

# Management of Anterior Cruciate Ligament Injuries

## Evidence-Based Clinical Practice Guideline

*Adapted by:*

The American Academy of Orthopaedic Surgeons Board of Directors  
August 22, 2022

*Endorsed by:*

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This clinical practice guideline (CPG) was developed by a physician volunteer clinical practice guideline development group based on a formal systematic review of the available 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 specific clinical circumstances.

## Disclosure Requirement

In accordance with AAOS policy, all individuals whose names appear as authors or contributors to the clinical practice guideline filed a disclosure statement as part of the submission process. All panel members provided full disclosure of potential conflicts of interest prior to voting on the recommendations contained within this clinical practice guideline.

## Funding Source

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## SUMMARY OF RECOMMENDATIONS

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Recommendations are formed when there is sufficient evidence by which to create a directional statement. This is defined as evidence from two or more high quality studies (i.e., a strong recommendation), two or more moderate quality studies (i.e., a moderate recommendation), or statements resulting in a strong or moderate strength following Evidence to Decision Framework upgrading and/or downgrading.

### HISTORY AND PHYSICAL

**A relevant history should be obtained, and a focused musculoskeletal exam of the lower extremities should be performed when assessing for an ACL injury.**

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★★

*Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.*

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### SURGICAL TIMING

**When surgical treatment is indicated for an acute isolated ACL tear, early reconstruction is preferred because the risk of additional cartilage and meniscal injury starts to increase within 3 months.**

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★★

*Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.*

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### SINGLE OR DOUBLE BUNDLE ACL RECONSTRUCTION

**In patients undergoing intraarticular ACL reconstruction single or double bundle techniques can be considered because measured outcomes are similar.**

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★★

*Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.*

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## **AUTOGRAFT VS. ALLOGRAFT**

When performing an ACL reconstruction, surgeons should consider autograft over allograft to improve patient outcomes and decrease ACL graft failure rate, particularly in young and/or active patients.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★★

*Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.*

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## **AUTOGRAFT SOURCE**

When performing an ACL reconstruction with autograft for skeletally mature patients, surgeons may favor BTB to reduce the risk of graft failure or infection, or hamstring to reduce the risk of anterior or kneeling pain.

Strength of Evidence: Strong

Strength of Recommendation: Moderate ★★★★★ (downgraded)

*Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.*

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## **ACL TRAINING PROGRAMS**

Training programs designed to prevent injury can be used to reduce the risk of primary ACL injuries in athletes participating in high-risk sports.

Strength of Evidence: Moderate

Strength of Recommendation: Moderate ★★★★★

*Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.*

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## **ANTEROLATERAL LIGAMENT / LATERAL EXTRAARTICULAR TENODESIS**

**ALL Reconstruction / LET** could be considered when performing hamstring autograft reconstruction in select patients to reduce graft failure and improve short-term function, although long-term outcomes are yet unclear.

Strength of Evidence: Strong

Strength of Recommendation: Moderate ★★★★★ (downgraded)

*Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.*

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## REPAIR VS. RECONSTRUCTION

ACL tears indicated for surgery should be treated with ACL reconstruction rather than repair because of the lower risk of revision surgery.

**Strength of Evidence:** Strong

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

*Evidence from two or more “High” quality studies with consistent findings for recommending for or against the intervention.*



## SUMMARY OF OPTIONS

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Options are formed when there is little or no evidence on a topic. This is defined as low quality evidence or a single moderate quality study (i.e., a limited strength option), no evidence or only conflicting evidence (i.e., a consensus option), or statements resulting in a limited or consensus strength following Evidence to Decision Framework upgrading and/or downgrading.

### **ASPIRATION OF THE KNEE**

**In the absence of reliable evidence, it is the opinion of the workgroup that physicians may consider aspirating painful, tense effusions after knee injury.**

**Strength of Evidence:** N/A

**Strength of Option:** Consensus ★★★★★

*Description: Evidence there is no supporting evidence, or limited level evidence was downgraded due to major concerns addressed in the EtD framework. In the absence of reliable evidence, the guideline work group is making a recommendation based on their clinical opinion.*

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### **ACL SURGICAL RECONSTRUCTION**

**ACL reconstruction can be considered in order to lower the risk of future meniscus pathology or procedures, particularly in younger and/or more active patients. ACL reconstruction may be considered to improve long term pain and function.**

**Strength of Evidence:** Low

**Strength of Option:** Limited ★★☆☆☆

*Description: Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention.*

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### **MENISCAL REPAIR**

**In patients with ACL tear and meniscal tear, meniscal preservation should be considered to optimize joint health and function.**

**Strength of Evidence:** Low

**Strength of Option:** Limited ★★☆☆☆

*Description: Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention.*

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## COMBINED ACL / MCL TEAR

In patients with combined ACL and MCL tears, non-operative treatment of the MCL injury results in good patient outcomes, although operative treatment of the MCL may be considered in select cases.

Strength of Evidence: Moderate

Strength of Option: Limited ★★☆☆

Description: Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention.

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## PROPHYLACTIC KNEE BRACING

Prophylactic bracing is not a preferred option to prevent ACL injury.

Strength of Evidence: Low

Strength of Option: Limited ★★☆☆

Description: Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention.

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## RETURN TO SPORT

Functional evaluation, such as the hop test, may be considered as one factor to determine return to sport after ACL reconstruction.

Strength of Evidence: Low

Strength of Option: Limited ★★☆☆

Description: Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention.

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## RETURN TO ACTIVITY FUNCTIONAL BRACING

Functional knee braces are not recommended for routine use in patients who have received isolated primary ACL reconstruction, as they confer no clinical benefit.

Strength of Evidence: Strong

Strength of Recommendation: Limited ★★☆☆ (downgraded)

Description: Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention.

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# INTRODUCTION

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## 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.

## GOALS AND RATIONALE

The purpose of this clinical practice guideline is to help improve treatment based on the current best evidence. Current evidence-based medicine (EBM) standards demand that physicians use the best available evidence in their clinical decision making. To assist them, this clinical practice guideline consists of a systematic review of the available literature regarding the treatment of ACL injuries. The systematic review detailed herein was conducted between June 06, 2020, and September 11, 2021 (initial literature search on August 5<sup>th</sup>, 2020 and final literature search on August 27<sup>th</sup>, 2021) and demonstrates where there is good evidence, where evidence is lacking, and what topics future research must target in order to improve the treatment of patients with anterior cruciate ligament injuries. AAOS staff and the physician work group systematically reviewed the available literature and subsequently wrote the following recommendations based on a rigorous, standardized process.

Musculoskeletal care is provided in many different settings by many different providers. We created this guideline as an educational tool to guide qualified physicians through a series of treatment decisions in an effort to improve the quality and efficiency of care. This guideline should not be construed as including all proper methods of care or excluding methods of care reasonably directed to obtaining the same results. The ultimate judgment regarding any specific procedure or treatment must be made in light of all circumstances presented by the patient and the needs and resources particular to the locality or institution.

Experience based clinician input optimizes interpretation and application of the guidelines, more accurately identifying patients who will benefit from specific treatment options. The individual patient and the patient's family dynamic will also influence treatment decisions. Therefore, the patient and/or the patient's guardian (when appropriate for minor patients) should be informed of available therapies and their relative risks and benefits in order to discuss with the physician and make an informed decision.

## 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 mutual communication between the patient and physician 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.

## **PATIENT POPULATION & SCOPE OF GUIDELINE**

This document is intended for use for both skeletally immature and skeletally mature patients who have been diagnosed with an ACL injury of the knee.

## **ETIOLOGY**

ACL rupture is typically the result of a traumatic, sports-related injury. This injury may be contact or non-contact. The majority of anterior cruciate ligament (ACL) injuries are non-contact injuries<sup>3</sup>. Female athletes have been reported to sustain non-contact ACL injuries at a rate higher than their male counterparts. Recent studies indicate a 2-4 fold increase in females compared to similarly trained males.<sup>10,11,12,13</sup>

## **INCIDENCE AND PREVALENCE**

The annual rate of patients who present with anterior cruciate ligament injuries has been estimated at 200,000 in the United States alone.<sup>5</sup> Although, the mean patient age (i.e., 29 years) for reconstruction remained constant from 1990 to 2006, the incidence of ACL reconstruction in patients aged >40 years has increased >200%—second in growth only to the <14-year age group.<sup>4,6</sup>

## **RISK FACTORS**

Risk factors for ACL injury include inclement weather, intercondylar notch stenosis, variations in sagittal condylar shape, increased tibial slope, increased posterior slope, and potential genetic influence.<sup>7,8</sup> Female athletes may be more predisposed to ACL injury due to a number of factors. Greatest predictors include anterior knee laxity, increased body mass index, and family history.<sup>14,15</sup> Additional factors may include biomechanical differences, increased posterior tibial slope, and hormones (with a greater proportion of injuries occurring in the follicular phase as compared to the luteal phase of the menstrual cycle).<sup>9,16,17</sup>

## **POTENTIAL BENEFITS, HARM, AND CONTRAINDICATIONS**

Most treatments are associated with some known risks, especially invasive and operative treatments. Contraindications vary widely based on the treatment administered. A particular concern when treating ACL injuries is routine surgical complications such as infection, DVT, anesthesia complications, etc. Other complications associated with ACL surgery include recurrent instability including graft re-tear and contralateral ACL tear, postoperative loss of motion or arthrofibrosis, neurovascular injury, kneeling pain, etc. Additional factors may affect the physician's choice of treatment including but not limited to associated injuries the patient may present with as well as the individual's co-morbidities, skeletal maturity, and/or specific patient characteristics including obesity, activities, work demands, etc.

## METHODS

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The methods used to perform this systematic review were employed to minimize bias and enhance transparency in the selection, appraisal, and analysis of the available evidence. These processes are vital to the development of reliable, transparent, and accurate clinical recommendations. To view the full AAOS clinical practice guideline methodology please visit <https://www.aaos.org/quality/research-resources/methodology/>.

This clinical practice guideline evaluates the management of anterior cruciate ligament injuries. The AAOS approach incorporates practicing physicians (clinical experts) and methodologists who are free of potential conflicts of interest relevant to the topic under study, as recommended by clinical practice guideline development experts.

This clinical practice guideline was prepared by the AAOS Anterior Cruciate Ligament Injury Guideline physician development group (clinical experts) with the assistance of the AAOS Clinical Quality and Value (CQV) Department (methodologists). To develop this clinical practice guideline, the clinical practice guideline development group held an introductory meeting on June 6<sup>th</sup>, 2020, to establish the scope of the clinical practice guideline. As physician experts, the clinical practice guideline development group defined the scope of the clinical practice guideline by creating PICO Questions (i.e., population, intervention, comparison, and outcome) that directed the literature search. The AAOS Medical Librarian created and executed the search (see Appendix III for search strategy).

### LITERATURE SEARCHES

The systematic review begins with a comprehensive search of the literature. Articles considered were published prior to the start date of the search in a minimum of three electronic databases; PubMed,

EMBASE, and the Cochrane Central Register of Controlled Trials. The medical librarian conducts the search using key terms determined from the guideline development group's PICO questions. The initial literature search was conducted August 5<sup>th</sup>, 2020, and a final literature search as conducted on August 27<sup>th</sup>, 2021.

A CQV methodologist will review/include only primary literature but will supplement the electronic search with a manual search of the bibliographies of secondary literature sources, such as systematic reviews, as available. The methodologist will then evaluate all recalled articles for possible inclusion based on the study selection criteria and will summarize the evidence for the guideline work group who assist with reconciling possible errors and omissions. A study attrition diagram is provided in the appendix of each document that details the numbers of identified abstracts, recalled and selected studies, and excluded studies that were evaluated in the CPG. The search strategies used to identify the abstracts is also included in the appendix of each CPG document.

### DEFINING THE STRENGTH OF RECOMMENDATION

Judging the quality of evidence is only a steppingstone towards arriving at the strength of a CPG recommendation. The strength of recommendation also takes into account the quality, quantity, and the trade-off between the benefits and harms of a treatment, the magnitude of a treatment's effect, and whether data exists on critical outcomes.

Strength of recommendation expresses the degree of confidence one can have in a recommendation. As such, the strength expresses how possible it is that a recommendation will be overturned by future evidence. It is very difficult for future evidence to overturn a recommendation that is based on many high quality randomized controlled trials that show a large effect. It is much more likely that future evidence will

overturn recommendations derived from a few small retrospective comparative studies. Consequently, recommendations based on the former kind of evidence are given a “strong” strength of recommendation and statement based on the latter kind of evidence are presented as options to the practicing clinician, rather than a directional recommendation, with either a “limited” strength or, in the event of no supporting or only conflicting evidence, a “consensus” strength.





**VOTING ON THE RECOMMENDATIONS**

The recommendations and their strength were voted on by the guideline development

group members during the final meeting. If disagreement between the guideline development group occurred, there was further discussion to see whether the disagreement(s) could be resolved. Recommendations were approved and adopted in instances where a simple majority (60%) of the guideline development group voted to approve; however, the guideline development group had consensus (100% approval) when voting on every recommendation for this guideline. Any recommendation strength upgrade or downgrade based on the Evidence-to-Decision Framework requires a super majority (75%) approval of the work group.

**INTERPRETING THE STRENGTH OF EVIDENCE**

**Table I. Level of Evidence Descriptions**

Strength	Overall Strength of Evidence	Description of Evidence Quality	Strength Visual
<b>Strong</b>	Strong or Moderate	Evidence from two or more “High” quality studies with consistent findings for recommending for or against the intervention. Or Rec is upgrade from Moderate using the EtD framework.	
<b>Moderate</b>	Strong, Moderate or Limited	Evidence from two or more “Moderate” quality studies with consistent findings, or evidence from a single “High” quality study for recommending for or against the intervention. Or Rec is upgraded or downgraded from Limited or Strong using the EtD framework.	
<b>Limited</b>	Limited or Moderate	Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention. Or Rec is downgraded from Strong or Moderate using the EtD Framework.	
<b>Consensus*</b>	No Evidence	There is no supporting evidence, or higher quality evidence was downgraded due to major concerns addressed in the EtD framework. In the absence of reliable evidence, the guideline work group is making a recommendation based on their clinical opinion.	

**Table II. Interpreting the Strength of a Recommendation or Option**

Strength of Recommendation	Patient Counseling (Time)	Decision Aids	Impact of Future Research
Strong	Least	Least Important, unless the evidence supports no difference between two alternative interventions	Not likely to change
Moderate	Less	Less Important	Less likely to change
Limited	More	Important	Change possible/anticipated
Consensus	Most	Most Important	Impact unknown

**REVIEW PERIOD**

Following the final meeting, the CPG draft undergoes a 3-week review period for additional input from external content experts. Written comments are provided on the structured review form. All reviewers are required to disclose their conflicts of interest.

Specialty societies relevant to the topic are solicited for nominations of individual reviewers approximately six weeks before the final meeting. The review period is announced as it approaches, and others interested are able to volunteer to review the draft. The chairs of the guideline work group review the draft of the guideline prior to dissemination.

Some specialty societies (both orthopaedic and non-orthopaedic) ask their evidence-based practice (EBP) committee to provide review of the guideline. The organization is responsible for coordinating the distribution of our materials and consolidating their comments onto one form. The chair of the external EBP committees provides disclosure of their conflicts of interest (COI) and manages the potential conflicts of their members.

Again, the AAOS asks for comments to be assembled into a single response form by the specialty society and for the individual

submitting the review to provide disclosure of potentially conflicting interests. The review stage gives external stakeholders an opportunity to provide evidence-based direction for modifications that they believe have been overlooked. Since the draft is subject to revisions until its approval by the AAOS Board of Directors as the final step in the guideline development process, confidentiality of all working drafts is essential.

The CPG is also provided to members of the AAOS Board of Directors (BOD), members of the Research and Quality Council (RQC), members of the Board of Councilors (BOC), and members of the Board of Specialty Societies (BOS) and members of the Committee on Evidence-Based Quality and Value (EBQV) for review and comment. The CPG is automatically forwarded to the AAOS BOD, RQC, and EBQV so that they may review it and provide comment prior to being asked to approve the document. Based on these bodies, over 200 commentators have the opportunity to provide input into each CPG.

The chairs of the guideline work group, the manager of the AAOS CQV unit, and the Director of AAOS CQV draft the initial responses to comments that address methodology. These responses are then reviewed by the chair and



co-chair, who respond to questions concerning clinical practice and techniques. All comments received and the initial drafts of the responses are also reviewed by all members of the guideline development group. All proposed changes to recommendation language as a result of the review period are based on the evidence. Final revisions are summarized in a report that is provided alongside the guideline document throughout the remainder of the approval processes and final publication.

The AAOS believes in the importance of demonstrating responsiveness to input received during the review process and welcomes the critiques of external specialty societies. Following final approval of the guideline, all individual responses are posted on our website <http://www.aaos.org/quality> with a point-by-point reply to each non-editorial comment. Reviewers who wish to remain anonymous notify the AAOS to have their names de-identified; their comments, our responses, and their COI disclosures are still posted.

### **THE AAOS CPG APPROVAL PROCESS**

This final clinical practice guideline draft must be approved by the AAOS Committee on Evidence Based Quality and Value, and subsequently the AAOS Research and Quality Council, and the AAOS Board of Directors. These decision-making bodies are described in the Anterior Cruciate Ligament Injury CPG eAppendix. Their charge is to approve or reject its publication by majority vote.

### **REVISION PLANS**

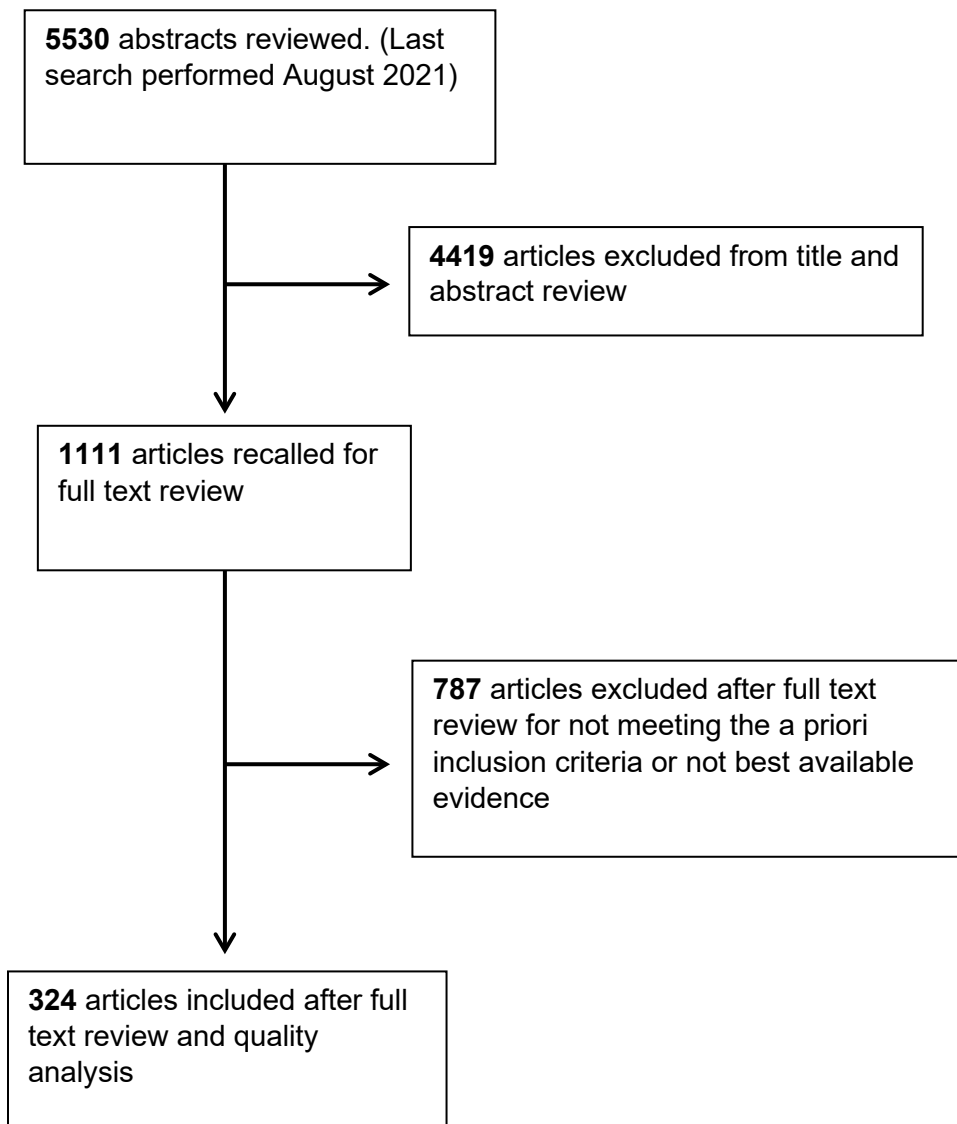
This clinical practice guideline represents a cross-sectional view of current treatment and may become outdated as new evidence becomes available. This clinical practice guideline will be revised in accordance with new evidence, changing practice, rapidly emerging treatment options, and new technology. This clinical practice guideline will be updated or withdrawn in five years.

### **CPG DISSEMINATION PLANS**

The primary purpose of the present document is to provide interested readers with full documentation of the best available evidence for various procedures associated with the topic of this review. Publication of most clinical practice guidelines is announced by an Academy press release, articles authored by the clinical practice guideline development group and published in the *Journal of the American Academy of Orthopaedic Surgeons*, and articles published in *AAOS Now*. Most clinical practice guidelines are also distributed at the AAOS Annual Meeting in the Resource Center. The final guideline recommendations and their supporting rationales will be hosted on [www.OrthoGuidelines.org](http://www.OrthoGuidelines.org).

Selected clinical practice guidelines are disseminated by webinar, the AAOS Learning Management Systems (LMS), Media Briefings, and by distributing them at relevant Continuing Medical Education (CME) courses and at the AAOS Resource Center.

## STUDY ATTRITION FLOWCHART



## RECOMMENDATIONS

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Recommendations are formed when there is sufficient evidence by which to create a directional statement. This is defined as evidence from two or more high quality studies (i.e., a strong recommendation), two or more moderate quality studies (i.e., a moderate recommendation), or statements resulting in a strong or moderate strength following Evidence to Decision Framework upgrading and/or downgrading.

## HISTORY AND PHYSICAL

---

**A relevant history should be obtained, and a focused musculoskeletal exam of the lower extremities should be performed when assessing for an ACL injury.**

**Strength of Evidence:** Strong

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

*Evidence from two or more “High” quality studies with consistent findings for recommending for or against the intervention.*

### Rationale

There were six high quality (Blanke 2020, Cooperman 1990, Jarbo 2017, Juyal 2013, Shelbourne 2009, Sobrado 2021), two moderate quality (Rayan 2009, Fowler 1989), and one low quality study (Pookarnjanamorakot 2014) evaluating history and physical examination as diagnostic tools for ACL injury.

Relevant history is important for diagnosing ACL injuries and concomitant pathology and should include at a minimum the mechanism and date 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 of the lower extremity with documentation of both distal perfusion and tibial/peroneal nerve function, assessment of varus and valgus laxity at 0 and 30 degrees of flexion, dial testing at 30 and 90 degrees of flexion, and evaluation of anterior-posterior laxity with Lachman’s and anterior drawer and rotational laxity with pivot shift and active buckling sign tests.

### Benefits/Harms of Implementation

A thorough history and physical exam will assist the practitioner in prompt and accurate diagnosis of ACL injuries and concomitant pathology. There are no known harms associated with appropriate implementation of this recommendation.

### Outcome Importance

The six high quality studies reviewed demonstrated the high significance of a sound history and physical toward assessing ACL injury.

**Cost Effectiveness/Resource Utilization**

Performing a sound history and physical should not add any significant cost to ACL injury assessment.

**Acceptability**

Evaluation and diagnosis of ACL injury using a relevant history and physical examination should have universal acceptability.

**Feasibility**

Most feasible to expect healthcare professionals to perform and incorporate relevant history and physical examination in assessment of ACL injury.

**Future Research**

Future research could help confirm the most useful history and physical exam findings for the diagnosis of ACL injury and concomitant pathology.

## SURGICAL TIMING

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**When surgical treatment is indicated for an acute isolated ACL tear, early reconstruction is preferred because the risk of additional cartilage and meniscal injury starts to increase within 3 months.**

**Strength of Evidence:** Strong

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

*Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.*

### Rationale

When indicated based on shared decision making with the patient, several studies have demonstrated benefit of early reconstruction. Range of motion was not affected by early versus delayed surgery: Baba (2019) <1 month, 2-3 months or >3 months; Herbst (2017) <48 hours vs after acute inflammatory phase; Bottoni (2008) <21 days vs >6 weeks; Chua (2020) <3 weeks vs > 3 weeks.

With respect to general patient satisfaction and function there was no convincing evidence that early versus later reconstruction had an impact on outcomes. Two studies (Baba 2019, Signorelli 2016) did show that instrumented laxity was less with early reconstructions compared to late reconstructions.

Regarding the presence of meniscus injury at time of ACL reconstruction several high quality studies, (Newman 2015, Anderson 2015, Mok 2019) and many lower quality studies, (Hur 2017, Everhart 2019, Baba 2019, Brambilla 2015, Keyhani 2020, Chavez 2020, Kawashima 2020, Krutsch 2017, Stone 2019, Chen 2019) showed that early ACL reconstructions had less meniscus injury than late ACL reconstructions at the time of surgery. The Newman (2015), Keyhani (2020), and Anderson (2015) studies showed that a delay of > 3 months was a predictor of more severe meniscus injury. The Everhart (2019) study showed that a delay of greater than 8 weeks resulted in an increased incidence of meniscus tears, while the Mok (2019) study showed that reconstructions performed within 12 months have fewer meniscus tears. They did not investigate whether the increased risk may have occurred prior to the 12-month point. The Kawashima (2020) study noted increased meniscus tears in reconstructions performed >5 months post-injury. Chavez (2020) noted an increase in meniscus tears in reconstructions performed >6 months after injury. The Newman (2015), Krutsch (2017), and Hur (2017) studies also showed that the meniscus injuries in the early reconstructions were more likely to be repairable than those in late reconstructions with variable definitions of early vs late reconstruction. Chen (2019) demonstrated that meniscus tears occurring after the injury MRI were increased in reconstructions performed >12 months post-injury. The Stone (2019) study found that reconstructions performed after >12 months had increased risk of subsequent medial meniscus tears. Snoeker (2020) showed that early ACL reconstruction resulted in fewer subsequent medial meniscus tears in the 5 years following surgery compared to delayed reconstruction.

With respect to the presence of articular cartilage damage at time of ACL reconstruction two high quality papers (Anderson 2015, Newman 2015) and several lower quality studies (Brambilla 2015, Chavez 2020, Everhart 2019, Kawashima 2020, Senorski 2019) showed that late ACL reconstructions had increased articular cartilage damage compared to early reconstructions at the time of surgery. The Anderson (2015) study showed this to occur as early as 3 months, while the Everhart (2019) study showed it to occur at 5 months. Brambilla (2015) showed that there was less intra-articular damage (meniscal and chondral) in reconstructions performed <3 months after injury compared to >12 months. Chavez (2020) showed increase in chondral damage if reconstruction performed > 6 months, while the Kawashima (2020) study demonstrated increased chondral damage after 5 months. Senorski (2019)

showed that older patients who waited > 1 year for reconstruction had greater risk of long-term osteoarthritis.

### **Benefits/Harms of Implementation**

Delaying ACL reconstruction after an ACL injury increases the risk of meniscal and chondral damage which could increase the risk of long-term post-traumatic osteoarthritis in the knee.

### **Outcome Importance**

If surgical decision making includes proceeding with an ACL reconstruction after an acute ACL injury, earlier reconstruction may decrease the risk of meniscal and chondral damage in the knee, and thus long-term degenerative changes in the knee.

### **Cost Effectiveness/Resource Utilization**

Earlier surgery does not increase cost and may decrease cost by reducing overall time in rehabilitation and recovery, with quicker return to activity, sports, and work, as well as reducing the likelihood of needing concomitant meniscal and articular cartilage procedures, which often add implant cost.

### **Acceptability**

Younger and more active patients should be treated as expeditiously as possible for this reason. Older, less active patients who may do well with nonoperative treatment of ACL tears can be considered differently.

### **Feasibility**

Performing ACL reconstruction within 3 months of an acute ACL tear is feasible in most settings.

### **Future Research**

Prospective studies controlling for confounders to continue to define the ideal time for surgical intervention after an ACL injury would be valuable. Studies to assess the cost effectiveness of early versus late ACL reconstruction would also be informative.

## SINGLE OR DOUBLE BUNDLE ACL RECONSTRUCTION

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**In patients undergoing intraarticular ACL reconstruction single or double bundle techniques can be considered because measured outcomes are similar.**

**Strength of Evidence:** Strong

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

*Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.*

### **Rationale**

There are twenty-four high quality studies (Adachi 2004, Adrayanti 2017, Aga 2018, Aglietti 2010, Beyaz 2017, Ibrahim 2009, Jarvela 2017, Jarvela 2008, Kang 2015, Karikis 2016, Liu 2016, Mayr 2016, Mayr 2018, Mohtadi 2019, Mohtadi 2015, Mohtadi 2016, Núñez 2012, Sasaki 2016, Sun 2015, Suomalainen 2012, Suomalainen 2011, Yang 2017, Zhang 2014, Irrgang 2021) that compare single to double bundle ACL reconstruction. The majority of the studies demonstrate no statistically significant difference in any outcome parameters. Five meta-analyses demonstrated no statistically significant difference between single and double bundle reconstruction in post-operative pain, Lysholm, or IKDC subjective knee scores.

### **Benefits/Harms of Implementation**

As with all surgery procedures, there are surgical risks and complications including but not limited to, graft failure, arthrofibrosis, infection, neurovascular injury, and anesthetic complications.

### **Outcome Importance**

The many high quality studies demonstrate that either single- or double-bundle ACL reconstruction can result in excellent functional and clinical outcomes.

### **Cost Effectiveness/Resource Utilization**

While equivalent in outcomes, double-bundle ACL reconstructions involve increased surgical time and increased costs.

### **Acceptability**

Single and double bundle ACL reconstructions are both acceptable procedures for the reconstruction of ACL deficient knees, when indicated.

### **Feasibility**

Both single- and double-bundle ACL reconstruction are feasible surgical treatment for ACL reconstruction.

### **Future Research**

While no differences have been noted at 10-year follow up, future research is indicated to determine any differences between single and double bundle ACL reconstructions in the rate of degenerative changes at long-term (> 20 year) follow up.

## AUTOGRAFT VS. ALLOGRAFT

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**When performing an ACL reconstruction, surgeons should consider autograft over allograft to improve patient outcomes and decrease ACL graft failure rate, particularly in young and/or active patients.**

**Strength of Evidence:** Strong

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

*Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.*

### Rationale

Autograft, as compared to allograft, particularly in young and/or active patients, is favored for treatment based on lower graft ruptures/revisions. Ten low quality studies (Lenehan 2015, Yabroudi 2016, Steadman 2015, Schilaty 2017, Perkins 2019, Maletis 2017, Maletis 2016, Kane 2016, Kaeding 2017, Engelman 2014), improved IKDC scores based on 1 high (Jia 2015) and one moderate quality (Li 2015), knee laxity based on one moderate (Li 2015) and one low quality study (Zhang 2017) and return to activity based on one high (Nwachukwu 2017) and one low quality study (Mardani-Kivi 2020). Despite five high quality studies (Yoo 2017, Nwachukwu 2017, Sun 2015, Jia 2015, McCarthy 2017) which did not favor autograft or allograft, Li (2015) performed a randomized controls trial compared allograft, autograft, and a hybrid graft and found the autograft and hybrid had significant improvement in functional scores compared to allograft.

### Benefits/Harms of Implementation

Use of autograft for primary ACL reconstruction reduces risk of re-injury and improves outcomes compared to allograft. Additional benefits include lower cost and avoiding risk (albeit low) of disease transmission. Potential harm of autograft use is increased surgical time (albeit short) and potential graft morbidity such as increased pain and functional deficits.

### Outcome Importance

Graft re-tear is a very important outcome, perhaps the most important outcome, particularly in younger patients returning to high level activity and sport. Functional outcomes are probably the next most important outcome and also favor autograft use. Graft morbidity is a less significant outcome, although still important to consider, with some potential advantages with allograft, while infection risk is low.

### Cost Effectiveness/Resource Utilization

Autograft is less expensive than allograft, even when considering surgical time for harvest. Lower re-tear rate is likely associated with cost savings as well.

### Acceptability

Autograft use is readily acceptable as this graft choice should be part of the armamentarium of all surgeons performing ACL reconstruction.

### Feasibility

Implementation is feasible as autograft use should be part of the armamentarium of all surgeons performing ACL reconstruction.



**Future Research**

Future research should evaluate the long-term consequences of differing graft options, as well as relative cost effectiveness.

## AUTOGRAFT SOURCE

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**When performing an ACL reconstruction with autograft for skeletally mature patients, surgeons may favor BTB to reduce the risk of graft failure or infection, or hamstring to reduce the risk of anterior or kneeling pain.**

**Strength of Evidence:** Strong

**Strength of Recommendation:** Moderate  (downgraded)

*Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.*

### **Rationale**

The autograft source recommendation was downgraded one level due to variable size of hamstring autografts. A total of eleven high quality and two moderate quality studies were identified to evaluate the comparison of bone patellar bone autograft and hamstring autograft. In the largest randomized control trial, Mohtadi (2019) reported on longer term data (5 years) in a randomized control trail between double bundle ACL, hamstring autograft, and bone patellar bone autograft with a total of 353 patients at 5-year follow up. This study demonstrates lower graft ruptures/revision in the bone patella bone autograft compared to the others. Added benefits of bone patella bone autograft compared to hamstring autograft were also noted in other high quality studies by Laboute (2018) and Drogset (2010). Bone patellar bone was also favored based on other studies (Maletis 2016, Sevimli 2020, Rousseau 2019, Lord 2020, King 2020, Rahardja 2020), however several have noted bone patellar bone associated with more knee pain (Rousseau 2019, Webster 2016, Mohtadi 2016).

### **Benefits/Harms of Implementation**

Surgeon and patient preference will be part of informed decision making to guide graft choice of ACL reconstruction.

### **Outcome Importance**

Graft re-tear is a very important outcome, perhaps the most important outcome, particularly in younger patients returning to high level activity and sport. Infection is rare but challenging complication. The importance of kneeling pain is likely patient specific.

### **Cost Effectiveness/Resource Utilization**

Likely cost neutral overall with shift in fixation methods but minimal otherwise.

### **Acceptability**

Use of bone patellar bone and hamstring autograft are readily acceptable as these grafts should be part of the armamentarium of all surgeons performing ACL reconstruction.

### **Feasibility**

Implementation is feasible as bone patellar bone and hamstring autograft should be part of the armamentarium of all surgeons performing ACL reconstruction.

### **Future Research**

Future research should evaluate the long-term consequences of differing graft options, as well as relative cost effectiveness. Quad tendon autograft deserves further study as an emerging option for ACL reconstruction.

## ACL TRAINING PROGRAMS

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**Training programs designed to prevent injury can be used to reduce the risk of primary ACL injuries in athletes participating in high-risk sports.**

**Strength of Evidence:** Moderate

**Strength of Recommendation:** Moderate 

*Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention.*

### **Rationale**

The high quality study of adolescent, female Speak Takraw athletes by Yarsiasat (2019) demonstrated that incorporating a training program that included strengthening maneuvers, plyometric and sports-specific agility exercises significantly reduced the rate of complete ACL tears 5.32 (1.11 to 15.58). There is no discussion of whether these ACL injuries are primary or secondary. The rate of partial ACL tears was not significantly different between groups.

A moderate quality study of male NCAA soccer athletes by Silvers-Granelli (2017) demonstrated significant reductions in total injuries ( $p < 0.001$ ), total knee injuries ( $p < 0.001$ ), and ACL injuries ( $p = 0.21$ ) in athletes performing the training program. There is no discussion of whether these ACL injuries are primary or secondary and no distinction between complete and partial ACL injury.

A moderate quality study of adolescent, female Danish football (soccer) athletes by Walden (2012) showed a significant reduction in ACL injury rate ratio (.36 95%CI 0.15 to 0.85,  $P = 0.02$ ). Partial ACL injuries with clinical instability and MRI confirmation were treated equal to complete ACL injuries in the analysis.

### **Benefits/Harms of Implementation**

There are three moderate quality studies (Walden 2012, Silvers-Granelli 2017, Olsen 2005) and one high quality study (Johnson 2020) demonstrating benefit of exercise training in ACL injury prevention. No high or moderate quality studies have demonstrated harm.

### **Outcome Importance**

ACL injury is a major source of musculoskeletal cost and morbidity. Additionally, it is a major source of time lost from sport participation. Many athletes and individuals never return to their pre-injury sport participation activity level.

### **Cost Effectiveness/Resource Utilization**

The cost of implementing training programs designed to prevent primary ACL injury is not well studied.

### **Acceptability**

Effective exercise programs capable of reducing primary ACL injury should be accepted widely by the sports medicine community.

### **Feasibility**

Compliance with structured exercise programs depends on the demands of the athlete in terms of time, space, equipment, and motivation.

## **Future Research**

Future research should examine ways to optimize exercise programs by decreasing their length/complexity while maximizing injury prevention benefits, elucidate the optimal timing/duration of program and the length of prevention effect, and assess the cost effectiveness of these programs. Additionally, recognizing that ACL injury risk increases dramatically from 11-17 years of age in both sexes and coincides with the increasing risk in females over males and additional research understanding the increased risk in pediatric patients, timing of this risk and subsequent intervention for prevention strategies.

## ANTEROLATERAL LIGAMENT / LATERAL EXTRAARTICULAR TENODESIS

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**ALL reconstruction / LET could be considered when performing hamstring autograft reconstruction in select patients to reduce graft failure and improve short-term function, although long-term outcomes are yet unclear.**

**Strength of Evidence:** Strong

**Strength of Recommendation:** Moderate  (downgraded)

*Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.*

### **Rationale**

The ALL/ LET recommendation was downgraded one level due to potential added incisions, implants, and time under anesthesia. Two high quality (Hamido 2020, Chen 2021) studies report a lower rate of graft rupture/failure when ALL reconstruction is performed at the time of ACL reconstruction with a hamstring autograft. Two high quality studies (Hamido 2020, Ibrahim 2017) report that post-operative function favors combined ACL and ALL reconstruction over isolated ACL reconstruction with a hamstring autograft. One high quality study (Getgood 2020) and two low quality studies (King 2020, Rowan 2019) report a lower rate of graft rupture/failure, ACL reinjury, or revision ACL surgery when LET is performed with hamstring ACL reconstruction. One high quality study (Vadala 2013) and two low quality studies (King 2020, Rowan 2019) report better post-operative function when LET is performed. The long-term impact of ALL reconstruction and LET are unclear. One moderate quality study (Castoldi 2020) reports a higher rate of lateral compartment osteoarthritis in patients that underwent LET, but these patients also had a higher rate of partial lateral meniscectomy during or after the time of ACL reconstruction.

### **Benefits/Harms of Implementation**

ALL reconstruction and LET are additional procedures that may require additional time under anesthesia, incisions, and implants. These may increase the peri-operative risks. One recent study (Castoldi 2020) demonstrated early signs of lateral compartment osteoarthritis in the ACL/LET cohort compared to the ACL only cohort. The key benefits of these procedures may be improved function and lower risk of revision surgery.

### **Outcome Importance**

Given the increasing incidence of ACL injury and the potential medical, financial, and psychosocial impact of revision surgery, evaluation of factors affecting the risk of re-operation is important.

### **Cost Effectiveness/Resource Utilization**

ALL reconstruction and LET are additional procedures that may require additional time under anesthesia and implants, both of which increase the overall cost. However, this may be balanced against the cost of revision surgery and subsequent rehabilitation.

### **Acceptability**

Much debate persists about anterolateral augmentation procedures, although they continue to rise in popularity. Selected use of this technique is appropriate based on surgeon and patient specific factors.

### **Feasibility**

Implementation of the recommendation is feasible, but a learning curve may exist for surgeons that have not performed these procedures previously.

### **Future Research**

Future research should focus on medium and long-term outcomes after ALL reconstruction or LET (including graft failure, osteoarthritis, and patient reported outcomes). Furthermore, the impact of ALL or LET with patellar tendon or quadriceps tendon grafts should be investigated, as the majority of current data pertains to hamstring ACL reconstruction. Additional research can also investigate the impact of these procedures on adolescents, especially females, who are at highest risk of graft failure.

## REPAIR VS. RECONSTRUCTION

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**ACL tears indicated for surgery should be treated with ACL reconstruction rather than repair because of the lower risk of revision surgery.**

**Strength of Evidence:** Strong

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

*Evidence from two or more “High” quality studies with consistent findings for recommending for or against the intervention. Also requires no reasons to downgrade from the EtD framework.*

### **Rationale**

Two high quality studies (Sporsheim 2019, Drogset 2006) and one low quality study (Achtnich 2016) show a lower rate of revision ACL surgery in patients undergoing primary reconstruction than in those undergoing repair. Regarding post-operative function, two high quality studies favor reconstruction (Drogset 2006, Kosters 2020) while two high quality studies favor repair (Sporsheim 2019, Murray 2020).

### **Benefits/Harms of Implementation**

ACL reconstruction is a common procedure and high quality studies suggest a lower rate of revision surgery compared to repair.

### **Outcome Importance**

Given the increasing incidence of ACL injury and the potential medical, financial, and psychosocial impact of revision surgery, evaluation of factors affecting the risk of re-operation is important.

### **Cost Effectiveness/Resource Utilization**

Both ACL reconstruction and repair are resource-intensive when accounting for surgical costs as well as post-operative rehabilitation. Revision surgery, when necessary, also requires substantial resources.

### **Acceptability**

While ACL repair research and technique continue to develop, ACL reconstruction is currently the standard of care.

### **Feasibility**

ACL reconstruction is currently the standard of care for primary ACL injury.

### **Future Research**

Future research should focus on lowering the rate of revision surgery for ACL repair. This may include innovations in patient selection based on tear location, biologic intervention and/or surgical technique.

## OPTIONS

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Low quality evidence, no evidence, or conflicting supporting evidence have resulted in the following statements for patient interventions to be listed as options for the specified condition. Future research may eventually cause these statements to be upgraded to strong or moderate recommendations for treatment.

### ASPIRATION OF THE KNEE

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**In the absence of reliable evidence, it is the opinion of the workgroup that physicians may consider aspirating painful, tense effusions after knee injury.**

**Strength of Evidence:** N/A

**Strength of Option:** Consensus ★★★★★

*Description: Evidence there is no supporting evidence, or limited level evidence was downgraded due to major concerns addressed in the EtD framework. In the absence of reliable evidence, the guideline work group is making a recommendation based on their clinical opinion.*

#### **Rationale**

No relevant articles have been published in the last 20 years regarding the benefit of aspiration in acutely injured knees.

#### **Benefits/Harms of Implementation**

Acute knee aspiration has the potential to decrease pain and improve early ROM in ACL injured knees. Acute aspiration may also decrease the presence of cytokines which may be implicated in the cascade progressing to osteoarthritis following ACL tear. Aspiration of the knee has the potential to introduce infection in an acutely injured knee.

#### **Outcome Importance**

Unclear.

#### **Cost Effectiveness/Resource Utilization**

Minimal cost, and minimal use of resources to perform aspiration.

#### **Acceptability**

If there are positive clinical implications, knee aspiration would be an acceptable treatment for acutely ACL injured knees when indicated.

#### **Feasibility**

Knee aspiration in acute ACL tears, if indicated, would be feasible in many situations. Prospective, randomized trials will be needed to determine the effect of aspiration of the hematoma following acute ACL tear in reducing pain and/or improving clinical outcome.

#### **Future Research**

Prospective, randomized trials will be needed to determine the effect of aspiration of the hematoma following acute ACL tear in reducing pain and/or improving clinical outcome.



## ACL SURGICAL RECONSTRUCTION

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**ACL reconstruction can be considered in order to lower the risk of future meniscus pathology or procedures, particularly in younger and/or more active patients. ACL reconstruction may be considered to improve long term pain and function.**

**Strength of Evidence:** Limited

**Strength of Option:** Limited ★★☆☆

*Description: Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.*

### Rationale

Two low quality studies (Dunn 2004, Streich 2011) demonstrate a lower risk of adverse events (meniscus injury, secondary meniscectomy) after ACL reconstruction (ACLR). One high quality study (Tsoukas 2016) and six low quality studies (Meuffels 2009, Yperen 2018, Kovalak 2018, Dawson 2016, Wellsandt 2018, Streich 2011) report better function after ACL reconstruction via patient reported outcomes. Two low quality studies (Kessler 2008, Wellsandt 2018) report more frequent progression to osteoarthritis with ACL reconstruction compared to non-operative treatment while one low quality study (Lin 2017) favors ACL reconstruction. One low quality study (Wellsandt 2020) reports more knee joint loading in patients treated non-operatively, but no difference in the rate of radiographic arthritis. Two low quality studies (Arderm 2017, Wellsandt 2018) report less long-term pain after ACL reconstruction compared to non-surgical treatment. One low quality study suggests better quality of life after ACL reconstruction (Arderm 2017). There is no significant difference in return to activity based on three low quality studies (Kovalak 2018, Wellsandt 2018, Wellsandt 2020). Group consensus suggests that age and activity levels are important considerations when deciding between treatment options. For example, the study by Dunn (2004) was conducted in young military personnel and favored surgical reconstruction. Finally, while the available literature does not typically consider the impact of concomitant meniscus or chondral injuries when comparing outcomes of surgical versus non-surgical treatment of ACL tears, the workgroup suggests that concomitant injuries should be factored into treatment decisions. Previous AAOS clinical practice guidelines have recommended prompt treatment of ACL tears associated with a locked knee due to displaced meniscus tear in order to prevent a flexion contracture and further meniscal deficiency. However, this was based on group consensus due to limited evidence.

### Benefits/Harms of Implementation

ACL reconstruction is a common procedure. While reconstruction offers a number of benefits, evidence regarding long-term differences in outcomes between operative and non-operative treatment is lacking.

### Outcome Importance

A number of outcomes are important in patients with an ACL injury. These include subjective and objective knee function, pain, return to activity, secondary injuries or surgeries, and progression to osteoarthritis. All of these are important and may have substantial medical, financial, and psychosocial effects.

### Cost Effectiveness/Resource Utilization

In the short-term, ACL reconstruction is more costly than non-operative treatment. Long-term cost-effectiveness comparisons are lacking.

### Acceptability

ACL reconstruction is a common procedure, so acceptability likely will not be a concern.

**Feasibility**

ACL reconstruction is a common procedure, so feasibility likely will not be a concern.

**Future Research**

Future research should strive for higher methodological quality. Additionally, stratified analyses (along the lines of age, activity level, patient goals, etc.) will help determine specifically which patients benefit from ACL reconstruction versus non-operative treatment.

## MENISCAL REPAIR

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**In patients with ACL tear and meniscal tear, meniscal preservation should be considered to optimize joint health and function.**

**Strength of Evidence:** Limited

**Strength of Option:** Limited ★★☆☆

*Description: Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.*

### Rationale

Prior CPG recommendations in 2014 presented limited evidence for concomitant meniscus repairs in conjunction with an ACL reconstruction. However, it supports that practitioners might consider meniscus repair because it improves patient outcomes. In this updated CPG, four low quality evidence studies favor meniscus repair due to improved healing (Hatayatama 2020), revision surgery (Pullen 2016), osteoarthritis progression (Pan 2015), and return to sports (Keyhani 2018). No study favors improvement in function in meniscus repair compared to no repair while performing an ACL reconstruction. There is one high quality (McCarthy 2017), one moderate quality (LaPrade 2015), and four low quality studies (Lord 2020, Hoshino 2021, Eken 2020, Cristiani 2020) that address meniscus repair versus resection. The high quality study (McCarthy 2017) notes that a meniscus repair has a higher rate of future knee procedures in the short term, particularly medial meniscus repairs, which was also supported by a low quality study (Lord 2020). Three low quality studies demonstrate conflicted opinions regarding meniscus repair vs. resection (Hoshino 2021, Eken 2020, Cristiani 2020).

Notable is that no study in the recent series demonstrated long term outcome or OA progression favoring meniscus repair vs. no repair vs. resection. All studies presented had 2-3 year follow up. Long term studies are lacking.

### Benefits/Harms of Implementation

The theoretical benefit of performing a meniscus repair is for long term knee preservation, however, evidence has not yet supported meniscus repairs to minimize or delay the rate of osteoarthritis. A meniscus repair may be associated with higher rates of subsequent knee surgery, but no additional adverse events were noted.

### Outcome Importance

With the improvement in device design, meniscus repairs are becoming more common as compared to technically easier meniscal resection or no repair. To date, there is not significant evidence to support meniscus repair, however, the potential substantial long-term benefit should still be considered.

### Cost Effectiveness/Resource Utilization

Meniscus repair is notably more costly (time and value of implants) than a meniscus resection or no repair.

### Acceptability

Early data will likely not sway the importance of meniscus repair as historical data has suggested meniscal resection clearly advances osteoarthritis progression in the long term. Patient factors such as age, BMI and activity level may be important considerations that affect the value of meniscal preservation.

**Feasibility**

The impact of this recommendation will not likely change practice.

**Future Research**

Long term studies that focus on meniscus repair and the rates of osteoarthritis progression are required in order to determine the value of this procedure.

## COMBINED ACL / MCL TEAR

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**In patients with combined ACL and MCL tears, non-operative treatment of the MCL injury results in good patient outcomes, although operative treatment of the MCL may be considered in select cases.**

**Strength of Evidence:** Moderate

**Strength of Option:** Limited ★★☆☆ (downgraded)

*Description: Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.*

### Rationale

The combined ACL/ MCL tear recommendation was downgraded one level due to imprecision of evidence.

Level 1 evidence:

Funchal (2019) in a prospective randomized trial demonstrated that when a combined ACL / MCL injury resulted in an arthroscopic finding of a “floating meniscus”, those patients randomized into the MCL reconstruction group had lower ACL reconstruction failure and better Tegner and Lysholm scores compared to the MCL non-operative group. This study supports that combined ACL/MCL injuries with greater MCL laxity may benefit from MCL reconstruction at time of ACL reconstruction.

Level 3 evidence:

Svantesson (2019) – Swedish registry study of 19,457 patients comparing the ACL revision incidence and KOOS scores of isolated ACL reconstructions and ACL reconstructions with concomitant MCL injuries treated with or without surgery. At 5 years, isolated ACL reconstructions had fewer revisions compared to the ACL/MCL combined injuries with MCL treated non-operatively; while the ACL/MCL combined injuries with the MCL treated surgically did not demonstrate increased ACL revision compared to isolated ACL reconstructions. This study provides evidence that surgical treatment of the MCL in some ACL/MCL injured knees may be beneficial to decrease the risk of subsequent ACL graft failure.

### Benefits/Harms of Implementation

MCL repair/reconstruction may decrease risk of recurrent ACL laxity/re-tear. MCL surgery may result in an early delay in return in quad strength and ROM but this normalizes by 2 years post op (Halinen 2009). Also, surgical treatment of MCL may decrease KOOS scores (Svantesson 2019).

### Outcome Importance

Decreasing the risk of ACL reconstruction failure.

### Cost Effectiveness/Resource Utilization

There is increased cost and time for surgical treatment of MCL injury. How these procedures impact the cost of postoperative rehabilitation and treatment of re-injury is unknown.

### Acceptability

Likely.

### Feasibility

In patients with combined ACL and MCL tears, non-operative treatment is feasible.

### Future Research

Prospective studies to determine which MCL tears need to be repaired/reconstructed while controlling for confounders such as severity and location of MCL injury.

## PROPHYLACTIC KNEE BRACING

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### Prophylactic bracing is not a preferred option to prevent ACL injury.

**Strength of Evidence:** Limited

**Strength of Option:** Limited ★★☆☆

*Description: Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.*

#### Rationale

One moderate quality (Sitler 1990) and one low quality study (Deppen 1994) informed this recommendation.

The Sitler (1990) study discussed the rate of knee ligament injuries in 1,396 braced versus unbraced intramural football players at West Point Military Academy over two fall seasons. Injuries to the medial collateral ligament was the primary outcome of interest in this study, but ACL injuries were tracked as a secondary endpoint. A greater number of ACL injuries occurred in the unbraced (n=12) than in the braced (n=4) group; however, this result was not significantly different (Fisher exact probability =0.81).

The Deppen (1994) study assessed the rate of knee ligament injuries in 524 first string, high school football players across four fall seasons. Again, MCL injury, was the primary outcome of interest, with ACL injury secondarily studied. 2 ACL injuries occurred in braced athletes across 21,640 exposures and 7 ACL injuries occurred in non-braced athletes across 19,484 exposures. This difference was not statistically significant (p>0.05), neither was the rate of non-contact versus contact ACL injury significant between groups (2 braced vs 5 non-braced p>0.05).

#### Benefits/Harms of Implementation

There is ample evidence that prophylactic knee bracing alters lower extremity biomechanics. These alterations in biomechanics may predispose to other injuries, and without demonstrated ACL injury prevention benefit, may increase rather than decrease overall injury risk. More importantly, reliance on the uncertain properties of prophylactic bracing could decrease participation in injury prevention exercise programs which have been shown to be protective against ACL and other lower extremity injuries.

#### Outcome Importance

ACL injury is a major source of musculoskeletal cost and morbidity. Additionally, it is a major source of time lost from sport. Many athletes and individuals never return to the same level of sport or activity following ACL injury.

#### Cost Effectiveness/Resource Utilization

The financial cost of prophylactic bracing would be considerable. Bilateral bracing of every athlete engaged in high-risk sport would add significantly to the cost of participation and heighten socio-economic bias. This would need to be weighed against any injury reduction benefit which has not been demonstrated to date.

#### Acceptability

Prophylactic bracing may potentially be acceptable to athletes participating in higher-risk sports

**Feasibility**

It is not likely feasible to employ prophylactic braces in every athlete for each competition and practice of high-risk sport for ACL injury.

**Future Research**

Future research could explore subgroups where bracing may show more significant effects.

## RETURN TO SPORT

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**Functional evaluation, such as the hop test, may be considered as one factor to determine return to sport after ACL reconstruction.**

**Strength of Evidence:** Limited

**Strength of Option:** Limited ★★☆☆

*Description: Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention.*

### Rationale

Two low quality studies (Nawasreh 2018, Toole 2017) show that application of hop test criteria for return to sport results in better return to preinjury quality of exercise and maintenance of level of sports participation for one year. There is little evidence regarding other criteria, including muscle function, timing of return to play, kinesiophobia, and other rating scales. Specifically, the optimal timing of functional testing and return to sport is unclear based on the literature. Nawasreh (2018) performed hop testing 6 months after surgery, while the timing was more variable in the study by Toole (2017) (mean 8.1 months after surgery). One low quality study (Beischer 2020) suggests that using 9 months as a criterion from return to sport results in a lower rate of graft failure/rupture while another (Webster 2021) finds no difference when 12-month criteria are applied.

### Benefits/Harms of Implementation

Hop testing criteria for return to sport presents little direct risk of harm. However, it is unclear whether there is a risk of adverse events if a patient were to meet hop test criteria but not others, including temporal parameters.

### Outcome Importance

Outcomes like return to sport and graft failure are important after ACL reconstruction. Therefore, establishing criteria for safe return to sport is crucial.

### Cost Effectiveness/Resource Utilization

Hop testing requires a competent tester and space for the testing. Many physical therapy or athletic training facilities are currently capable of performing such assessments. Other testing, such as muscular function, may require more expensive or space-prohibitive equipment.

### Acceptability

Hop testing has been described for quite some time, so the recommendation will be acceptable to clinicians.

### Feasibility

Implementation of hop testing criteria is reasonable but requires personnel and space to perform the testing.

### Future Research

Future research should strive for higher study quality and focus on the impact of various criteria (time from surgery, functional testing, strength testing, psychological readiness, etc.) on safe return to activity after ACL reconstruction in order to establish better evidence-based guidelines.



## RETURN TO ACTIVITY FUNCTIONAL BRACING

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**Functional knee braces are not recommended for routine use in patients who have received isolated primary ACL reconstruction, as they confer no clinical benefit.**

**Strength of Evidence:** Strong

**Strength of Recommendation:** Limited ★★☆☆ (downgraded)

*Description: Evidence from one or more “Low” quality studies with consistent findings or evidence from a single “Moderate” quality study recommending for or against the intervention*

### Rationale

The Return to Activity Functional Bracing recommendation has been downgraded two levels for imprecision of evidence (e.g., heterogeneity of patient characteristics, graft choice, and rehabilitation protocols).

Two high quality (McDevitt 2004, Birmingham 2008), but limited studies showed no significant differences between braced and unbraced individuals returning to full activity following isolated primary ACL reconstruction. The studies follow a multitude of clinical, patient-reported, and injury outcomes after ACL reconstruction. One study included patients with bone-patellar tendon-bone autografts, the other study included patients with hamstring autografts. While both are high quality and concordant, the studies are limited by several factors. First, the studies utilized braces that may be inferior in fit and quality to custom braces available today. Second, the studies were relatively short term: 12 months for McDevitt and 24 months for Birmingham (but with compliance only measured for 12 months). The studies vary in terms of timing and duration of the bracing protocol, do not involve large cohorts and may be underpowered for some outcomes. Hence, current evidence, though limited, does not demonstrate any benefit from bracing during the process of returning to sport after ACL reconstruction.

### Benefits/Harms of Implementation

There are no proven benefits to functional bracing following primary ACL reconstruction. While there are no significant harms, there is increased cost and early bracing has been linked to decreased thigh circumference.

### Outcome Importance

The two high quality studies included a wide range of clinical, injury, and patient-reported outcomes, many of high significance. The studies are not large cohorts and may be underpowered for some outcomes.

### Cost Effectiveness/Resource Utilization

Functional bracing increases the cost of ACL recovery by approximately \$200 - \$2,000, depending on choice of brace. Current evidence does not establish a benefit from the additional cost.

### Acceptability

The use of functional bracing during return to activity/sport after ACL reconstruction is variable. This recommendation should be acceptable to the sports medicine community.

### Feasibility

Highly feasible for surgeons not to require a brace for return to activity and sport progression after isolated ACL reconstruction.

### Future Research

While there is no evidence to date of clinical benefit from brace use for return to activity following isolated ACL reconstruction, the variance in bracing protocols and relatively small size of the study cohorts

suggests more research is warranted. Opportunities for further study include analysis of newer custom designed braces, the impact of graft choice on bracing efficacy, outcomes of long term bracing after return to sport, and the potential role of bracing in subgroups such as high risk young athletes as well as following treatment of combined injuries such as multi-ligament reconstructions or ACL reconstruction and meniscal repair.

# APPENDICES

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## Appendix I: References

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## Appendix II: PICO Questions and Inclusion Criteria Used to Define Literature Search

1. In subjects who sustain a knee injury, is physical exam an accurate diagnostic modality for ACL tear?
2. In patients with a knee injury with symptomatic effusions, does aspiration result in better patient outcomes?
3. In patients with primary ACL tear, does surgical reconstruction result in improved patient outcomes?
4. In patients with combined injury of ACL tear and meniscal tear, if repairable, does ACL reconstruction and preservation/repair of the meniscal tear result in improved patient outcomes?
5. In patients with ACL tear and MCL tear, does reconstruction of the ACL and non-operative treatment of the MCL tear result in improved patient outcomes?
6. In patients with acute isolated ACL tear, what timing of reconstruction surgery is indicated to protect articular cartilage and menisci?
7. In symptomatic patients who require intra-articular ACL reconstruction, does single or double bundle treatment result in better patient outcomes?
8. In patients undergoing ACL reconstruction, which graft type results in better patient outcomes?
9. In patients who have received isolated primary ACL reconstruction, does functional knee bracing result in improved patient outcomes?
10. In patients who had not been diagnosed with an ACL injury, does prophylactic knee bracing prevent ACL injury?
11. In patients participating in high-risk sports, do training programs reduce primary ACL injuries?
12. In patients who have had an ACL injury or ACL reconstruction, what are the factors and criteria to consider for return to play decision making?
13. In patients with an ACL tear receiving primary ACL reconstruction, does adding ALL (anterolateral ligament) / LET (lateral extraarticular tenodesis) result in improved patient outcomes?
14. In patients with isolated primary ACL tear, does treatment with repair or reconstruction result in improved patient outcomes?

## Study Inclusion Criteria

- Study must be of an Anterior Cruciate Ligament injury or prevention thereof
  - Article must be a full article report of a clinical study.
    - Retrospective non-comparative case series, **medical records review**, meeting abstracts, historical articles, editorials, letters, and commentaries are excluded.
  - Confounded studies (i.e. studies that give patients the treatment of interest AND another treatment) are excluded.
  - Case series studies that have non-consecutive enrollment of patients are excluded.
  - Controlled trials in which patients were not stochastically assigned to groups AND in which there was either a difference in patient characteristics or outcomes at baseline AND where the authors did not statistically adjust for these differences when analyzing the results are excluded.
  - All studies of “Very Weak” strength of evidence are excluded.
  - All studies evaluated as Level V will be excluded.
  - Composite measures or outcomes are excluded even if they are patient oriented.
- 
- Study must appear in a peer-reviewed publication
  - Study should have **10 or more patients per group**
  - Study must be of humans
  - Study must be published in English
  - Study must be published in or after 1990 for surgical treatment, bracing, and prevention
  - Study must be published in or after 1966 for nonoperative treatment
  - Study must be published in or after 1966 for all others non specified
  - Study results must be quantitatively presented
  - For surgical treatment, a **minimum of 2 year follow up** duration
  - For nonoperative treatment **a minimum of 6 months**, but quality for those that are less than 2 years is downgraded one step
  - For prevention studies a minimum of one sport season (dependent on sport)
  - For any given follow-up time point in any included study, there must be  $\geq 50\%$  patient follow-up (if the follow-up is  $>50\%$  but  $<80\%$ , the study quality will be downgraded by one Level)
  - For any included study that uses “paper-and-pencil” outcome measures (e.g., SF36), only those outcome measures that have been validated will be included
  - Study must not be an in vitro study
  - **Study must not be a biomechanical study**
  - Study must not have been performed on cadavers

We will only evaluate surrogate outcomes when no patient-oriented outcomes are available.

We did not include systematic reviews or meta-analyses compiled by others or guidelines developed by other organizations. These documents are developed using different inclusion criteria than those specified by the AAOS work group. Therefore, they may include studies that do not meet our inclusion criteria. We recalled these documents, if the abstract suggested they might provide an answer to one of our recommendations, and searched their bibliographies for additional studies to supplement our systematic review

\*2020 literature search for all PICO's will be performed from last search date of 2014 CPG

View background materials via the ACL CPG [eAppendix 1](#)

View data summaries via the ACL CPG [eAppendix 2](#)

## Appendix III: Literature Search Strategy

<b>Database:</b>	<b>MEDLINE</b>
<b>Interface:</b>	Ovid (Ovid MEDLINE ® and Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Daily and Versions® 1946 to August 5, 2020)
<b>Date of Initial Search:</b>	8/4/2020
<b>Search</b>	ACL 2020
<b>Line</b>	<b>Search Strategy</b>
<b>1</b>	anterior cruciate.mp. OR ((ACL OR ACLR) AND (knee OR reconstruct* OR injur* OR repair* OR tear* OR rupture? OR avuls* OR sport*)).ti,ab.
<b>2</b>	English.lg.
<b>3</b>	(exp "Animals"/ NOT Humans/) OR exp "Cadaver"/ OR (animal? OR dog OR dogs OR canine OR horse OR horses OR equine OR mouse OR mice OR rat OR rats OR rabbit OR rabbits OR sheep OR porcine OR pig OR pigs OR rodent? OR monkey?).ti. OR (cadaver* OR in vitro).ti,ab. OR ((comment OR editorial OR letter OR historical article) NOT clinical trial).pt. OR address.pt. OR news.pt. OR newspaper article.pt. OR pmcbook.af. OR case reports.pt. OR (case report? OR abstracts OR editorial OR reply OR commentary OR letter).ti.
<b>4</b>	(1 AND 2) NOT 3
<b>5</b>	(exp Sensitivity and Specificity/ OR (sensitiv* OR (predictive AND value?) OR accuracy).ti,ab.) NOT ((exp *Diagnostic Imaging/ OR (tomograph* OR radiograph* OR magnetic resonance OR MRI OR MR OR CT OR (X AND ray*) OR imaging OR ultrasonography OR ultrasound? OR scan*).ti.) NOT (exp *Physical Examination/ OR ((physical OR clinical OR McMurray*) ADJ (examination? OR test?)).ti,ab.))
<b>6</b>	(arthrocentesis OR aspirat*).mp.
<b>7</b>	reconstruct*.mp. OR (surgery OR surgical OR repair*).ti,ab.
<b>8</b>	(conservative* OR nonoperativ* OR non operativ* OR nonsurgical* OR non surgical* OR non reconstructive OR no reconstruction OR no surgery OR without reconstruction OR without surgery OR without surgical* OR untreated).ti,ab.
<b>9</b>	tenodes*.mp. OR (anterolateral ligament OR anterolateral reconstruction OR extra?articular).ti,ab.
<b>10</b>	((((anterior cruciate OR ACL OR ACLR) ADJ4 reconstruct*) AND ((anterior cruciate OR ACL OR ACLR) ADJ4 repair*)).mp.

11	meniscectom*.mp. OR (menisc* ADJ3 (repair* OR surgery OR procedure OR resect* OR remov*)).ti,ab.
12	medial collateral.mp. OR MCL.ti,ab.
13	exp Time-to-Treatment/ OR ((time OR timing or delay* OR early) ADJ4 (surgery OR surgical OR reconstruct* OR repair*)).ti,ab.
14	(single AND double AND bundle).ti,ab.
15	(allograft* OR allogenic OR alloplastic OR homologous).mp. AND (autograft* OR autograft* OR autogenous OR autologous).mp.
16	(brace? OR bracing?).mp.
17	((neuromuscular OR proprioceptive OR balance OR conditioning OR prevention OR plyometric? OR stretch*) ADJ3 (training OR program* OR exercis*)) OR warm* up?).ti,ab.
18	((return* OR resum*) AND (sport* OR activ* OR play* OR participat* OR competition OR athlet*)).mp.
19	randomized controlled trial.pt. OR exp Randomized Controlled Trials as Topic/ OR random allocation/ OR random*.ti,ab.
20	(MEDLINE OR (systematic* AND review*) OR meta analys*).ti,ab. OR (meta analysis OR systematic review).pt.
21	19 OR 20
22	4 AND (5 OR 14 OR 16) AND 21
23	4 AND (6 OR (7 AND (11 OR 12)) OR 13 OR 15 OR 18)
24	4 AND ((7 AND (8 OR 9)) OR 10 OR 17)
25	22 OR 23
26	limit 25 to yr="2014-Current"
27	limit 24 to yr="1966-Current"
28	26 OR 27
29	limit 28 to ez=20200804-20210827

<b>Database:</b>	<b>Embase</b>
<b>Interface:</b>	Elsevier
<b>Date of Initial Search:</b>	8/6/2020
<b>Search</b>	ACL 2020
<b>Line</b>	<b>Search Strategy</b>
<b>1</b>	anterior cruciate' OR ((ACL OR ACLR) AND (knee OR reconstruct* OR injur* OR repair* OR tear* OR rupture\$ OR avuls* OR sport*)):ti,ab,kw
<b>2</b>	abstract report'/de OR abstracts:ti OR 'book'/de OR 'editorial'/de OR 'editorial':it OR editorial:ti OR 'note'/de OR 'note':it OR 'letter'/de OR reply:ti OR commentary:ti OR 'letter':it OR letter:ti OR 'case study'/de OR 'case report'/de OR 'chapter':it OR 'conference paper'/exp OR 'conference paper':it OR 'conference abstract':it OR 'conference review':it OR 'cadaver'/de OR 'in vitro study'/exp OR (cadaver* OR 'in vitro'):ti,ab OR 'animal experiment'/exp OR (animal\$ OR dog OR dogs OR canine OR horse\$ OR equine OR mouse OR mice OR rat OR rats OR rabbit\$ OR sheep OR porcine OR pig OR pigs OR rodent\$ OR monkey\$):ti
<b>3</b>	(#1 NOT #2) AND [english]/lim
<b>4</b>	('Sensitivity and Specificity'/de OR 'Diagnostic Accuracy'/de OR (sensitiv* OR (predictive AND value\$) OR accuracy):ti,ab) NOT (('Radiodiagnosis'/mj OR (tomograph* OR radiograph* OR 'magnetic resonance' OR MRI OR MR OR CT OR (X AND ray*) OR imaging OR ultrasonography OR ultrasound\$ OR scan*):ti) NOT ('Physical Examination'/mj OR ((physical OR clinical OR McMurray*) NEXT/1 (examination\$ OR test\$)):ti,ab))
<b>5</b>	arthrocentesis OR aspirat*
<b>6</b>	reconstruct* OR (surgery OR surgical OR repair*):ti,ab
<b>7</b>	Conservative Treatment'/de OR (conservative* OR nonoperativ* OR 'non operativ*' OR nonsurgical* OR 'non surgical*' OR 'non reconstructive' OR ((no OR without) NEXT/2 (reconstruction OR surgery OR surgical* OR untreated))):ti,ab
<b>8</b>	tenodes* OR ('anterolateral ligament' OR 'anterolateral reconstruction' OR extra\$articular):ti,ab
<b>9</b>	((('anterior cruciate' OR ACL OR ACLR) NEAR/4 reconstruct*) AND (('anterior cruciate' OR ACL OR ACLR) NEAR/4 repair*))
<b>10</b>	meniscal repair'/de OR meniscectomy/de OR (meniscectom* OR (menisc* NEAR/3 (repair* OR surgery OR procedure OR resect* OR remov*)):ti,ab
<b>11</b>	medial collateral' OR MCL:ti,ab

<b>12</b>	Time to Treatment'/de OR ((time OR timing or delay* OR early) NEAR/4 (surgery OR surgical OR reconstruct* OR repair*)):ti,ab
<b>13</b>	(single AND double AND bundle):ti,ab
<b>14</b>	(allograft* OR allogenic OR alloplastic OR homologous) AND (autograft* OR 'auto graft*' OR autogenous OR autologous)
<b>15</b>	brace\$ OR bracing\$
<b>16</b>	((neuromuscular OR proprioceptive OR balance OR conditioning OR prevention OR plyometric\$ OR stretch*) NEAR/3 (training OR program* OR exercis*)) OR 'warm* up\$':ti,ab
<b>17</b>	(return* OR resum*) AND (sport* OR activ* OR play* OR participat* OR competition OR athlet*)
<b>18</b>	randomized controlled trial'/exp OR 'randomized controlled trial (topic)'/exp OR 'randomization'/de OR random*:ti,ab,kw
<b>19</b>	systematic review'/exp OR 'meta analysis'/exp OR ((systematic* NEAR/2 review*):ti,ab,kw) OR 'meta analys*':ti,ab,kw
<b>20</b>	#18 OR #19
<b>21</b>	#3 AND (#4 OR #13 OR #15) AND #20
<b>22</b>	#3 AND (#5 OR (#6 AND (#10 OR #11)) OR #12 OR #14 OR #17)
<b>23</b>	#3 AND ((#6 AND (#7 OR #8)) OR #9 OR #16)
<b>24</b>	(#21 OR #22) AND [2014-3000]/py
<b>25</b>	#23 AND [1966-3000]/py
<b>26</b>	#24 OR #25
<b>27</b>	(#24 OR #25) AND [6-8-2020]/sd NOT [28-8-2021]/sd

<b>Database:</b>	Cochrane Central Register of Controlled Trials (CENTRAL)
<b>Interface:</b>	Wiley ( <a href="https://www.cochranelibrary.com/central">https://www.cochranelibrary.com/central</a> )
<b>Date of Initial Search:</b>	8/5/2020
<b>Search</b>	ACL 2020
<b>Line</b>	<b>Search Strategy</b>
1	"anterior cruciate" OR ((ACL OR ACLR) AND (knee OR reconstruct* OR injur* OR repair* OR tear* OR rupture? OR avuls* OR sport*)):ti,ab
2	"conference abstract":pt OR (cadaver* OR "in vitro"):ti,ab OR (abstracts OR editorial OR reply OR commentary OR letter OR animal* OR dog OR dogs OR canine OR horse OR horses OR equine OR mouse OR mice OR rat OR rats OR rabbit OR rabbits OR sheep OR porcine OR pig OR pigs OR rodent? OR monkey?):ti
3	(#1 NOT #2)
4	([mh "Sensitivity and Specificity"] OR (sensitiv* OR (predictive AND value?) OR accuracy):ti,ab) NOT (([mh ^Diagnostic Imaging] OR (tomograph* OR radiograph* OR "magnetic resonance" OR MRI OR MR OR CT OR (X AND ray*) OR imaging OR ultrasonography OR ultrasound? OR scan*):ti) NOT ([mh ^"Physical Examination"] OR ((physical OR clinical OR McMurray*) NEXT/1 (examination? OR test?):ti,ab))
5	arthrocentesis OR aspirat*
6	reconstruct* OR (surgery OR surgical OR repair*):ti,ab
7	(conservative* OR nonoperativ* OR "non operativ*" OR nonsurgical* OR "non surgical*" OR "non reconstructive" OR ((no OR without) NEXT/2 (reconstruction OR surgery OR surgical* OR untreated))):ti,ab
8	tenodes* OR ("anterolateral ligament" OR "anterolateral reconstruction" OR extra?articular):ti,ab
9	((("anterior cruciate" OR ACL OR ACLR) NEAR/4 reconstruct*) AND ((("anterior cruciate" OR ACL OR ACLR) NEAR/4 repair*))
10	meniscectom* OR (menisc* NEAR/3 (repair* OR surgery OR procedure OR resect* OR remov*)):ti,ab

<b>11</b>	"medial collateral" OR MCL:ti,ab
<b>12</b>	[mh "Time-to-Treatment"] OR ((time OR timing or delay* OR early) NEAR/4 (surgery OR surgical OR reconstruct* OR repair*)):ti,ab
<b>13</b>	(single AND double AND bundle):ti,ab
<b>14</b>	(allograft* OR allogen?ic OR alloplastic OR homologous) AND (autograft* OR "auto graft*" OR autogenous OR autologous)
<b>15</b>	brace? OR bracing?
<b>16</b>	((neuromuscular OR proprioceptive OR balance OR conditioning OR prevention OR plyometric? OR stretch*) NEAR/3 (training OR program* OR exercis*)) OR "warm* up?"):ti,ab
<b>17</b>	((return* OR resum*) AND (sport* OR activ* OR play* OR participat* OR competition OR athlet*))
<b>18</b>	#3 AND (#4 OR #13 OR #15)
<b>19</b>	#3 AND (#5 OR (#6 AND (#10 OR #11)) OR #12 OR #14 OR #17)
<b>20</b>	#3 AND ((#6 AND (#7 OR #8)) OR #9 OR #16) with Publication Year from 1966 to 2020, in Trials
<b>21</b>	(#18 OR #19) with Publication Year from 2014 to 2020, in Trials
<b>22</b>	#20 OR #21 ( <i>with Cochrane Library publication date from Aug 2020 to Aug 2021 - ON UPDATE</i> )
<b>23</b>	(allograft* OR allogen?ic OR alloplastic OR homologous) OR (autograft* OR "auto graft*" OR autogenous OR autologous)
<b>24</b>	#3 AND #23 <i>with Publication Year from 2014 to 2020, in Trials</i>
<b>25</b>	#3 AND #23 <i>with Cochrane Library publication date from Jan 2014 to Aug 2020</i>



## **Appendix IV: Guideline Development Group Disclosures**

### **Robert Brophy, MD, FAAOS- Co-Chair**

Robert H Brophy, MD, FAAOS Submitted on: 08/28/2019

AAOS: Board or committee member (\$0) Committee member (Self)

American Journal of Sports Medicine: Editorial or governing board (\$0) Editorial Board (Self)

American Orthopaedic Association: Board or committee member (\$0) committee member (Self)

American Orthopaedic Society for Sports Medicine: Board or committee member (\$0) Committee member (Self)

Journal of the American Academy of Orthopaedic Surgeons: Editorial or governing board (\$5,000) Deputy Editor (Self)

### **Kent Jason Lowry, MD, FAAOS- Co-Chair**

Kent Jason Lowry, MD, FAAOS Submitted on: 11/04/2019

AAOS: Board or committee member (\$0)

ASTM: Board or committee member (\$0)

### **Henry Ellis, MD, FAAOS**

Henry Bone Ellis Jr, MD, FAAOS Submitted on: 11/05/2019

AAOS: Board or committee member (\$0) Evidence Based, Quality, and Value (Self)

Pediatric Orthopaedic Society of North America: Board or committee member (\$0)

Pediatric Research in Sports Medicine: Board or committee member (\$0)

### **Neeraj Patel, MD, MPH, MBS**

(This individual reported nothing to disclose); Submitted on: 05/27/2020

### **Julie Dodds, MD, FAAOS**

Julie A Dodds, MD, FAAOS Submitted on: 05/06/2019

AAOS: Board or committee member (\$0)

Arthroscopy Association of North America Board of Directors: Board or committee member (\$0)

Mitek: Paid presenter or speaker (\$0) Number of Presentations: 0

### **Christopher C. Kaeding, MD**

Christopher C Kaeding, MD, FAAOS Submitted on: 02/18/2020

Active Implants: Research support (\$0)

American Orthopaedic Society for Sports Medicine: Board or committee member (\$0)

Arthrex, Inc: Paid presenter or speaker (\$0) Number of Presentations: 0

Ceterex: Research support (\$0)

International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member (\$0)

Smith & Nephew: Paid presenter or speaker (\$0) Number of Presentations: 0

Smith & Nephew: Research support (\$0)

Vericel: Research support (\$0)

Zimmer: Research support (\$0)

### **Anthony Beutler, MD**

Anthony Beutler, MD Submitted on: 04/27/2020

American Medical Society for Sports Medicine: Board or committee member (\$0) AMSSM - Collaborative Research

Network, Chair Leadership Committee (Self)

Saunders/Mosby-Elsevier: Publishing royalties, financial or material support (\$2,000) Editor for "Sports Medicine

Resource Manual" Textbook (Self)

Wolters Kluwer Health - Lippincott Williams & Wilkins: Publishing royalties, financial or material support (\$5,000)

UpToDate Author Royalties (Self)

### **Andrew Gordon, MD**

Andrew H Gordon, MD, PhD

Submitted on: 05/01/2020

American Academy of Physical Medicine and Rehabilitation: Board or committee member

### **Richard Shih, MD, FACEP**

Richard Shih, MD (This individual reported nothing to disclose); Submitted on: 05/10/2020

View background materials via the ACL CPG [eAppendix 1](#)

View data summaries via the ACL CPG [eAppendix 2](#)