MANAGEMENT OF ANTERIOR CRUCIATE LIGAMENT INJURIES

SUMMARY

This Guideline has been endorsed by the following organizations:
Disclaimer
This Clinical Practice Guideline was developed by an AAOS multidisciplinary volunteer Work Group based on a systematic review of the current scientific and clinical information and accepted approaches to treatment and/or diagnosis. This Clinical Practice Guideline is not intended to be a fixed protocol, as some patients may require more or less treatment or different means of diagnosis. Clinical patients may not necessarily be the same as those found in a clinical trial. Patient care and treatment should always be based on a clinician’s independent medical judgment, given the individual patient’s clinical circumstances.

Overview
This clinical practice guideline is based on a systematic review of published studies on the treatment of anterior cruciate ligament (ACL) injuries in skeletally mature and immature patients. In addition to providing practice recommendations, this guideline also highlights gaps in the literature and areas that require future research.

This guideline is intended to be used by all appropriately trained surgeons and all qualified physicians managing the treatment of anterior cruciate ligament injuries. It is also intended to serve as an information resource for decision makers and developers of practice guidelines and recommendations.

Intended Users
This guideline is intended to be used by orthopaedic surgeons and physicians managing patients with anterior cruciate ligament injuries. Typically, orthopaedic surgeons will have completed medical training, a qualified residency in orthopaedic surgery, and some may have completed additional sub-specialty training. Insurance payers, governmental bodies, and health-policy decision-makers may also find this guideline useful as an evolving standard of evidence regarding treatment of anterior cruciate ligament injuries. Physical therapists, occupational therapists, nurse practitioners, athletic trainers, emergency room physicians, primary care physicians, physiatrists, physician assistants and other healthcare professionals who routinely see this type of patient in various practice settings may also benefit from this guideline.

ACL treatment is based on the assumption that decisions are predicated on patient and physician mutual communication with discussion of available treatments and procedures applicable to the individual patient. Once the patient has been informed of available therapies and has discussed these options with his/her physician, an informed decision can be made. Clinician input based on experience with conservative management and the clinician’s surgical experience and skills increases the probability of identifying patients who will benefit from specific treatment options.
SUMMARY OF RECOMMENDATIONS

The following is a summary of the recommendations of the AAOS clinical practice guideline on the Management of Anterior Cruciate Ligament Injuries. This summary contains rationales that explain how and why these recommendations were developed; however, it does not contain the evidence reports supporting these recommendations. All readers of this summary are strongly urged to consult the full guideline and evidence report for this information. We are confident that those who read the full guideline and evidence report will see that the recommendations were developed using systematic evidence-based processes designed to combat bias, enhance transparency, and promote reproducibility.

This summary of recommendations is not intended to stand alone. Treatment decisions should be made in light of all circumstances presented by the patient. Treatments and procedures applicable to the individual patient rely on mutual communication between patient, physician, and other healthcare practitioners.

ACL HISTORY AND PHYSICAL

Strong evidence supports that the practitioner should obtain a relevant history and perform a musculoskeletal exam of the lower extremities, because these are effective diagnostic tools for ACL injury.

Strength of Recommendation: Strong ★★★★★

RATIONALE

There were six high-strength and four moderate-strength studies evaluating history and physical examination as diagnostic tools for ACL injury. A relevant history is important for diagnosing ACL injuries and concomitant pathology and should include at a minimum the mechanism of injury, history of hearing/feeling a popping sensation, ability to bear weight, ability to return to play, history of mechanical symptoms of locking or catching, localization of pain if possible, and any history of prior knee injuries. History of hearing/feeling a popping sensation and associated swelling is important in predicting an ACL injury.

Appropriate physical exam is important in diagnosing ACL injuries and concomitant pathology and should also be performed including at a minimum: a neurovascular exam with documentation of both distal perfusion and tibial/peroneal nerve function, assessment for joint line tenderness or obvious step off/deformity, evaluation for an effusion, assessment of varus and valgus laxity at 0 and 30 degrees of extension, evaluation of anterior-posterior and rotational laxity. Lachman’s test should be performed and has been shown to be sensitive for ACL injury.
ACL RADIOGRAPHS
In the absence of reliable evidence, it is the opinion of the work group that in the initial evaluation of a person with a knee injury and associated symptoms [giving way, pain, locking, catching] and signs [effusion, inability to bear weight, bone tenderness, loss of motion, and/or pathological laxity] that the practitioner obtain AP and lateral knee xrays to identify fractures or dislocations requiring emergent care.

Strength of Recommendation: Consensus ★★★★

RATIONALE
While recognizing that various criteria for performing knee radiographs have been published, the consensus opinion recommends that practitioners initially evaluating a patient with an acute knee injury should obtain AP and lateral radiographs of the knee. In the setting of acute knee injury, radiographs may lead to the diagnosis of fracture, dislocation, ligament disruption, neoplasm, foreign body, and/or soft tissue injury that could lead to loss of the limb or limb function. Early diagnosis of these disorders may decrease morbidity from the injury.

If a MRI or CT scan is already available additional radiographs may not be necessary. This recommendation is consistent with current practice.

ACL MAGNETIC RESONANCE IMAGING (MRI)
Strong evidence supports that the MRI can provide confirmation of ACL injury and assist in identifying concomitant knee pathology such as other ligament, meniscal, or articular cartilage injury.

Strength of Recommendation: Strong ★★★★★

RATIONALE
Fifteen high strength and two moderate strength studies demonstrated that MRI has a high sensitivity and specificity in diagnosing ACL tears, but somewhat lower sensitivity and specificity at identifying concomitant injuries and other problems.2,30,38,40,41,42,55,59,65,89,91,92,97,101,105,107,116

A combination of history, clinical examination (Lachman test), and radiographs has similar diagnostic accuracy as MRI for identifying ACL tears. An MRI could be used in conjunction with the history and physical examination.

ACL PEDIATRIC
There is limited evidence in skeletally immature patients with torn ACLs, but it supports that the practitioner might perform surgical reconstruction because it reduces activity related disability and recurrent instability which may lead to additional injury.

Strength of Recommendation: Limited ★★★☆
RATIONALE
There was one low and two very low strength studies comparing surgical reconstruction to non-operative treatment. Surgical reconstruction demonstrated a significant advantage over non-operative treatment in objective knee stability (KT1000, pivot shift, Lachman), subjective knee function scores (IKDC, Zarins and Rowe score, Lysholm), and Tegner activity score. None of three studies reported a clinically significant valgus deformity or limb length discrepancy.

ACL YOUNG ACTIVE ADULT
Moderate evidence supports surgical reconstruction in active young adult (18-35) patients with an ACL tear.

Strength of Recommendation: Moderate ★★★

RATIONALE
The recommendation is based on one study of one prospective randomized cohort and two studies of moderate strength. The evidence indicates that ACL reconstruction decreases pathologic laxity, as measured by the Lachman, KT-1000, and pivot shift tests, and reduces episodes of instability and the incidence of subsequent injuries including meniscal tears.

ACL MENISCAL REPAIR
There is limited evidence in patients with combined ACL tears and reparable meniscus tears, but it supports that the practitioner might repair these meniscus tears when combined with ACL reconstruction because it improves patient outcomes.

Strength of Recommendation: Limited ★★★★

RATIONALE
Nine low strength and two very low strength studies were included in this recommendation. One low strength study reported improved subjective knee function (Lysholm knee score and IKDC Score) and reduced activity related pain and swelling with repaired (51%)/stable (49%) menisci compared to meniscectomy at the time of ACL reconstruction. Objective functional outcomes as evidenced by single leg hops scores were also improved in the repaired/stable meniscus group. One low strength study and one very low strength study reported reduced radiographic abnormalities in knees with repaired/stable menisci and a reduced incidence of osteophytes following repair compared to medial meniscectomy. Likewise, a very low strength study reported a reduction in pain following lateral meniscus repair compared to lateral meniscectomy combined with ACL reconstruction. Several studies reported improved outcomes with ACL reconstruction and menisci repair, but the groups were not directly comparable.
ACL RECURRENT INSTABILITY
There is limited evidence comparing non-operative treatment to ACL reconstruction in patients with recurrent instability, but it supports that the practitioner might perform ACL reconstruction because this procedure reduces pathologic laxity.

Strength of Recommendation: Limited ★★★★

RATIONALE
One prospective comparative study was included.\textsuperscript{24} With respect to recurrent instability, this study compared two groups of interest – an ACL-unstable group that ultimately did not undergo ACL reconstruction despite persistent pathologic laxity (Group II in the article, considered "copers") as well as an ACL-unstable group that ultimately did undergo late ACL reconstruction following recurrent instability (Group IV in the article). The late ACL reconstructions in Group IV occurred 9 to 84 months after injury. Of the 147 patients in Group II, only 11 had meniscal surgery. Of the 46 patients in Group IV, 29 had meniscal surgery. The article also reports an ACL-stable group with hemarthrosis (Group I) and an ACL-unstable group that underwent early ACL reconstruction (Group III).

At final evaluation of symptoms, 18\% of the non-ACL-reconstructed, unstable patients (Group II) reported giving way with sports while only 3\% of the late-ACL-reconstructed patients (Group IV) reported giving way with sports. Similarly, 9\% of the non-ACL-reconstructed, unstable patients (Group II) reported giving way with activities of daily life, while only 3\% of the late-ACL-reconstructed patients (Group IV) reported giving way with activities of daily life. Objective instrumented and physical examination findings paralleled these subjective findings. This is without undergoing ACL reconstruction (Group II), 84\% of patients demonstrated positive KT-1000 arthrometer measurements (>3 mm side-to-side difference with manual maximum testing) and 84\% had positive pivot shift testing. Following late ACL reconstruction (Group IV), 70\% of patients demonstrated positive KT-1000 arthrometer measurements and 52\% had positive pivot shift testing.

ACL CONSERVATIVE TREATMENT
There is limited evidence to support non-surgical management for less active patients with less laxity.

Strength of Recommendation: Limited ★★★★

RATIONALE
This recommendation is based on one moderate-strength, one low strength and three very low strength studies.\textsuperscript{24,31,71,93,29} Patients were classified based on activity level and knee laxity at initial injury. The following three groups were considered particularly low risk: (1) Patients participating in less than 50 hours of jumping or cutting sports and less than 5 mm of side to side difference based on KT-1000 or manual maximal testing, (2) Patients participating in 50-199 hours of jumping or cutting sports with less than 5 mm of side to side difference based on KT-1000 or manual maximal testing, and (3) Patients
participating in less than 50 hours of jumping or cutting sports with 5-7 mm of side to side difference based on KT-1000 or manual maximal testing. Collectively, these low risk groups were found to have lower rates of late meniscal surgery and ACL reconstruction than patients in the high risk groups treated non-operatively. Thus, low risk patients may do well with non-operative treatment. However, 25% of the low risk patients ultimately required surgery, including ACL reconstruction or meniscal surgery.

**ACL SURGERY TIMING**

When ACL reconstruction is indicated, moderate evidence supports reconstruction within five months of injury to protect the articular cartilage and menisci.

**Strength of Recommendation: Moderate 🌟🌟🌟**

**RATIONALE**

With respect to performing ACL reconstruction early following injury, three moderate strength studies evaluated the effect of timing on outcome following ACL reconstruction. Post-operative range of motion was not different if surgery was performed within 48 hours of injury, within 3-7 days of injury, or within 2 weeks of injury; or if surgery was delayed more than 3 weeks of injury, delayed for a minimum of 6 weeks of injury, or delayed for 8-12 weeks of injury. Strength and stability by KT 1000 were also not different between early and delayed ACL reconstruction. However, performing ACL reconstruction early, within three weeks of injury, increased the rate of re-operation from 0% to 8%. Complications included pain with extension (n=11), meniscus tear (n=1), and failed ACL reconstruction (n=2). With respect to delaying ACL reconstruction to a time point past the injury, there were two high-strength studies of same cohort of patients and three moderate-strength studies that compared early (within 3-5 months from injury) versus late (after 3-5 months from injury) ACL reconstruction. Early reconstruction improved objective knee stability as measured by the Lachman test and pivot shift test. Three studies demonstrated a higher activity level in the patients that underwent early ACL reconstruction. One study reported higher function in patients that underwent early ACL reconstruction.

Early reconstruction also decreased the incidence of meniscus tears from 62% to 37% and decreased the incidence of subsequent meniscectomy surgery from 44% to 8%. One moderate-strength study stratified outcome by meniscus injury, which was not emphasized in the high-strength study but was supported by their data. Further, in the setting of meniscus treatment, the rate of meniscal repair was 29% with early ACL reconstruction and 12% when ACL reconstruction was delayed beyond 3 months.

The importance of this recommendation was based on improving patient function and protecting the knee with ACL injury from further meniscus injury, which could reduce the risk for premature osteoarthritis.
ACL COMBINED MCL
There is limited evidence in patients with acute ACL tear and MCL tear to support that
the practitioner might perform reconstruction of the ACL and non-operative treatment of
the MCL tear.

Strength of Recommendation: Limited ★★★★

RATIONALE
Two low strength studies evaluated isolated reconstruction of the ACL in acute
ACL/MCL and chronic ACL/MCL injuries in which the MCL injury was high grade, but
not complete (no or minimal valgus laxity when tested in full extension) 43,75 Both used
hinged braces in the post-operative period. Their results for ACL laxity and function are
comparable to ACL reconstruction in isolated ACL tears. Valgus laxity was reduced from
pre-operative status, but still present. This did not seem to alter functional status.

ACL LOCKED KNEE
In the absence of reliable evidence, it is the opinion of the work group that patients with
an ACL tear and a locked knee secondary to a displaced meniscal tear have prompt
treatment to unlock the knee in order to avoid a fixed flexion contracture.

Strength of Recommendation: Consensus ★★★★

RATIONALE
There were no published studies that met the criteria for this recommendation. The work
group felt that, if left untreated for a sufficient period of time, a locked knee may lead to a
fixed flexion contracture that may no longer be recoverable and could thus threaten the
functional viability of the leg.

The torn meniscus is also more likely to be repairable if the meniscus is reduced early.
Prolonged knee flexion may lead to articular cartilage damage as well.

ACL SINGLE OR DOUBLE BUNDLE RECONSTRUCTION
Strong evidence supports that in patients undergoing intra-articular ACL reconstruction
the practitioner should use either single bundle or double bundle technique, because the
measured outcomes are similar.

Strength of Recommendation: Strong ★★★★★

RATIONALE
There are four high and eight moderate strength studies that compare single to double
bundle ACL reconstruction 1,3,5,51,53,56,77,79,93,99,114,123 The majority of the studies
demonstrate no statistically significant difference in any outcome parameters. Meta-
analysis demonstrated no statistically significant difference between single and double
bundle reconstruction in post-operative pain, Lysholm or IKDC subjective knee scores.
**ACL AUTOGRRAFT SOURCE**

Strong evidence supports that in patients undergoing intra-articular ACL reconstruction using autograft tissue the practitioner should use bone-patellar tendon-bone or hamstring-tendon grafts, because the measured outcomes are similar.

**Strength of Recommendation: Strong ★★★★★**

**RATIONALE**

There were four high-strength, and 19 moderate-strength studies included in this recommendation. 3,7,10,13,22,27,28,34,49,52,63,64,86,95,94,100,115,118,119,122 Graft choice did not matter with respect to stability testing in three high-strength studies and ten moderate-strength studies. 10,16,26,48,72,111,159,243,287,294,308 Patient satisfaction, normal IKDC score, and graft failure were also not different between the two graft choices. 10,13,22,27,28,49,52,63,64,96,115

However, significantly more post-operative kneeling pain was present in the patella tendon group as demonstrated by two high-strength studies and one moderate-strength study. 28,52,96

**ACL AUTOGRRAFT VS ALLOGRAFT**

Strong evidence supports that in patients undergoing ACL reconstructions, the practitioner should use either autograft or appropriately processed allograft tissue, because the measured outcomes are similar, although these results may not be generalizable to all allografts or all patients, such as young patients or highly active patients.

**Strength of Recommendation: Strong ★★★★★**

**RATIONALE**

This recommendation was built upon two high strength studies and seven moderate strength studies. 26,39,62,63,85,111,112,113,117 The preparation of allografts varies with respect to procurement, processing, storage, and implantation. Each of these steps can affect the mechanical properties and incorporation of the graft. Understanding these limitations, there were two high strength and six moderate strength studies available that compared ACL reconstruction with autograft and allograft tissues.

Combining the autograft and nonirradiated allograft data from two studies, there was a 6% failure rate with autograft and a 9% failure rate with nonirradiated allograft, which was not a statistically significant difference. 11,112 In contrast, there was a 34% failure rate with irradiated allograft (2.5 Mrad). The difference between failures in the autograft group and the irradiated allograft group was statistically significant.

Five moderate strength prospective comparative studies, similarly demonstrated that the clinical outcomes of ACL reconstruction with allograft were not significantly different from those with autograft. 26,62,63,84,117
The allografts used in the study by Gorschewsky et al. were sterilized with osmotic treatment, oxidation, and solvent drying with acetone. In contrast, the other studies involved the use of fresh-frozen allografts or cryopreservation. The patient-oriented outcomes, physical examination findings, instrumented laxity measurements, and complications in the allograft group in the study by Gorschewsky et al. were much worse than those in the other treatment arms of the other five prospective comparative studies.

While outcomes following ACL reconstruction using autograft tissue and using non-irradiated allograft tissue are similar overall, these results may not be generalizable to specific subsets of patients with ACL rupture, such as athletes and young patients. In fact, a longitudinal cohort study indicated a higher failure rate of allograft tissue in younger patients (Figure 3, Kaeding -- Sports Health 2011).

**ACL FEMORAL TUNNEL TECHNIQUE**

Moderate evidence supports that in patients undergoing intra-articular ACL reconstruction the practitioner could use either a tibial independent approach or transtibial approach for the femoral tunnel, because the measured outcomes are similar.

**Strength of Recommendation: Moderate ★★★★

**RATIONALE**

There were seven moderate, one low, and one very low strength studies that compared intra-articular ACL reconstruction with use of a tibial independent to a transtibial approach to create the femoral drill hole.

Research on this recommendation did not evaluate the techniques used for ACL reconstructions in skeletally immature patients. The tibial independent approach included both outside-in and medial portal drilling techniques. The studies demonstrate no consistent differences between the two techniques in objective metrics or patient reported outcomes. Meta-analysis of the study demonstrated no difference in IKDC knee exam or Lysholm scores.

**ACL POST-OP FUNCTIONAL BRACING**

Moderate evidence does not support the routine use of functional knee bracing after isolated ACL reconstruction, because there is no demonstrated efficacy.

**Strength of Recommendation: Moderate ★★★

**RATIONALE**

Three moderate strength studies compared the use of functional bracing following ACL reconstruction to either the use of no brace or a neoprene knee sleeve. None of the studies showed statistically significant benefit of the functional brace in any of the functional or laxity measurements, including Tegner activity scale, Lysholm score, ACL
Quality of Life, IKDC score, instrumented laxity testing, and limb hop distance symmetry. These results held up for one and two years in all of the studies. Based on this moderate evidence for lack of efficacy in the use of functional knee bracing following ACL reconstruction, its routine use cannot be supported.

**ACL PROPHYLACTIC BRACES**

Limited evidence supports that the practitioner might not prescribe prophylactic knee braces to prevent ACL injury, because they do not reduce the risk for ACL injury.

**Strength of Recommendation: Limited ★★★ ★ ★ ★

**RATIONALE**

One moderate strength and one low strength study demonstrated no reduction in ACL injury rates with ACL prophylactic bracing in high school and collegiate American football players.\

**ACL NEUROMUSCULAR TRAINING PROGRAMS**

Moderate strength evidence from pooled analyses with a small effect size (Number Needed to Treat=109) supports that neuromuscular training programs could reduce ACL injuries.

**Strength of Recommendation: Moderate ★★★★★

**RATIONALE**

One moderate strength study of female adolescent handball players and two low strength studies of adult male and adolescent female soccer players demonstrated significant reduction in ACL injuries after neuromuscular training. Five moderate strength studies showed a non-significant reduction and one moderate strength study showed a non-significant increase in ACL injuries (note: we were unable to confirm statistically significant reductions in injury reported by some of the aforementioned studies when reanalyzing the raw data). No high strength double-blind randomized control trials implementing neuromuscular training interventions were identified, likely due to the difficulty in blinding of athletes and the need to cluster randomize athletes by team. A two-step process of pooled analyses was employed. The initial pooled analysis contained all best available quality studies meeting the a priori inclusion criteria for this recommendation (Figure 11. Meta-Analysis of All Investigations Meeting Inclusion Criteria for ACL Neuromuscular Training Programs), showed no quantitative heterogeneity (0%), and indicated a relative risk reduction of 53 (20 to 72%). However, content and delivery methods among programs in these studies demonstrated qualitative heterogeneity; therefore a subset of the most homogeneous programs was identified. Programs were considered homogeneous if they contained similar exercise modalities and training implementation strategies (e.g., plyometrics, strengthening, instructor feedback to athletes). The second pooled analysis of the homogeneous programs (Figure 12. Meta-Analysis of Investigations that Employed the Most Homogeneous Intervention)
confirmed significant relative risk reduction of 62 (41 to 79%) favoring neuromuscular training programs for prevention of non-contact ACL injuries. The majority of the reported programs were coach-led and compliance was fair to poor, when reported. The current analyses indicate that the number needed to treat to prevent one ACL injury is approximately 109 athletes (Figure 13. Number Needed to Treat (NNT) Analysis for Most Homogeneous Investigations (NNT =108.75). An assessment of the studies included in this analysis demonstrated no publication bias (Figure 1D)

ACL POST-OP PHYSICAL THERAPY
For those undergoing post-operative rehabilitation after ACL reconstruction, moderate evidence supports early, accelerated, and non-accelerated protocols because they have similar outcomes.

Strength of Recommendation: Moderate ★★★★

RATIONALE
One high and one moderate strength study compared two year patient outcomes between a 19-week accelerated rehabilitation program versus a 32 week non-accelerated program. The rehabilitative programs were common relative to limits in knee ROM, the amount of weight bearing permitted, and type of rehab activity prescribed --however the accelerated programs had earlier initiation of activities known to strain the ACL, including unrestricted ROM (week 4 versus week 8), earlier weaning from brace (weeks 2-6 versus weeks 4-6), earlier OKC full knee extension (week 6 versus week 12), earlier CKC and functional tasks (week 5-6 versus week 12). At 24-months post ACL reconstruction, the two groups had similar knee laxity, clinical assessments, patient satisfaction, activity levels and functional scores; and similar detection of passive motion and knee extensor strength.

Other moderate strength studies examine early unrestricted motion and weight bearing (immediate versus 2-4 weeks; immediate versus 5-6 weeks) and early initiation open kinetic chain quadriceps exercise (limited range [90 – 40°] starting at 4 versus 12 weeks in isolation, and all reported similar patient outcomes with early versus late initiation of these activities. Early, accelerated protocols may include early weight bearing, range of motion, and strengthening including the addition of open kinetic chain exercises at six weeks.

ACL RETURN TO SPORTS
Limited strength evidence does not support waiting a specific time from surgery/ injury, or achieving a specific functional goal prior to return to sports participation after ACL injury or reconstruction.

Strength of Recommendation: Limited ★★★★
RATIONALE

The rationale for return to play and secondary injury risk was based on one low and one very low strength study.\textsuperscript{37,104} Early return (mean five months) versus late return (mean nine months) to sport was not different for subsequent ipsilateral ACL injury, subjective and objective functional outcomes or knee laxity.\textsuperscript{37} Similarly, early return to sports (<6 months versus >6 months) was not associated with increased incidence of either contralateral or ipsilateral ACL injury.\textsuperscript{104}

The rationale for return to play based on achieving functional criteria was based on one low strength study.\textsuperscript{11} This study reported similar potential return to pre-injury sport levels in those who attempted to return before 12 months relative to those who returned after 12 months.