Title
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Journal
Current Reviews in Musculoskeletal Medicine, 11(2)

ISSN
1935-973X

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Publication Date
2018-06-01

DOI
10.1007/s12178-018-9490-3

Peer reviewed

Current Reviews in Musculoskeletal Medicine (2018) 11:316–319
https://doi.org/10.1007/s12178-018-9490-3

PCL UPDATE (K JONES AND M ALAIA, SECTION EDITORS)

Open Tibial Inlay PCL Reconstruction: Surgical Technique and Clinical Outcomes

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Published online: 24 April 2018

Abstract

Purpose of Review To review the current literature on clinical outcomes following open tibial inlay posterior cruciate ligament (PCL) reconstruction and provide the reader with a detailed description of the author's preferred surgical technique.

Recent Findings Despite earlier biomechanical studies which demonstrated superiority of the PCL inlay technique when compared to transtibial techniques, recent longitudinal cohort studies have shown no significant differences in clinical or functional outcomes at 10-year follow-up. Furthermore, no significant clinical differences have been shown between graft types used and/or single- versus double-bundle reconstruction methods.

Summary The optimal treatment for the PCL-deficient knee remains unclear. Open tibial inlay PCL reconstruction is safe, reproducible, and avoids the "killer turn" that may potentially lead to graft weakening and failure seen in transtibial reconstruction methods. No significant differences in subjective outcomes or clinical laxity have been shown between single-bundle versus double-bundle reconstruction methods.

Keywords Posterior cruciate ligament · Open tibial inlay · Sports medicine

Introduction

Injuries to the posterior cruciate ligament (PCL) are rare with an incidence as low as 3% in the outpatient setting [1]. Current surgical techniques include transtibial and tibial inlay PCL reconstruction methods. The transtibial PCL reconstruction method results in the formation of a long oblique tibial tunnel and an acute "killer turn" as the graft traverses the knee joint into the femoral tunnel. Early biomechanical studies by Markolf et al. showed that this "killer turn" leads to graft thinning and potentially early failure following cyclic loading [2•]. In order to avoid the "killer turn" seen in transtibial techniques, Jakob et al. and later Berg developed and popularized the open tibial inlay method of PCL reconstruction which relies on a posterior arthrotomy and direct visualization of the PCL tibial attachment site [3, 4]. The open tibial inlay technique allows for anatomic placement of the PCL graft at its tibial attachment site and direct bone-to-bone healing for added fixation strength. The purpose of this review is to discuss the clinical outcomes following open tibial inlay PCL reconstruction and provide the reader with a detailed description of the author's preferred surgical technique.

Indications/Contraindications

Significant controversy exists over the indications for surgical PCL reconstruction given the lack of prospective randomized control trials. Non-operative management is typically reserved for isolated grade 1 or 2 PCL injuries and has been shown to result in adequate knee range of motion and quadriceps strength at an average of 14.3 years follow-up [5]. The authors prefer to pursue operative management for acute grade III PCL tears in some elite young athletes, acute displaced avulsion fractures from the tibial attachment site, acute and chronic combined ligamentous injuries, and chronic isolated grade III PCL injuries with persistent symptoms of pain or instability. No recent high-quality studies exist in the current literature showing specific indications for performing PCL reconstruction using any specific technique.

This article is part of the Topical Collection on *PCL Update*

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Surgical Technique

There are two main types of surgical technique for PCL reconstruction: transtibial and tibial inlay. Within each of these technique types, extreme heterogeneity exists with regard to graft type, fixation method, and number of bundles reconstructed. This heterogeneity is likely due to the low level of evidence of the studies comparing different surgical techniques in the existing literature. Furthermore, given the low level of evidence of current clinical studies comparing surgical technique, it is difficult to determine superiority of one technique over another. As a result, surgical technique for PCL reconstruction is often based upon surgeon preference, clinical training, and anecdotal experience. The authors' preferred technique of open tibial inlay PCL reconstruction is described below.

Arthroscopy/Femoral Tunnel

The patient is placed in the supine position and undergoes general endotracheal anesthesia in order to maintain a secure airway throughout the procedure. The surgeon then performs a comprehensive knee examination under anesthesia looking for any concomitant capsuloligamentous injuries that may need to be addressed. A thigh tourniquet is placed but not inflated. The patient is then placed in the lateral decubitus position and the operative extremity is prepped and draped in normal sterile fashion. The patient is then rotated into the supine position, skin incisions are marked, and a diagnostic knee arthroscopy is performed. The PCL is closely examined and any residual incompetent tissue is removed using a combination of arthroscopic shavers and punches. The native PCL femoral footprint is maintained in order to guide tunnel placement. An attempt to preserve the meniscofemoral ligaments is made if they are intact. The femoral tunnel is placed in the anterior and distal portion of the PCL footprint in order to reconstruct the anterolateral bundle of the PCL. Next, a medial skin incision through the underlying capsule is created to optimize drill guide placement and tunnel orientation. An outside-in arthroscopic drill guide is carefully placed approximately 1 cm from the margin of the articular cartilage and a femoral guide pin is advanced into the native PCL footprint. A 10-mm cannulated drill is then placed over the guide pin and a femoral tunnel is created. Tunnel size may vary depending on the size of the graft. The intra-articular portion of the femoral tunnel is then debrided of any residual tissue with a combination of arthroscopic rasp and shaver. An 18-gauge metal wire loop is then placed through the femoral tunnel into the posterior aspect of the femoral notch for later graft passage.

PCL Graft Preparation

An Achilles tendon allograft is the author's preferred graft type given its high collagen content, ability to provide bone-to-bone tibial fixation, and lack of donor site morbidity. There are no high-level prospective studies comparing autograft to allograft. However, numerous low evidence cohort studies have shown no difference in short-term clinical outcomes amongst graft types including bone-tendon-bone and soft tissue grafts [6, 7].

Approximately 30 mm of the tendinous portion of the Achilles allograft is tubularized using a running locked braided polyester suture and sized for the previously drilled 10-mm femoral tunnel. A trapezoidal bone plug 25 mm in length and 13 mm in width is then fashioned, predrilled, and tapped for a 6.5-mm cancellous screw. A 35-mm partially threaded cancellous screw with metal washer is then inserted into the cortical side of the bone plug and advanced 2 mm beyond the cancellous surface.

Open Tibial Inlay

With the help of non-sterile operating room personnel, the patient is carefully rotated into the prone position making sure not to contaminate the operative field. A posteromedial incision as described by Burks is made after the limb is exsanguinated and a thigh tourniquet inflated [8]. The incision is made down to the level of the investing fascia over the medial head of the gastrocnemius being careful not to damage the medial sural cutaneous nerve which typically lies in the midline posteriorly. The fascia is sharply incised and blunt as well as sharp dissection are then used to carefully develop the interval between the semimembranosus and medial gastrocnemius muscles down to the level of the joint capsule. A vertical posterior capsulotomy is then performed exposing the PCL's posterior tibial attachment. Sometimes a branch of the middle geniculate vein traverses across the superior aspect of the popliteus muscle. Most of the time, the surgical dissection is superior to this and it can be avoided. However, occasionally, it needs to be suture ligated. A combination of burr, rongeurs, and osteotomes are then used to resect the tibial insertion site and to create a bony trough for the previously prepared graft. The PCL graft bone plug is then inserted and secured using the previously placed 6.5-mm cancellous screw and washer. Sutures attached to the tendinous portion of the graft are then passed through the previously placed 18-gauge wire loop and the wire is then pulled shuttling the graft through the femoral tunnel. Once appropriate graft position is confirmed, the posterior joint capsule is repaired, the tourniquet is deflated, hemostasis is achieved, and the wound is closed in layers.

Final Graft Tensioning

The patient is sterilely rotated back to the supine position and the graft is examined arthroscopically. The knee is cycled numerous times noting that the graft should lengthen slightly as the knee is brought into full extension. The graft is then

tensioned in approximately 80–90° of knee flexion and secured with a 9 × 25-mm soft tissue interference screw and reinforced with a bone staple. Arthroscopic portals and the medial femoral tunnel incision are irrigated and closed in standard fashion. Post-operative examination under anesthesia should note normal tibial step-off as well as a negative posterior drawer [9].

Outcomes

Cooper et al. showed that in 41 patients with grade 3 posterior laxity undergoing open tibial inlay PCL reconstruction, the mean improvement in posterior drawer was greater than 2 grades and subjective International Knee Documentation Committee (IKDC) scores increased significantly [10]. Individuals who underwent reconstruction with allograft showed increased improvement in IKDC scores at 2 years compared to those with autograft but no difference in posterior knee stability tested via Telos stress radiography was detected [10]. Furthermore, Noyes et al. showed in a study of 19 patients undergoing open tibial inlay PCL reconstruction with double-bundle quadriceps tendon bone autograft that 18 noted functional improvement and only 1 noted persistent pain with daily activities. Eleven patients returned to low-impact sports with no problems [11]. In comparison to transtibial techniques, open tibial inlay has shown comparable clinical and radiographic results. Song et al. in a prospective cohort study comparing 36 patients who underwent transtibial reconstruction versus 30 who underwent tibial inlay showed no difference in post-operative Lysholm knee scores, Tegner activity scores, posterior laxity, or radiographic evidence of osteoarthritis at an average of 148 months follow-up [12•]. These results were most recently supported by a systematic review of 7 studies by Shin et al. comparing clinical outcomes between 149 patients undergoing single-bundle transtibial reconstruction versus 148 patients undergoing single-bundle tibial inlay reconstruction again showing no difference in functional outcome scores but both groups with considerable residual posterior laxity [13•]. Currently, there are no recent high-level studies known to the authors comparing clinical outcomes in patients undergoing single-bundle versus double-bundle tibial inlay PCL reconstruction despite numerous cadaveric studies demonstrating conflicting results.

Complications

Complications following open tibial inlay PCL reconstruction are uncommon but include infection, stiffness, residual posterior laxity, and iatrogenic neurovascular injury. Residual posterior laxity following open tibial inlay PCL reconstruction has been demonstrated in numerous studies with varying clinical relevance. Despite this residual posterior laxity, many patients are asymptomatic and note improved functional outcome scores. Papalia et al. in their systematic review showed the possibility of post-operative hematoma formation due to the larger posterior exposure as well as traction neuropraxia to the saphenous nerve from prolonged retractor placement [14]. Recent studies by Seo et al. have demonstrated the possibility of popliteal artery compression if the tibial bone block is placed too far laterally or not adequately recessed in the prepared tibial trough [15]. Furthermore, the risk of neurovascular injury may be increased in the setting of multiligamentous knee injuries with prior vascular repair due to scar tissue formation and altered anatomy.

Future Directions

Prospective randomized clinical trials are needed in order to help delineate the optimal surgical technique, graft type, and fixation method. Given the relatively low incidence of this injury, it may be necessary to create multicenter trials in order to obtain the necessary statistical power to derive clinical recommendations.

Conclusions

The optimal treatment for the PCL-deficient knee remains unclear. No significant differences in clinical or functional outcomes have been shown in studies comparing transtibial to open tibial inlay PCL reconstruction. Currently, open tibial inlay PCL reconstruction remains a safe, reproducible, and clinically effective method of PCL reconstruction.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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