

EVIDENCE SUMMARY

ACL reconstruction

Anatomy & Pathophysiology

EPIDEMIOLOGY & RISK FACTORS

- ACL injury accounts for between 40% and 50% of all knee ligament injuries [6, 7].
- Female athletes have a two to eight times higher risk of ACL tear than male athletes [6, 7].
- The increased risk in female athletes is thought to occur because women have different landing biomechanics, specifically greater total valgus knee loading in landing and landing more erectly [6, 7].
- Female athletes have increased quadriceps-to-hamstring strength, which causes greater anterior shear [6, 7].
- Proposed additional risk factors for ACL injury include smaller notches, smaller ligaments (reduced area in cross section), greater generalized ligament laxity, increased knee laxity, and absence of the COL5A1 gene [6, 7].
- Skiing, soccer, basketball, and football are the highest-risk sports for ACL injury [6, 7].

MECHANISM & BIOMECHANICS

- The mechanism of ACL injury is typically a valgus load with internal tibial rotation and anterior tibial translation while the knee is in almost full extension [6, 7].
- The in situ force of the ACL is highest at 30 degrees of flexion in response to anterior tibial load [6, 7].
- The anteromedial bundle of the ACL provides anterior restraint and is evaluated by Lachman and anterior drawer tests [6, 7].
- The posterolateral bundle of the ACL provides rotatory restraint and is evaluated by the pivot shift test [6, 7].

ASSOCIATED INJURIES

- Associated injuries are common with ACL tears [6, 7].
- Acute lateral meniscal tears are more common than acute medial tears, whereas medial tears occur more often with chronic ACL deficiency [6, 7].
- MCL injuries occur in approximately 25% of cases and are typically treated nonoperatively [6, 7].

- PLC injuries occur in approximately 10% of cases [6, 7].
- Lack of recognition of a PLC injury has been cited as a common cause of ACL reconstruction failure [6, 7].
- Chronic ACL deficiency is associated with higher incidences of both complex meniscal tears not amenable to repair and chondral injury [6, 7].

PATHOPHYSIOLOGY & LONG-TERM OUTCOMES

- Currently there is no high-level evidence to suggest that ACL reconstruction reduces the risk of development of arthritis [6, 7].
- Chondral and meniscal injuries that occur at the time of initial ACL rupture have been demonstrated to be the main predictors of arthritic change [6, 7].
- The most common reasons for failure to return to play or sport after ACL reconstruction are pain and fear of reinjury [6, 7].
- Primary repair of ACL tears is not currently recommended because myofibroblasts “coat” the ends of the ACL stumps, making primary healing unlikely [1, 2].
- Arthrofibrosis is the most common complication following ACL reconstruction and often occurs with reconstruction for acute ACL tears [1, 2].
- The risk of arthrofibrosis is minimized by the achievement of full range of motion prior to surgery [1, 2].
- In skeletally immature patients, the most common complications after ACL reconstruction include arthrofibrosis, growth disturbance, and secondary injury of the same or the contralateral ACL [3].
- An overall incidence of arthrofibrosis of 8.3% was reported in a cohort of 902 young patients (average age = 15 years) treated with ACL reconstruction [3].
- Risk factors for arthrofibrosis in young patients include female sex, older age, the use of bone–patellar tendon–bone autograft, and concomitant meniscal repair [3].
- Growth arrest can occur after ACL reconstruction in skeletally immature patients despite efforts to avoid this complication [3].
- Clinically important growth disturbances, including tibial recurvatum and genu valgum, have been reported after transphyseal ACL reconstruction using physeal-respecting techniques [3].
- Focal physeal bone bridges were noted in five knees in a review of 43 patients who underwent transphyseal ACL reconstruction using soft-tissue graft, although no patient had resultant limb deformity [3].
- Growth disturbance has been reported with physeal-sparing techniques, with one patient in a series of all-epiphyseal ACL reconstructions developing clinically significant growth arrest [3].
- The incidence of second ACL injury in young athletes (average age = 17 years) within 2 years of the index surgery is more than five times greater than that of healthy control athletes [3].
- Nearly 30% of young athletes sustained a second ACL injury within 24 months of return to sports, with approximately one-third of the injuries occurring in the ipsilateral knee and two-thirds in the contralateral knee [3].
- Patients younger than 20 years at the time of ACL reconstruction had a 29% chance of sustaining a second ACL injury (either knee) within 5 years of the index surgery [3].

- In a cohort of 85 patients younger than 18 years, 32% sustained a second ACL injury, with later return to sport being protective against new ACL injury [3].
- Athletes younger than 25 years who return to sports had a secondary rate of ACL injury (ipsilateral or contralateral knee) of 23% [3].

CLINICAL EVALUATION

- Young athletes with ACL tears frequently report the sudden onset of knee pain that may be accompanied by a popping sensation after a noncontact, twisting-type injury [4].
- Difficulty bearing weight and hemarthrosis are commonly present in acute ACL tears [4].
- Clinical tests for ACL deficiency include the Lachman, anterior drawer, and pivot shift tests [4].
- Results of clinical tests for ACL deficiency should be compared with similar tests performed on the contralateral, unaffected knee, particularly in young, anxious patients [4].
- The presence of associated meniscal injuries may be established by evaluating for tenderness of the joint line and decreased passive knee motion [4].
- Injuries of the collateral ligaments may be evaluated by varus and valgus stress testing of the knee performed at 0° and 30° of flexion [4].
- MRI of the knee has a sensitivity of 95% and specificity of 88% for confirming an ACL tear [4].
- MRI is helpful for elucidating additional injuries and assessing physeal patency in skeletally immature patients [4].
- A bone age study is generally performed for skeletally immature patients to estimate the amount of remaining skeletal growth before surgical treatment [4].
- Standing hip-to-ankle alignment radiographs may be obtained to evaluate for preexisting angular deformity or limb-length discrepancy before surgical intervention [4].

Clinical Presentation

HISTORY AND SYMPTOMS

- Young athletes with ACL tears frequently report the sudden onset of knee pain after a noncontact, twisting-type injury [4].
- The onset of knee pain in young athletes with ACL tears may be accompanied by a popping sensation [4].
- Difficulty bearing weight is commonly present in young athletes with ACL tears [4].
- Hemarthrosis is commonly present in young athletes with ACL tears [4].

PHYSICAL EXAMINATION

- Initial evaluation includes inspecting the soft tissues of the affected limb [4].
- Initial evaluation includes performing passive motion of the ipsilateral hip, knee, and ankle [4].

CQ HAND + UPPER LIMB

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- Initial evaluation includes carefully palpating the entire affected limb [4].
- Initial evaluation includes assessing neurovascular status [4].
- Clinical tests for ACL deficiency include the Lachman test [4].
- Clinical tests for ACL deficiency include the anterior drawer test [4].
- Clinical tests for ACL deficiency include the pivot shift test [4].
- Clinical tests for ACL deficiency may be difficult to perform and/or interpret in a young, anxious patient [4].
- Results of clinical tests for ACL deficiency should be compared with similar tests performed on the contralateral, unaffected knee [4].
- Clinical tests for ACL deficiency may need to be repeated in a young, anxious patient [4].
- The presence of associated meniscal injuries may be established by evaluating for tenderness of the joint line [4].
- Decreased passive knee motion may indicate a meniscal injury with displacement [4].
- The dial test can be performed to evaluate the posterolateral corner of the knee [4].
- The posterior drawer test can be performed to evaluate the posterior cruciate ligament [4].
- Limb alignment and lengths are assessed clinically if ACL injury is suspected in a skeletally immature patient [4].
- The patient's degree of physiologic maturity may be gauged by use of Tanner staging of sexual maturation in skeletally immature patients [4].

IMAGING

- Orthogonal radiographs of the affected knee should be obtained [4].
- Additional radiographs should be obtained as suggested by the physical examination findings [4].
- MRI of the knee has a 95% sensitivity for confirming an ACL tear [4].
- MRI of the knee has an 88% specificity for confirming an ACL tear [4].
- MRI of the knee is helpful for elucidating additional injuries [4].
- MRI of the knee is helpful for assessing physeal patency [4].
- A bone age study is generally performed for skeletally immature patients before surgical treatment to estimate the amount of remaining skeletal growth [4].
- A bone age study consists of a PA radiograph of the left hand compared with the Greulich and Pyle atlas of normal standards [4].
- Standing hip-to-ankle alignment radiographs may be obtained to evaluate for preexisting angular deformity before surgical intervention [4].
- Standing hip-to-ankle alignment radiographs may be obtained to evaluate for limb-length discrepancy of the lower limbs before surgical intervention [4].

Investigations

- In young, anxious patients, results of clinical tests for ACL deficiency should be compared with similar tests performed on the contralateral, unaffected knee and may need to be repeated [4].
- If ACL injury in a skeletally immature patient is suspected, limb alignment and lengths are assessed clinically [4].
- The patient's degree of physiologic maturity may be gauged by use of Tanner staging of sexual maturation [4].
- Orthogonal radiographs of the affected knee should be obtained, with additional radiographs obtained as suggested by the physical examination findings [4].
- MRI of the knee is helpful for elucidating additional injuries and assessing physeal patency [4].
- Before surgical treatment, a bone age study (a PA radiograph of the left hand compared with the Greulich and Pyle atlas) is generally performed for skeletally immature patients to estimate the amount of remaining skeletal growth [4].
- Standing hip-to-ankle alignment radiographs may be obtained to evaluate for preexisting angular deformity or limb-length discrepancy of the lower limbs before surgical intervention [4].
- A thorough workup of failed ACL reconstruction should include acquiring prior imaging and considering all causes of graft failure, including technical issues, unrecognized concomitant ligament injuries, coronal or sagittal malalignment, biological failure of graft incorporation, and other patient-related issues [1].

Treatment

NON-OPERATIVE MANAGEMENT

- Initial management of ACL injury consists of physical therapy to restore motion [1].
- Immobilization is avoided in the initial management of ACL injury [1].
- Full range of motion (ROM) and good quadriceps control should be achieved prior to surgery [1].
- Treatment should be individualized based on age, activity level, instability, associated injuries, and other medical factors [1].

SURGICAL TECHNIQUE

- Primary repair of ACL tears is not currently recommended [1].
- Myofibroblasts “coat” the ends of the ACL stumps, making primary healing unlikely [1].
- Single-bundle reconstruction is the most commonly performed ACL reconstruction technique [1].
- There is currently no difference in patient-reported outcomes between single-bundle and double-bundle ACL reconstruction techniques [1].
- Independent femoral tunnel drilling techniques focus on placing a more horizontal femoral tunnel (10- or 2-o'clock position) to center the graft in the middle of the femoral ACL footprint [1].

- A more horizontal graft position may reduce rotational instability [1].
- Graft selection for ACL reconstruction depends on patient factors and surgeon preference [1].
- Common graft choices for ACL reconstruction include bone–patellar tendon–bone (BPTB) autograft, four-strand hamstring autograft, quadriceps tendon autograft, and allograft [1].
- BPTB autograft demonstrates faster incorporation into bone tunnels than hamstring autograft [1].
- BPTB autograft is often the graft of choice for patients who desire an early return to sports activity [1].
- Several studies have demonstrated a higher incidence of arthritis associated with the use of BPTB autograft than with hamstring autograft 5 to 7 years after ACL reconstruction [1].
- BPTB autograft harvest carries the risk of anterior knee pain, pain with kneeling, loss of extension, and poorer recovery of quadriceps strength [1].
- Hamstring autograft is similar in strength to the native ACL but is less stiff [1].
- Hamstring autograft harvest carries the risk of weakness of knee flexion and internal rotation, along with injury to branches of the saphenous nerve [1].
- Both BPTB and quadriceps tendon with bone block grafts carry the risk of patellar fracture [1].
- Use of allograft with ACL reconstruction in younger, more active patients is associated with a higher rate of rerupture [1].
- Chemically processed and irradiated allografts have demonstrated higher rates of failure than fresh frozen allografts [1].
- Allografts have been demonstrated to incorporate into bone tunnels more slowly than autografts [1].
- Use of allograft includes infection risk with *Clostridium* species, hepatitis, and human immunodeficiency virus (HIV), although rates are low at 1:1.6 million [1].
- Preimplantation culture of allografts is not widely recommended [1].

POSTOPERATIVE REHABILITATION

- Most postoperative rehabilitation protocols encourage early motion with an emphasis on extension and weight bearing [1].
- Exercises that do not endanger the ACL graft are dominated by the hamstrings, such as isometric hamstrings [1].
- Exercises that do not endanger the ACL graft involve active knee ROM between 35 and 90 degrees of flexion [1].
- Closed kinetic chain rehabilitation and compressive loading are emphasized because they allow physiologic cocontraction of the muscles around the knee [1].
- Open kinetic chain extension exercises, particularly with the knee near full extension, place increased stress on the reconstructed ACL and should be avoided for the first 6 weeks [1].
- No difference in outcome has been found between accelerated and nonaccelerated rehabilitation programs [1].
- Postoperative bracing has not proved beneficial after ACL reconstruction except in downhill skiers [1].

- Early progressive eccentric exercise has yielded good initial results in terms of muscle size and function after ACL reconstruction [1].

COMPLICATIONS

- The most common technical error leading to graft failure is tunnel malposition [1].
- Vertical graft placement results in decreased rotational stability [1].
- Anterior placement of the femoral tunnel results in flexion loss [1].
- Arthrofibrosis is the most common complication following ACL reconstruction [1].
- Arthrofibrosis often occurs with reconstruction for acute ACL tears [1].
- The risk of arthrofibrosis is minimized by the achievement of full ROM prior to surgery [1].
- Aberrant hardware placement, defined as interference screw divergence of >30 degrees for femoral tunnels or >15 degrees for tibial tunnels, can result in complications [1].
- Infection occurs in less than 1% of ACL reconstruction cases [1].
- Irrigation and débridement with graft retention are successful in up to 85% of post-ACL reconstruction infection cases [1].

REVISION ACL RECONSTRUCTION

- Causes of graft failure in revision ACL reconstruction include technical issues, unrecognized concomitant ligament injuries, coronal or sagittal malalignment, biological failure of graft incorporation, and other patient-related issues [1].
- A thorough workup of failed ACL reconstruction should include acquiring prior records [1].

Complications

GENERAL COMPLICATIONS

- Graft failure is a complication of ACL reconstruction [1].
- Irrigation and débridement with graft retention are successful in up to 85% of infected ACL reconstruction cases [1].

SKELETALLY IMMUNE PATIENTS

- The most common complications occurring after ACL reconstruction in skeletally immature patients include arthrofibrosis, growth disturbance, and secondary injury of the same or the contralateral ACL [3].
- In a retrospective case series of 902 young patients (average age 15 years) treated with ACL reconstruction, the overall incidence of arthrofibrosis was 8.3% [3].
- Female sex, older age, the use of bone–patellar tendon–bone autograft, and concomitant meniscal repair are additional risk factors for arthrofibrosis in skeletally immature patients [3].

- Growth arrest can occur after ACL reconstruction in skeletally immature patients despite the use of physeal-respecting techniques [3].
- In a case series of four patients (average age 14.2 years) who underwent transphyseal ACL reconstruction using physeal-respecting techniques, clinically important growth disturbances including tibial recurvatum and genu valgum developed [3].
- In a retrospective review of 43 patients (average age 14.8 years) who underwent transphyseal ACL reconstruction using soft-tissue graft, focal physeal bone bridges were noted in five knees, although no patient had resultant limb deformity [3].
- Growth disturbance has been reported with physeal-sparing techniques, including one patient in a series of all-epiphyseal ACL reconstructions who developed clinically significant growth arrest [3].
- In a 2014 cohort study of young athletes (average age 17 years), nearly 30% sustained a second ACL injury within 24 months of return to sports [3].
- In the same 2014 cohort study, approximately one-third of second ACL injuries occurred in the ipsilateral knee and two-thirds in the contralateral knee [3].
- In a 2014 case-control study, patients younger than 20 years at the time of ACL reconstruction had a 29% chance of sustaining a second ACL injury within 5 years of the index surgery [3].
- In a cohort of 85 patients younger than 18 years who underwent primary ACL reconstruction with autograft, 32% sustained a second ACL injury [3].
- A systematic review and meta-analysis found that athletes younger than 25 years who return to sports had a secondary rate of ACL injury (ipsilateral or contralateral knee) of 23% [3].

References

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