intraoperatively, the most pressing concern is damage to the popliteal neurovascular structures. These structures are at greatest risk during tibial-sided drilling. The all-arthroscopic tibial inlay technique innately provides some decreased risk due to the lack of popliteal fossa dissection. In addition, the current instrumentation: a tibial guide with a plunge blocking insert and retrograde socket drilling with the FlipCutter both provide additional safety features. Likewise, the all-arthroscopic inlay technique affords arthroscopic visualization and fluoroscopic confirmation of drill position at all times. Intermittent checks of thigh and calf tone are important to ensure that compartment syndrome does not develop in response to fluid extravasation into the soft tissue. This is especially important when operating in the early postoperative period in a multiligament-injured knee or knee dislocation in which the joint capsule may be damaged. Iatrogenic cartilage damage or subsequent avascular necrosis of the medial femoral condyle can be avoided by placing the starting and exiting points for the femoral tunnels clear of the subchondral bone. Graft-tensioning errors are made intraoperatively but oftentimes not recognized until the postoperative period. Over-constraint of the knee is possible with excessive graft tensioning or poor graft position. Conversely, under tensioning the graft can lead to residual laxity and subsequently the development of early arthrosis. In the postoperative period, overaggressive or overly cautious rehabilitation may lead to graft failure or knee stiffness, respectively.

Discussion

While there are limited clinical data regarding the success of the double-bundle all-arthroscopic tibial inlay PCL-R, this technique is a natural progression in the evolution of the treatment of PCL injury and is grounded in sound biomechanical evidence [11, 22, 24, 33, 34]. The use of a double-bundle graft is supported by a number of in vitro biomechanical studies which have found the double-bundle PCL-R to more closely reproduce normal knee biomechanics and kinematics [20, 21, 33, 35]. A recent systematic review of the literature supported the biomechanical basis for use of the double-bundle graft. In particular, the systematic review found that there may not be a definitive advantage to double-bundle PCL-R in regard to anteroposterior stability; however, there is a distinct advantage of double-bundle PCL-R in regard to rotational stability in the setting of unrecognized or untreated PLC injury [19]. Most recently, in a controlled biomechanical study, Wijdicks et al. [20] rebuffed the equivalence of the single-bundle graft to anteroposterior stability and suggested that the double-bundle graft is superior to resisting posterior translation at all flexion angles greater than 0°. In addition, these authors found comparable results to previous studies in that the double-bundle PCL-R restored rotational stability to a significantly greater degree than did the single-bundle PCL-R [20]. Although the time-zero biomechanical data suggest superiority of a double-bundle graft, there are currently no high-level clinical studies that support the use of double-bundle reconstruction over single-bundle reconstruction or vice versa [19].

While there is no “gold standard” surgical technique for reconstruction of the PCL, the biomechanical advantages of the tibial inlay technique (either open or arthroscopic) have been documented. The inlay technique avoids the “killer turn” and subsequent graft elongation or failure which has been demonstrated in cadaveric studies [36, 37]. The arthroscopic inlay approach is biomechanically comparable to the open inlay approach at time zero and avoids the morbidity associated with a posterior approach to the knee and violation of the posteromedial joint capsule [22, 24, 38]. We are aware of four clinical or functional outcome studies involving the double-bundle all-arthroscopic tibial inlay PCL-R technique, all with promising results [27, 39–41]. In 2005 and 2006, the short-term results of the all-arthroscopic double-bundle tibial inlay PCL-R were documented to be comparable to historical controls [27, 40]. More recently, Kim et al. [39] compared cohorts of isolated PCL injuries undergoing either single-bundle transtibial reconstructions, single-bundle arthroscopic tibial inlay reconstructions, or double-bundle arthroscopic tibial inlay reconstructions. The authors found that the mean Lysholm and range of motion at final follow-up were equivalent between all groups; however, the single-bundle transtibial reconstructions had significant increased laxity as compared to the double-bundle arthroscopic inlay group [39]. The results of the Kim et al. study [39] suggest some functional advantage of the all-arthroscopic tibial inlay double-bundle PCL-R in the isolated PCL-injured knee. Until recently, the clinical and functional results of this technique in the multiligamentous injured knee were largely unknown. Recent work from our institute implementing this surgical technique in a multiligament-injured patient cohort suggests that at greater than 2 years following surgery, this technique is clinically, functionally, and radiographically comparable to the transtibial and open tibial inlay techniques in a similar patient population [41].

Conclusion

Although injury to the PCL is less frequent than ACL injury, incorrect management of PCL ruptures can ultimately lead to a cascade of events similar to that of ACL injury, thus resulting in knee joint arthrosis. Multiple surgical techniques exist for the reconstruction of the PCL, including transtibial drilling, open tibial inlay, and arthroscopic tibial inlay. Arthroscopic tibial inlay circumvents the potential for graft failure associated with the "killer turn" in transtibial PCL-R, and eliminates the potential morbidity accompanying an open surgical approach to the posterior knee associated with open tibial inlay. Furthermore, double-bundle PCL-R more closely recapitulates the normal knee kinematics following PCL injury. Lastly, the emerging clinical results for the all-arthroscopic tibial inlay double-bundle PCL-R are comparable if not superior to the alternative surgical techniques. For all these reasons, we recommend the all-arthroscopic tibial inlay double-bundle PCL-R.

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