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Complications of Anterior Cruciate Ligament Reconstruction

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Abstract

Injury to the anterior cruciate ligament (ACL) can result in recurrent instability, impairment, and progressive joint damage in athletes who return to high-risk sports activities. ACL reconstruction often is indicated. With refinement of surgical techniques and accelerated rehabilitation, the number of complications following ACL reconstruction has greatly decreased since the 1980s. Nevertheless, ACL reconstruction remains a complex procedure with multiple steps and many possible complications. Understanding the incidence and etiology of the more common complications associated with ACL reconstruction during the preoperative and postoperative periods is important to manage (if not avoid) the risk of these complications.

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If injury to the anterior cruciate ligament (ACL) is not reconstructed, recurrent instability, impairment, and progressive joint damage can occur in athletes who return to high-risk sports activities.[1] ACL reconstruction is often indicated for these patients. Current techniques for ACL reconstruction involve multiple steps, each of which can be made more demanding if the prior steps are done suboptimally. Nevertheless, with the refinement of surgical and modern rehabilitation techniques, the number of complications following ACL reconstruction has greatly decreased since the 1980s. This chapter reviews the incidence and etiology of some of the common complications that occur in the preoperative, perioperative, and postoperative periods. Methods to evaluate and manage (if not avoid) the risk of these complications are presented.

Timing of Surgery

Many authors have reported an increased rate of stiffness in the knees of patients who undergo ACL reconstruction in the first few weeks after injury.[2-7] Mohtadi and associates[2] reported a 7% incidence of stiffness requiring manipulation following ACL reconstruction in a study of 537 patients. Indications for manipulation included a 10° loss of full extension, or flexion less than 120°. An increased rate of stiffness occurred in patients treated with ACL reconstruction in the first 2 weeks after injury. There was no correlation between stiffness and the type of graft used (patellar tendon versus hamstring).

Shelbourne and associates[3] reported on a study of 169 patients undergoing ACL reconstruction with patellar tendon grafts. In the 33 patients who were treated with reconstructive surgery in 0 to 7 days following injury, there was a 17% incidence of stiffness. In the patients who had reconstructive surgery 7 to 21 days after injury, stiffness occurred in 11%. In patients treated with ACL reconstruction more than 3 weeks following injury, there was no stiffness. The authors also examined the effect of an accelerated rehabilitation program and found that, across all groups, accelerated rehabilitation decreased the incidence of stiffness.

Others studies have not found an association between early surgery and stiffness.[8-10] In a prospective study of 185 patients with ACL injuries, Hunter and associates[9] reported no difference in flexion or

extension in patients who underwent early versus delayed surgical reconstruction.

The etiology of stiffness following ACL reconstruction is multifactorial and includes both technical surgical factors and the timing and quality of postoperative rehabilitation. It is not simply the amount of time after injury that influences the quality of postoperative motion. A normal inflammatory healing response occurs following knee injury. Patients who undergo ACL reconstruction of an acutely inflamed knee have an increased risk of postoperative stiffness. Delaying reconstruction until swelling has resolved, full motion is achieved, and quadriceps control is restored will decrease the risk of arthrofibrosis.

There are two scenarios in which ACL reconstruction has been advocated soon after injury. In knees with an ACL tear and a concomitant locked bucket-handle meniscal tear, some authors have advocated early surgery to repair the meniscal tear with simultaneous ACL reconstruction.[11] Early surgery allows restoration of full extension, which would not be possible with a locked bucket-handle tear. In addition, meniscal tear repairs with concomitant ACL reconstruction have a higher healing rate than those done in ACL-stable knees.[12] Other authors have suggested that it is advantageous to repair or resect the meniscus immediately and reconstruct the ACL on a delayed basis after knee motion has been restored.[13,14] Shelbourne and Johnson[13] reported a decreased rate of stiffness using this two-stage approach. O'Shea and Shelbourne[14] reported on 59 patients treated with staged reconstruction with early meniscal repair. ACL reconstruction was done at an average of 77 days after meniscal repair. At the time of ACL reconstruction, 89% of the meniscal repairs were fully or partially healed. The authors reported several benefits to this approach, including a decreased risk of postoperative stiffness and the ability to pursue more aggressive attempts at meniscal preservation because meniscal tears that had not healed could be treated with trephination or resection at the time of ACL reconstruction. Delaying ACL surgery also allows the patient time to mentally and physically prepare for the surgery.

The timing of ACL reconstruction in patients who present with locked knees remains controversial, with studies in the literature supporting both immediate and staged reconstructions. In practice, the surgeon must make a recommendation based on the condition of the knee and the needs and interests of the patient. If the patient is willing to accept a small increased risk for range-of-motion complications, the authors perform the surgery as soon as possible and treat the displaced meniscus. If the patient is unwilling to accept the increased risk for range-of-motion complications, or if the knee has been locked for a considerable time before surgery, a staged procedure is recommended.

Early ACL reconstruction also is recommended when the ACL tear occurs in combination with a grade 3 medial collateral ligament (MCL) tear. In a canine study, Woo and associates[15] found that when the ACL and MCL were completely transected, a threefold increase in valgus and rotational laxity was present at 12-week follow-up compared with patients in whom the ACL was only partially transected or was left intact. At 12-week follow-up, the ultimate strength of the MCL in knees with a complete ACL tear was only 80% of the strength found in the control knees. The authors concluded that MCL healing is adversely affected by continued ACL instability. Other authors have found that acute ACL reconstruction performed in patients with combined ACL and MCL injuries is associated with a higher rate of postoperative stiffness.[4,16,17] Petersen and Laprell[17] compared 27 patients who underwent early (within 3 weeks) ACL reconstruction for combined ACL and MCL injuries with 37 patients who had ACL reconstruction after 6 weeks of nonsurgical treatment of the MCL injury. They found that patients who had delayed ACL surgery had lower rates of stiffness and higher Lysholm scores. Other authors have found that grades 1 and 2 MCL tears can be treated nonsurgically before ACL reconstruction.[18-20] Combined ACL and MCL injuries that open to valgus stress when in full extension imply injury to the posterior oblique ligament and may not respond to nonsurgical treatment.[21] Although femoral-sided MCL tears can heal with stiffness, tibial-sided lesions have an increased risk of failure to heal, which may result from interposition of the pes anserine tendons. Most grade 1 and 2 MCL tears will heal nonsurgically and should be treated with bracing and therapy to regain full range of motion. After the stiffness and inflammation of the acute injury resolve, ACL reconstruction can be performed. For grade 3 MCL tears, an initial trial of bracing is indicated to allow resolution of the acute knee injury. In tears that involve the deep MCL and posterior oblique ligament (as evidenced by a grade 3 opening both at 30° and full knee extension), nonsurgical treatment may be unsuccessful and

MCL repair or advancement with repair of the posterior oblique ligament can be performed at the time of ACL reconstruction.

Fluid Extravasation and Compartment Syndrome

Compartment syndrome is a rare complication of knee arthroscopy; however, fluid extravasation can complicate any arthroscopic procedure.[22-26] Compartment syndrome is associated with tourniquet use; however, compartment pressures usually decrease rapidly with tourniquet release.[27] Compartment syndrome also is associated with violation of the posterior capsule.[27,28] Delaying surgery for 1 to 2 weeks if a capsular injury is seen on MRI scans can minimize fluid extravasation. Tourniquet use also can be avoided by the use of hypotensive anesthesia.[29] If a tourniquet is used, risk can be minimized by limiting tourniquet pressure and inflation time. If signs of compartment tightness develop, the tourniquet should be released. If fluid extravasation does not resolve rapidly, the procedure should be aborted. More information on compartment syndrome is available in chapter 49.

Nerve Injury

Nerve injury in ACL reconstruction can occur as a result of surgical technique or positioning. The anatomy of the saphenous nerve has been well described. The nerve descends in Hunter's canal along the medial thigh and becomes superficial 10 cm proximal to the knee. It branches off to the infrapatellar branch distal to the adductor hiatus and lies posterior to the sartorius muscle. Saphenous nerve injury has been reported during the harvest of the patellar tendon graft and during medial meniscal repair.[30-32] More information on saphenous nerve injury is available in chapter 50.

Figure 1 Patient positioning for a left ACL reconstruction. The right leg is positioned in a well leg holder for protection from pressure injury to nerves and to avoid hip hyperextension.

The peroneal nerve descends in the posterior thigh and lies distally along the medial head of the biceps, lateral to the lateral head of the gastrocnemius. The common peroneal nerve then passes posterior to the head of the fibula and courses laterally and anteriorly around the fibular neck to penetrate the peroneus longus muscle. Injury to the peroneal nerve has been associated with lateral meniscal repair.[32-34] The nerve can be stretched by retractors placed anterior to the gastrocnemius and may be more susceptible to neurapraxia if a tourniquet has been used for a prolonged period, creating a double-crush injury. In addition, nerve entrapment in the repair by sutures tied around the nerve has been reported.[32]

Nerve injury can result from patient positioning. The patient's position should allow gentle, comfortable positioning of both limbs with padding over bony prominences (Figure 1). Hyperextension of the hip can cause tension on the femoral nerve. The peroneal nerve of the nonsurgical leg should be protected.

Treatment of nerve injury resulting from arthroscopy has been reported by Kim and associates.[35] In general, isolated sensory deficits have a better prognosis and are managed by frequent reevaluation and avoiding reinjury or nerve irritation. Nerve injuries resulting from tourniquet use usually resolve over a period of weeks to months and motor block is rare. If a motor deficit is encountered, especially in patients who have had ACL reconstruction with a concomitant lateral meniscal repair, early electrodiagnostic studies should be done. However, electrodiagnostic studies often are not helpful during the 3-week period after injury. Therefore, in the setting of motor block associated with a lateral meniscal repair, early surgical exploration may be warranted with release of any sutures or devices that are potentially entrapping the nerve.

Postoperative Complications

Infection

Infection after ACL reconstruction is a rare but potentially devastating complication. Fewer than 1% or approximately 1 per 500 reconstructions are complicated by a deep joint space infection.[22,36-41] In a study of 1,356 patients, 1 patient with culture-positive joint space infection was reported.[22] Indelli and associates[37] reviewed 3,500 consecutive ACL reconstructions and found an infection rate of 0.14%. Prior surgery and a concomitant open procedure have been implicated as potential risk factors. In a study of 831 consecutive patients, McAllister and associates[39] reported 4 patients (0.48%) with septic arthritis following ACL reconstruction. Three of those four patients had a previous surgical procedure. Williams and associates[36] retrospectively reviewed 2,500 reconstructions and reported 7 patients (0.3%) with deep knee infections. Six of these patients had an associated open procedure (such as meniscal repair, posterolateral corner reconstruction, or MCL repair). Longer surgical time and larger incisions may be a contributing factor in these infections. Instrument contamination also is a known cause of infection after ACL reconstruction. When infection rates increase, a search for a possible source of contamination (such as graft boards) should be undertaken.[40,41]

The diagnosis of a deep knee infection following ACL reconstruction is not always straightforward. Patients frequently present with infection in the first 2 weeks after surgery, although the literature has recorded infections that occur up to 4 weeks postoperatively. A high level of suspicion is required to make the diagnosis. Progressive pain is the key symptom leading to a correct diagnosis. Patients may have fever, increased erythema, or incisional drainage. The physical examination is not always helpful in making the diagnosis. A joint aspirate should be evaluated for cell count and differential, a Gram stain should be done, and aerobic and anaerobic cultures should be evaluated with a sensitivity panel. Laboratory studies should include a serum white blood cell count with differential, erythrocyte sedimentation rate, C-reactive protein, and blood cultures. Organisms frequently cultured include *Staphylococcus aureus, Staphylococcus epidermidis*, and streptococcal species.[37-40,42] Although no study has shown an increased risk of infection with allograft implantation, several instances of infection with *Clostridium* that were responsible for several deaths have been reported. These cases have been linked to tissue bank processing. An infection occurring with allograft transplantation may require special attention to identify rare species, including spore-forming organisms.[43]

The goals of treatment are to eradicate the infection, prevent and or limit damage to the articular cartilage, restore range of motion, and minimize functional disability. Patients should be started on intravenous antibiotics after aspiration of the joint fluid and before identification of the organism. Prompt arthroscopic lavage and débridement of necrotic and infected tissue is imperative and repeated débridements are often necessary. Open débridement of all incisions should be considered if there is a concern about wound infection. Consultation with an infectious disease specialist also is warranted to help in guiding treatment. Typically, a 6-week course of culture-specific antibiotics followed by a 3- to 4-week course of oral antibiotics is recommended. Duration of the therapy should be based on clinical response. Because animal studies have shown that the administration of nonsteroidal anti-inflammatory drugs along with antibiotics can reduce the damage to articular cartilage, some investigators recommend their routine use.[37,44]

The decision to retain or sacrifice the graft is based on careful consideration of several factors, including time to detection and intervention, the type and virulence of the infecting organism, the appearance and competence of the graft, and the patient's response to treatment. The consensus opinion of physicians supports retention of the graft whenever possible.[36,39,45] Removal of the graft and later implantation is a reasonable alternative that is often necessary.[38,45] Burks and associates[38] described four patients who had early graft removal and early revision reconstruction (within 6 weeks) after completion of a course of antibiotics. The outcomes in this small study were excellent. Most authors recommend waiting at least 6 to 9 months before reimplantation.[45] Despite the option chosen, it is important to counsel the patient about the possible need for future surgeries, including repeated débridements, graft removal, manipulation, lysis of adhesions, hardware removal, and possible revision of the ACL reconstruction.

The results of ACL reconstructions complicated by infection are inferior to uncomplicated ACL surgery. However, prompt treatment can lead to acceptable outcomes.[39,40] Functional disability after infection is rarely caused by graft failure. Even in the presence of an intact graft and stable knee, poor outcomes can result from persistent pain that may be

caused by cartilage damage. Other poor outcomes reported in the literature have resulted from postoperative infectious arthrosis, arthrofibrosis, osteomyelitis, sepsis, and conversion to total knee arthroplasty.[37,39,40] Although rare, ACL reconstructions complicated by infection can lead to significant disability. Diagnosis requires a high index of suspicion. Early recognition and prompt treatment can lead to acceptable outcomes.

Thromboembolic Disease

Although deep venous thrombosis (DVT) or pulmonary embolism is rare, it is the most life-threatening complication following knee arthroscopy or ACL reconstruction.[46,47] Navarro-Sanz and Fernandez-Ortega[47] recently reported on a 46-year-old man who had a fatal pulmonary embolus 1 week after undergoing an uncomplicated partial medial meniscectomy. The authors thoughtfully expressed concern about the lack of guidelines and recommendations to prevent this fatal complication.

In a review of 1,354 ACL reconstructions, 2 clinically apparent DVTs and 1 nonfatal pulmonary embolism were identified.[22] Jaureguito and associates[48] retrospectively reviewed 2,050 patients who underwent arthroscopic knee surgery and found a 0.24% incidence of symptomatic DVT. In the same study, the authors prospectively studied 239 patients using preoperative and postoperative duplex ultrasound and found 7 patients with DVT for an overall incidence of 2.9%. Five of the seven patients were asymptomatic. In a prospective study of 67 male patients between the ages of 19 and 39 years, Cullison and associates[49] found 1 patient with asymptomatic DVT using compression ultrasonography. Based on these findings, Cullison and associates did not recommend routine prophylaxis or routine screening for DVT. A controlled randomized trial by Wirth and associates[50] found that administration of low-molecular weight heparin (LMWH) for 7 to 10 days postoperatively reduced the incidence of DVT, which was detected by compression sonography. Of 117 patients who received the anticoagulant, there were no episodes of major bleeding and four episodes of minor bleeding, which included slight gastrointestinal bleeding. One patient had a drop in platelet levels. The authors recommended the routine use of LMWH for 7 to 10 days after arthroscopic surgery. However, it appears that the therapeutic benefit of LMWH is offset by the risk of complication. Independent analysis of the data presented in the study showed that a significant number of patients will need to be treated to prevent just one case of DVT. Doing a "number needed to treat analysis" of the data revealed that 30.79 patients will need to be treated with LMWH to prevent 1 case of DVT. Because 1 bleeding complication resulted after treatment of 38.46 patients, the complication risks offset the benefits of treatment of symptomatic DVT. However, the use of prophylaxis and close follow-up for the patient with an increased risk for DVT is recommended by the authors of this chapter.

Overall, the incidence of occult DVT after arthroscopic knee surgery is approximately 3%, with a much lower rate of symptomatic thromboembolic disease. Currently, there is no consensus regarding the use of prophylaxis or routine screening. Pending the results of more and larger randomized trials, it would be prudent to educate the patient on measures to reduce the risk for DVT and for physicians to diagnose and treat DVT aggressively when it is suspected. In patients with a history of hypercoagulability or thromboembolic disease, the use of prophylaxis is recommended.

Tunnel Enlargement

Tunnel enlargement following ACL reconstruction has been well described. Although tunnel expansion does not appear to adversely affect function following primary reconstruction, it may significantly complicate revision ACL surgery.

The etiology of tunnel enlargement following ACL reconstruction is multifactorial.[51,52] It is reportedly more common after hamstring reconstruction than after reconstruction with bone-tendon-bone autograft.[53-55] Hoher and associates[52] classified the etiology into mechanical factors (such as the type of graft fixation used and motion of the graft within the tunnel) and biologic factors (such as the increased levels of cytokines within the synovial fluid after injury).

Many different methods have been used to secure an ACL graft to both the tibial and femoral tunnels. The goal is to provide fixation that is stable enough to allow for early rehabilitation until biologic incorporation of the graft, which usually occurs by 12 weeks after surgery.[56,57] Fixation of the graft at the level of the joint, or aperture fixation, is primarily accomplished with the use of interference screws that restrict motion of the graft within the tunnel. Fixation distal to the joint line, as seen with extracortical fixation, will allow increased longitudinal and horizontal motion, often termed the bungee effect and windshield wiper effect, respectively.

In a prospective study, Buelow and associates[58] showed that at the time of interference screw implantation (time zero), there was an increase in area of both the femoral and tibial tunnels of approximately 75%. Although interference screws provide aperture fixation, the authors showed that the compressive stiffness of the screw is frequently greater than the surrounding cancellous bone. This situation leads to an immediate enlargement of the tunnels.

In the same study, Buelow and associates[58] also showed that with a fixation construct at a point distal to the joint line there was a 65% increase in the tunnel area after 6 months. This finding also has been documented in other studies using nonaperture fixation.[53,54,59] Any factor that leads to increased graft motion before incorporation may play a role in the tunnel enlargement process. For example, a graft placed in a nonisometric position will lead to increased graft motion. Zijl and associates[60] showed that tibial tunnel enlargement occurred more commonly with anteriorly placed tunnels.

Despite the clear benefits of accelerated rehabilitation,[61] increased knee motion and aggressive return to activities in the early postoperative period may contribute to tunnel expansion.[51,55,62,63] The process of tunnel expansion appears to be self-limited, stabilizing by 3 months after surgery.[62,64,65] This finding is consistent with the studies by Rodeo and associates[66] and Liu and associates[67] that have shown that incorporation of soft-tissue grafts into bone tunnels takes approximately 12 weeks. Aggressive rehabilitation during this period may be more problematic for patients with hamstring grafts than bone-tendon-bone grafts because healing to the tunnel wall is slower for tendon grafts than for bone grafts.

The biologic theory to tunnel widening notes that inflammatory cytokines (such as interleukins and tumor necrosis factor) are present in elevated concentrations within the synovial fluid after ACL rupture.[68] Clatworthy and associates[54] and Fink and Associates[65] have shown the presence of synovial fluid within the tunnels following ACL reconstruction. As the synovial fluid gains access to the graft-tunnel interface, cytokines contained within the fluid may stimulate osteoclastic activity leading to tunnel enlargement.

The use of allograft tissue for ACL reconstruction also has led to tunnel enlargement. Jackson and associates[69] showed that allografts processed with ethylene oxide often led to an increased cellular response and ultimate graft failure. Although ethylene oxide is no longer used in the sterilization process, there is still concern that a subclinical immune response may lead to a hostile local environment.

During the patient's preoperative evaluation for revision reconstruction, a detailed history and physical examination should be performed and records from the previous surgery should be obtained, if possible. Radiographic evaluation should include AP and lateral radiographic views to detect tunnel widening. CT or MRI also may be useful to better quantify tunnel enlargement and osteolysis. With large tunnels (> 1.5 cm), hardware removal and bone grafting of the defect may be required as part of a staged procedure. It is often possible for a patient to return for a revision ACL reconstruction in 6 to 12 weeks after bone graft incorporation. In surgery involving difficult hardware removal, the graft may be positioned in the over-the-top position, a nonanatomic location. Other options to address large tunnels include using larger bone blocks, placement of stacked interference screws, or conversion to a two-incision technique to create divergent tunnels.

Loss of Motion

Loss of motion after ACL reconstruction can be the result of a multitude of factors, many of which can be avoided by diligent attention to detail and by prompt and aggressive treatment when indicated. The effect of timing of the surgery on postoperative loss of motion has been described earlier. Other causes of reduced motion include improper graft placement, inadequate rehabilitation, formation of a fibrous nodule, and arthrofibrosis. The patient who has difficulty regaining motion early in the rehabilitation process requires special attention to avoid long-term disability.

Improper Graft Placement A graft that is malpositioned in a nonisometric position during ACL reconstruction is a common factor contributing to loss of postoperative motion. Normal knee kinematics require that the graft be positioned accurately in both the tibial and femoral tunnels. The tibial tunnel should be centered approximately 7 mm anterior to the anterior edge of the posterior cruciate ligament in the posterior portion of the ACL footprint.[70,71] Other landmarks include the anterior horn of the lateral meniscus and the anterolateral spine of the medial tibial eminence.[72] If placed too anteriorly on the tibia, the graft will impinge in the intercondylar notch as the knee is fully extended. This placement will result in a loss of full extension, which is not well tolerated by the patient and

frequently is more disabling than the preoperative instability.[73] When placed too posteriorly on the tibia, the graft will be in an unfavorable vertical position that will limit its ability to restrict anterior tibial translation.

The femoral tunnel should be positioned at the location of the ACL stump in the far posterior wall of the femoral notch, leaving 1 to 2 mm of bone posteriorly at the 11 o'clock or 1 o'clock position. A femoral tunnel positioned too anteriorly will tighten excessively in flexion and either limit flexion or result in significant graft stretching. Positioning the graft too posteriorly (in the over-the-top position) may lead to increased graft tension during knee extension and can limit full motion if more than 3 mm of graft lengthening occurs between the angle at which the graft was fixed and full knee extension. More information on tunnel positioning and graft placement is available in chapter 49.

The best treatment for graft impingement is prevention. However, when graft placement is determined to be the cause of a stiff knee, the surgeon must decide whether to attempt to salvage the graft by enlarging the tunnel (notchplasty) or to remove the graft and revise the reconstruction.

Inadequate Rehabilitation Lack of motivation by the patient, lengthy immobilization, or inadequate postoperative rehabilitation can lead to significant loss of motion after ACL reconstruction. Improved outcomes have been achieved with accelerated rehabilitation protocols that allow immediate motion and weight bearing.[61] It is important to stress to the patient both preoperatively and postoperatively the importance of gaining full terminal extension and at least 90° of flexion at 4 weeks postoperatively.[74] Loss of flexion is better tolerated and easier to treat than loss of extension.[73] Inability to gain acceptable motion requires manipulation under anesthesia within 3 months from the time of surgery. Loss of extension frequently requires surgical treatment.

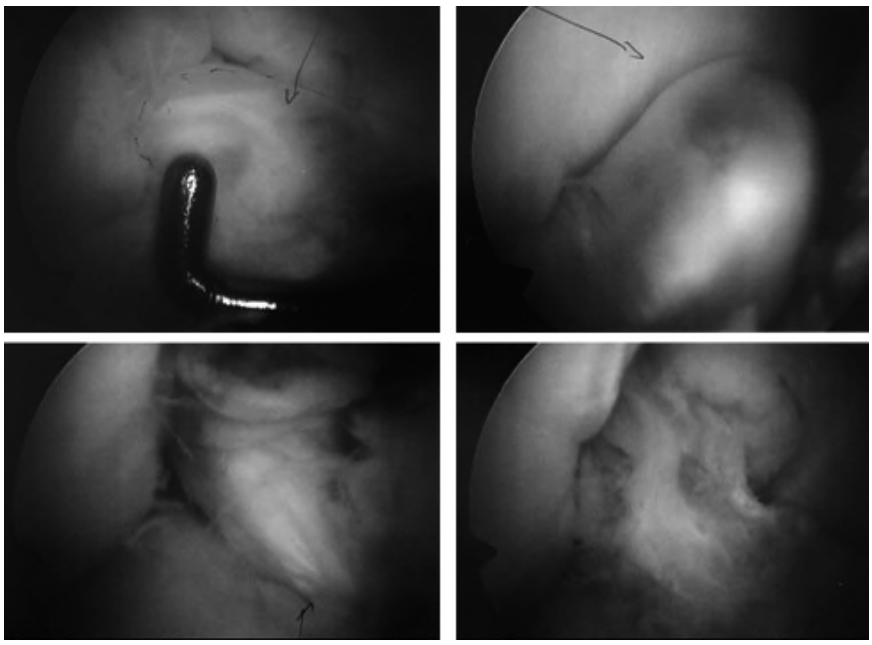

Figure 2 Arthroscopic views of a cyclops lesion following an ACL reconstruction that was treated with débridement.

Cyclops Lesion A cyclops lesion is a fibroproliferative scar that may be found in the anterior aspect of the intercondylar notch after ACL reconstruction or ACL injury[75,76] (Figure 2). Jackson and Schaefer[75] first described this phenomenon consisting of a dense fibrous nodule with a central area of granulation tissue, which can lead to a loss of full extension. The lesion may be caused by a graft placed too anteriorly within the notch, graft hypertrophy, or failure to débride the native ACL stump during reconstruction. This condition is treated with arthroscopic débridement of the nodule, which can lead to excellent results.[22,75,77]

Arthrofibrosis Arthrofibrosis is an uncommon, poorly understood complication following knee surgery. Its etiology appears to be related to an overactive cellular response stimulated by cytokines. Dense scar tissue and adhesions form within the suprapatellar pouch, medial gutter, and lateral gutters, limiting both flexion and extension.[78] Patellofemoral kinematics also are affected, with the patella being drawn distally, posteriorly, and into flexion by the contracting infrapatellar and peripatellar scar tissue. In the most severe forms of arthrofibrosis, arthroscopic débridement is unlikely to resolve the motion loss, and open débridement and scar excision should be considered.[79] Regaining full range of motion after the development of arthrofibrosis, regardless of the treatment, is difficult.

Summary

ACL reconstruction remains a complex surgery with multiple steps,

each of which has potential pitfalls. However, with the appropriate selection of patients, optimal surgical timing, attention to surgical detail, and accelerated postoperative rehabilitation, an excellent result can be achieved.

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