Arthroscopic Trans-septal Portal to Treat Extension Deficits from Arthrofibrosis

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Arthroscopic debridement is one option to treat arthrofibrosis of the knee. While this technique has typically been described for debriding proliferative scar tissue within the anterior knee compartment, this technique can also be used to treat contractures of the posterior knee compartment. The posterior trans-septal portal allows excellent access to and visualization of structures within the posterior knee. Use of this portal helps ensure successful release of the posterior compartment and enables improved range of motion in patients with stubborn extension deficits secondary to arthrofibrosis.

Introduction

Arthrofibrosis is characterized by a loss of knee motion that may be accompanied by pain and functional impairment. Scar tissue formation followed by contraction of structures both within and surrounding the knee joint results in restriction of normal motion[1]. This condition may occur secondary to surgery, trauma, or degenerative arthritis. Both ligamentous injury and repair or reconstruction may lead to loss of motion. The incidence of motion loss varies according to the degree of injury. Intra-articular ligament reconstruction or extra-articular repair, technical errors, injury severity, timing of surgery, delayed postoperative physical rehabilitation, heterotopic ossification, prolonged immobilization, infection, and complex regional pain syndrome may also lead to motion loss. Genetic factors may also play a role. One study found that patients with arthrofibrosis were more likely to have HLA-Cw*08 and less likely to have HLA-Cw*07 genotype[2]. The pathophysiology of arthrofibrosis is characterized by pain, inflammation and immobility.Arthrofibrosis of the knee can result in significant functional limitation. This is accompanied by an increased stress on the extensor mechanism and patella, particularly with limitations in full knee extension[3-5]. Scarring can occur from the patella to the intercondylar notch, suprapatellar pouch and ultimately within the articular surfaces. Capsular and quadriceps contractions further reduce joint mobility. Shelbourne has noted that subtle deficits in extension after ACL surgery lead to much higher prevalence of degenerative changes[6].

The anatomic site of scarring dictates the limitation of motion (flexion, extension, patellar mobility). Arthrofibrosis may be localized or diffuse and may or may not affect the extra-articular soft tissues. Symptoms include stiffness, pain, limping, swelling, crepitus and/or weakness. Magnetic resonance imaging (MRI) can help to both diagnose and determine the extent of the disease. Flexion loss is often better tolerated and more easily treated than extension loss[1]. Late stage disease may lead to patella inferna[7]. Treatment begins with conservative management including NSAIDs and physical therapy (PT), as well as steroids injections and cryotherapy. Static or dynamic bracing may also be used for treatment[8,9]. Manipulation under anesthesia, surgical debridement and lysis of adhesions can be utilized for recalcitrant cases[10]. In refractory cases, open capsular release may be necessary. In extreme cases, particularly in the older patient, arthrodesis and total knee arthroplasty may be viable alternatives.

Assessment

Normal knee range of motion is from zero to 135 degrees of flexion, with 10 to 120 degrees described as the arc of active function[1]. Given the normal variation amongst individuals, the best method to assess is to compare with the contralateral knee assuming no pathologic conditions. Knee motion depends on a smooth articulation between the femur and tibia; a flexible and spacious joint capsule; free space in the lateral and medial recesses, intercondylar notch, and suprapatellar pouch; and sufficient meniscal motion[1]. Any one of these factors may lead to limitations in joint motion. A thorough evaluation of the knee is recommended to ascertain which abnormalities are responsible.

Evaluation of patients with arthrofibrosis begins with an accurate history focusing on the initial injury or surgical intervention leading to the limitation in motion.The disease time course should be elicited as well as the progression of the disease.The clinician should ask about pain, feelings of instability, mechanical symptoms, history of knee injuries or surgeries, and length of immobilization leading up to the present state. It is also important to inquire about prior therapies (operative and nonoperative) and limitations in functional deficits as a result

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of motion loss. One of the goals of the evaluation is to rule out other causes of motion loss that may require different management such as motor dysfunction owing to nerve injury, extensor mechanism compromise, meniscal tears, loose bodies, and quadriceps inhibition from intraarticular effusion.

Physical exam begins with the patient supine with the knee extended and relaxed. Inspection is the first part of the exam, beginning with the skin and contour of the knee which can be altered by hypertrophic synovium and scar formation. Patellar mobility is then assessed including any tendinous adhesion of the patellar tendon to the tibia. Immobility of the patellar tendon may limit full extension secondary to inhibition of proximal patellar excursion during knee "lock out"[11]. Next, range of motion is examined both passively and actively and compared to the unaffected knee. A soft tissue block is indicated by a "soft end feel" compared to the firm, hard clunk of a bony block (11). Collateral and cruciate ligaments are then assessed for integrity. Finally, meniscal pathology is evaluated by flexing the knee to 90 degrees and palpating the medial and lateral joint lines.

Imaging can be very helpful in the evaluation and includes both x-rays and MRI of the knee. X-rays can identify loose bodies within the knee in cases of anterior knee fibrosis. Calcification of the infrapatellar fat pad may be seen on lateral x-ray, whereas calcification of the MCL (Pelligrini-Steada lesion) is best evaluated on AP radiographs. MCL calcification impairs both flexion and extension. MRI, on the other hand, is excellent for assessing other potential causes of knee motion limitation including extensor mechanism injuries, meniscal tears, articular fractures, and cyclops lesions.

Treatment

The first line of treatment for arthrofibrosis is aggressive rehabilitation, including physical therapy several times weekly and dynamic bracing. "Prone hangs" where patients lie face-down and hang their knees off the end of a table, are a good exercise for patients with flexion contractures. However, nonoperative therapies are less likely to improve motion in patients with more than 30 degrees of extension loss or in those who are more than 6 months out from their inciting event[11]. At this point, surgical arthroscopy with lysis of adhesions is recommended. Traditionally, lysis of adhesions in the anterior part of the knee involves removing scar tissue from the medial and lateral recesses in addition to the suprapatellar pouch and infrapatellar fat pad. It yields good results with significant improvement in knee extension, however, posterior capsular contracture often leaves a residual knee extension limitation.

The challenge in addressing posterior capsular contracture has been the proximity of neurovascular structures and thus the need for open release. Arthroscopic methods utilizing purely anterior portals do not afford visualization of the posterior compartments. Even with posterior portals, instrumenting the posterior compartments in combination with transnotch visualization is quite difficult. Therefore, posterior capsular release was previously done open with posteromedial, posterolateral, or a combination of incisions.[4,12].

We describe an option for treating a residual deficit in full knee extension using a posterior capsular release performed through the trans-septal portal. There are no absolute contraindications for posterior trans-septal capsular release. However, the septum is a relatively small area of tissue located between the PCL and the popliteal neurovascular structures. The surgeon should take heed of any prior surgical procedures or injuries involving the posterior aspect of the knee which might have disrupted the normal anatomy and lead to increased risk for iatrogenic injury while placing the posterior trans-septal portal. Previously, some open posterior releases were performed with posteromedial and posterolateral incisions only when absolutely necessary such as in cases of persistent debilitating loss of extension[10]. Using traditional anterior and posterior portals with arthroscopy provides limited views of posterior structures such as the posterior portions of the femoral condyles, the periphery of the posterior horns of the menisci, the back of the PCL, the ligament of Wrisberg, the posterior septum, and posterior capsule[13]. Additionally, these portals do not allow adequate placement of arthroscopic instruments.

Anatomy

The posterior septum serves as a physical barrier between the PCL and posterior capsule which separates the posterior knee into posteromedial and posterolateral compartments (Figure 1). Kim et al. measured the dimensions of these compartments using MRA of cadaveric knees at 90 degrees of flexion and found an average anterior-to-posterior distance of 11.7mm in the posteromedial compartment and 7.9mm in the posterolateral compartment, with an average ratio of 1.5 between the two distances[14]. They also noted that the popliteal artery was always located lateral to the posterior septum.

The trans-septal portal allows the surgeon to both visualize and instrument the entire posterior compartment simultaneously. This portal approach has been used to carry out complete synovectomies, PCL reconstructions, PCL avulsion fracture, excision of ganglion cysts of the PCL, removal of loose bodies or tumors from behind the PCL and repairs of the posterior horn of the medial meniscus[3-5,15-22]. The portal lends itself nicely to a minimally invasive approach to posterior capsule release for persistent flexion contracture of the knee secondary to arthrofibrosis.

The posterior trans-septal portal is created by shaving synovial tissue along with a mild distal posterior capsular release to better visualize the posterior tibia. The PCL insertion can be clearly identified. Ahn et al have shown that the popliteal neurovascular structures are significantly shifted posteriorly during this limited posterior capsular release[23]. Cosgarea et al found a mean sagittal distance of 29.1 +/− 11 mm from the popliteal artery to mid-PCL, and 9.7 +/− 5mm from popliteal arterty to proximal PCL measured on MRI in a cadaveric study that simulated arthroscopic conditions with knees at 90 degrees of flexion[24]. A cadaveric study by Pace and Wahl examined the mean distance between the PCL

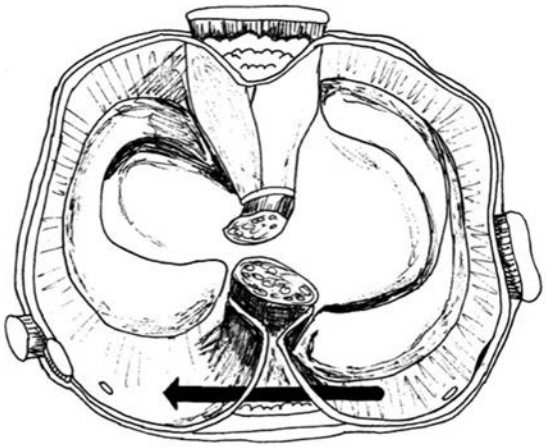

Figure 1. An artist's rendition of the knee in the axial plane with the arrow in the location of the posterior trans-septal portal.

and popliteal artery following a transverse capsulotomy in knees examined arthroscopically at 90 degrees of flexion[25]. Between the popliteal artery and PCL was a mean distance of 19.3mm; between the posterolateral portal and peroneal nerve was a mean distance of 40mm while between the posteromedial portal and saphenous vein was a mean distance of 22.6mm. They concluded that there was a safe zone of at least 15mm between the posterior portals, posterior capsule, and neurovascular structures of the posterior knee. The importance of knee flexion to maximizing the PCL to popliteal artery distance was shown by Matava et al. who found a mean distance of 5.4mm at 0 degrees of knee flexion increasing to a mean of 9.3mm at 100 degrees of flexion in MRI studies of cadaveric knees under arthroscopic conditions[26].

Technique

The procedure is performed under general anesthesia. Patients should receive an epidural catheter for postoperative pain control to improve physical therapy and maintain knee motion gained from surgery. The knee is examined when the patient is under anesthesia, with documentation of the range of motion. A tourniquet and leg holder are then placed over the proximal thigh. The patient should be distal on the table so as to optimize access to the posterior aspect of the knee. The contralateral leg is abducted and placed in a well-leg holder. The foot of the table is sufficiently low to allow the operative knee to hang in 90 degrees of flexion.

To begin, anteromedial and anterolateral portals are made next to the medial and lateral borders of the patellar tendon and one centimeter proximal to the joint line. A complete diagnostic arthroscopy is performed, assessing the anterior compartments including the suprapatellar pouch and medial and lateral recesses for any scar tissue. A thorough lysis of adhesions is then completed in the anterior compartments. The surgeon then reexamines range of motion of the knee. If residual extension deficits persist, the surgeon proceeds with formation of the posterior portals to access the posterior structures of the knee.

The technique used by the senior author is a modification of that described by Ahn et al[13]. With the knee in 90 degrees of flexion, a standard 30-degree arthroscope is passed from the anteromedial portal through the intercondylar notch into the posterolateral compartment while staying lateral to the ACL and medial to the lateral femoral condyle. The surgeon should palpate the posterolateral knee, noting the location of the lateral femoral condyle and lateral joint line. Transillumination of the skin will show the location of superficial veins which should be avoided as often the peroneal nerve will travel close to these vessels. An 18-gauge spinal needle is used under direct arthroscopic visualization to mark the location of the posterior portal, approximately 5mm posterior to the lateral femoral condyle and 10mm above the joint line[13]. Again using direct visualization, a small longitudinal incision is made in the skin and then a hemostat is used to expand the portal. The same method is then used to make the posteromedial portal. The arthroscope is passed from the anteromedial portal through the intercondylar notch between the medial femoral condyle and PCL to reach the posteromedial compartment.

Once both posterior portals have been made, the arthroscope is placed in the posteromedial portal and a switching stick is inserted into the posterolateral portal to localize the septum. The septum is pushed medially with the switching stick. The PCL should be identified anteriorly. Next, a motorized shaver is placed into the anterolateral portal and taken through the notch to the posteromedial compartment. With the shaver blades facing anteriorly so as to protect the PCL and neurovascular structures, a small entry hole is made in the center of the posterior septum (Figure 2). Following formation of the posterior trans-septal portal, the arthroscope can then be inserted from the posterolateral portal, though the trans-septal portal, and into the posteromedial compartment. Once the posteromedial compartment is thoroughly examined and all structures released, the arthroscope should also be inserted from the posteromedial portal, through the septum, and into the posterolateral compartment to complete a thorough evaluation of the knee.

The septum is the final obstacle to full access to the posterior compartment. The posterior capsule can then be gently released off the proximal tibia using an electrothermal device. Release should continue until the capsular fiber attachment is fully released. At this point, the junction between

Figure 2. A small entry hole is made in the center of the posterior septum using a motorized shaver.

the popliteus muscle belly and tendon can be well visualized laterally. Any bleeding of the inferior geniculate transgression can be controlled with electrocautery.

In the immediate postoperative period, the patient is placed in a hinged knee brace locked in full extension. Typically, the patient is admitted to the hospital for one to two days for aggressive range of motion and CPM. Daily physical therapy should focus on range of motion and gait training. Weight bearing on the operated knee is encouraged in a "heel-to-toe" manner as tolerated. We recommend use of a CPM machine while in the unlocked brace to allow flexion. Refractory extension deficits may benefit from a period of brief extension casting, typically 2-3 days. The indwelling epidural catheter should be continued for one to two days after surgery and then removed to provide patients with optimal pain control as they begin early range of motion immediately post-op. Aggressive pain management is key to optimizing postoperative rehabilitation.

Physical therapy should be daily for the first two weeks after surgery. During this time, the brace is kept in full extension while sleeping, but may be unlocked during therapy and ambulation. In those patients requiring casting, the cast is "bivalved" and used at night as a splint[11]. Crutches are weaned as tolerated. The brace can be discontinued after about two weeks and physical therapy decreased to two to three times per week. The patient can then increase activity level gradually, but should avoid activities that may increase pain or swelling of the operative knee and thus lead to recurrent loss of motion. Anti-inflammatory medications are used liberally in the first two weeks along with omega three fatty acids to minimize inflammation.

Discussion

Previously, evaluation of posterior knee structures such as the posterior horn of the medial meniscus, have been difficult to evaluate secondary to limited access. The arthroscopic blind spot, as described by Morin and Steadman, is located in the posteromedial compartment when viewed through the traditional anterolateral and anteromedial portals[27]. They reported that this blind spot averages 21.5% of the meniscocapsular periphery when viewed with a 30 degree scope anteriorly and a 70 degrees scope posteriorly. The posterior trans-septal portal removes this blind spot and allows for complete visualization of the posterior knee compartment.

Gee et al. reported on a series of ten individuals who underwent arthroscopic posterior capsule release[11]. The average preoperative loss of extension was 25 degrees and improved to less than five degrees immediately postoperatively. No infections or neurovascular complications were observed. Eight patients reported good outcomes, while two less satisfied patients included one with a psychiatric comorbidity and another with advanced patellofemoral degenerative disease.

Mariani described a series of 18 patients who underwent arthroscopic release of both heads of the gastrocnemius using the trans-septal portal[28]. This series showed an average increase in arc of motion from 60 degrees to 90 degrees, with an average extension deficit of 34 degrees preoperatively to an average of three degrees postoperatively. The only complication in this series was development of a synovial fistula at the posteromedial portal, but no neurovascular injuries.

No complications using this portal have been reported in the literature. However, the neurovascular structures are potentially at risk due to their close proximity to the PCL. Previous authors describing this approach have recommended resecting only a small portion of the septum at a time using the tip of the shaver and also using a switching stick as a guide from the posterolateral portal to sequentially excise medial septum, intervening fatty tissue, and then lateral septum[13]. The initial opening in the septum can then be enlarged by bringing the shaver in from the posterolateral portal. Kim et al. recommend performing initial penetration from the posterolateral compartment into the posteromedial compartment to protect the popliteal artery which they found to always be located laterally to the posterior septum[14]. In addition, they noted that the safe zone is then wider in the zone of penetration in the posteromedial compartment. The shaver should be handled gently with careful use of suction to avoid injuring the PCL or the neurovascular structures.

The saphenous nerve is at risk when making the incision for the posteromedial portal. However, using a spinal needle under direct arthroscopic visualization when marking the portal site as well as transilluminating the skin with the arthroscope can help decrease the chances of saphenous nerve injury[13].

An additional complication with this procedure is that of iatrogenic injury when using the transnotch arthroscope approach to create the trans-septal portal. This is most likely to occur in patients with small knees or in those with prominent tibial spine bone spurs[13]. Boytim and al. have stated that this approach is also difficult in patients with advanced degenerative disease[29]. Additionally, Ahn et al. also recommend enlarging the intercondylar space with a round trocar prior to the insertion of the arthroscope[11].

Conclusion

Arthrofibrosis of the knee results in functional impairment secondary to pain and loss of range of motion. Physical therapy is the first line of treatment for this condition. However, recalcitrant cases may require lysis of adhesions to restore a functional range of motion. Historically, the posterior compartment of the knee has been difficult to access when using traditional portals to address extension deficits. The posterior trans-septal portal allows improved ability to treat conditions in the posterior knee. This results in improved knee extension, especially when combined with aggressive physical therapy post-operatively.

References

1. **Magit D, Wolff A, Sutton K, Medvecky MJ.** Arthrofibrosis of the knee. *J Am Acad Orthop Surg.* 2007 Nov;15(11):682-94.

2. **Skutek M, Elsner HA, Slateva K, et al.** Screening for arthrofibrosis after anterior cruciate ligament reconstruction: analysis of association with human leukocyte antigen. *Arthroscopy*. 2004:20(5):469-73.
3. **Lindenfeld TN, Wojtys EM, Husain A.** Surgical treatment of arthrofibrosis of the knee. *Instr Course Lect*. 2000;49:211-221.
4. **DeHaven KE, Cosgarea AJ, Sebastianelli WJ.** Arthrofibrosis of the knee following ligament surgery. *Inst Course Lect*. 2003;52:369-381.
5. **LaPrade RF, Pedtke AC, Roethle ST.** Arthroscopic posteromedial capsular release for knee flexion contractures. *Knee Surg Sports Traumatol Arthrosc*. 2008;16:469-475.
6. **Shelbourne KD, Urch SE, Gray T, Freeman H.** Loss of normal knee motion after anterior cruciate ligament reconstruction is associated with radiographic arthritic changes after surgery. *Am J Sports Med* 2012 Jan;40(1):108-13.
7. **Paulos LE, Wnorowski DC, Greenwald AE.** Infrapatellar contracture syndrome: Diagnosis, treatment, and long term followup. *Am J Sports Med* 1994;22:440-449.
8. **Melegati G, Tornese D, Bandi M, Volpi P, Schonhuber H, Denti M.** The role of the rehabilitation brace in restoring knee extension after anterior cruciate ligament reconstruction: a prospective controlled study. *Knee Surg Sports Traumatol Arthrosc* 2003;11:322-326.
9. **Mikkelsen C, Cerulli G, Lorenzini M, Bergstrand G, Werner S.** Can a postoperative brace in slight hyperextension prevent extension deficit after anterior cruciate ligament reconstruction? A prospective randomized study. *Knee Surg Sports Traumatol Arthrosc* 2003;11:318-321.
10. **Steadman JR, Burns TP, Peloza J.** Surgical treatment of arthrofibrosis of the knee. *J Orthop Tech* 1993;1:119-127.
11. **Gee A, Kelly JD IV.** Capsular release using the posterior trans-septal portal. *Techniques in Knee Surgery*. 2010;9:128-130.
12. **Cosgarea AJ, DeHaen KE, Lovelock JE.** The surgical treatment of arthrofibrosis of the knee. *Am J Sports Med*. 1994;22:184-191.
13. **Ahn JH, Ha CW.** Posterior trans-septal portal for arthroscopic surgery of the knee joint. *Arthroscopy*. 2000;16:774-779.
14. **Kim JS, Song HT, et al.** The safe establishment of a trans-septal portal in the posterior knee. *Knee Surg Traumatol Arthosc*. 2011;19:1320-1325.
15. **Kwon OS, Park MJ, Kelly JD IV.** Arthroscopic treatment of a PCL avulsion fracture in a skeletally immature patient. *Orthopedics*. 2011; 34(2):137.
16. **Tsai TY, Yang YS, et al.** Arthroscopic excision of ganglion cysts of the posterior crucitate ligaments using posterior trans-septal portal. *Arthroscopy*. 2012;28(1):95-99.
17. **Kyung BS, Lee SH, et al.** Arthroscopic treatment of synovial chondromatosis at the knee posterior septum using a trans-septal approach: report of two cases. *Knee*. 2011;doi:10.1016/j.knee.2011.10.003.
18. **Ahn JH, Wang JH, et al.** A pull out suture for transection of the posterior horn of the medial meniscus: using a posterior trans-septal portal. *Knee Surg Sports Traumatol Arthrosc*. 2007;15:1510-1513.
19. **Kim JH, Shin DE, Dan JM, et al.** Arthroscopic suture anchor repair of posterior root attachment injury in medial meniscus: technical note. *Arch Orthop Trauma Surg*. 2009;129:1085-1088.
20. **Ahn JH, Yoo JC, Lee SH.** Arthroscopic loose-body removal in posterior compartment of the knee joint: a technical note. *Knee Surg Sports Traumatol Arthrosc*. 2007;15:100-106.
21. **Ahn JH, Chung YS, Oh I.** Arthroscopic posterior cruciate ligament reconstruction using the posterior trans-septal portal. *Arthroscopy*. 2003;19:101-107.
22. **Ahn JH, Wang JH, Lim HC, et al.** Double transosseous pull out suture technique for transection of posterior horn of medial meniscus. *Arch Orhop Trauma Surg*. 2009;129:387-392.
23. **Ahn JH, Wang JH, Lee SH, et al.** Increasing the distance between the posterior cruciate ligament and the popliteal neurovascular bundle by a limited posterior capsular release during arthroscopic transtibial posterior cruciate ligament reconstruction: a cadaveric angiographic study. *Am J Sports Med*. 2007;35(5):787-92.
24. **Cosgarea AJ, Kramer DE, et al.** Proximity of the popliteal artery to the PCL during simulated knee arthroscopy. *Journal of Knee Surgery*. 2006;19(3):181-5.
25. **Pace JL, Wahl CJ.** Arthroscopy of the posterior knee compartments: neurovascular relationships during arthroscopic transverse capsulotomy. *Arthroscopy*. 2010;26:637-642.
26. **Matava MJ, Sethi NS, Totty WG.** Proximity of the posterior cruciate ligament insertion to the popliteal artery as a function of the knee flexion angle: implications for PCL reconstruction. *Arthroscopy*. 2000;16:796-804.
27. **Morin WD, Steadman JR.** Arthroscopic assessment of the posterior compartments of the knee via the intercondylar notch: the arthroscopist's field of view. *Arthroscopy*. 1993;9(3):284-90.
28. **Mariani PP.** Arthroscopic release of the posterior compartments in the treatment of extension deficit of knee. *Knee Surg Sports Traumatol Athrosc*. 2011;18:736-741.
29. **Boytim MJ, Smith JP, Fischer DA, Quick DC.** Arthroscopic posteromedial visualization of the knee. *Clin Orthop*. 1995;310:82-86.