Agency for Healthcare Research and Quality
Advancing Excellence in Health Care

NATIONAL GUIDELINE CLEARINGHOUSE

General

Guideline Title

American Academy of Orthopaedic Surgeons clinical practice guideline on management of anterior cruciate ligament injuries.

Bibliographic Source(s)

American Academy of Orthopaedic Surgeons (AAOS). American Academy of Orthopaedic Surgeons clinical practice guideline on management of anterior cruciate ligament injuries. Rosemont (IL): American Academy of Orthopaedic Surgeons (AAOS); 2014 Sep 5. 619 p. [132 references]

Guideline Status

This is the current release of the guideline.

This guideline meets NGC's 2013 (revised) inclusion criteria.

Regulatory Alert

FDA Warning/Regulatory Alert

Note from the National Guideline Clearinghouse: This guideline references a drug(s) for which important revised regulatory and/or warning information has been released.

- December 14, 2016 – General anesthetic and sedation drugs : The U.S. Food and Drug Administration (FDA) is warning that repeated or lengthy use of general anesthetic and sedation drugs during surgeries or procedures in children younger than 3 years or in pregnant women during their third trimester may affect the development of children's brains. Consistent with animal studies, recent human studies suggest that a single, relatively short exposure to general anesthetic and sedation drugs in infants or toddlers is unlikely to have negative effects on behavior or learning. However, further research is needed to fully characterize how early life anesthetic exposure affects children's brain development.

Recommendations

Major Recommendations

Definitions of the strength of recommendations (Strong, Moderate, Limited, and Consensus) and Strength Visual (****, ***, **, *) are provided at the end of the "Major Recommendations" field.

Note from the American Academy of Orthopaedic Surgeons (AAOS): The following is a summary of the recommendations of the AAOS Clinical Practice Guideline on the Management of Anterior Cruciate Ligament Injuries. All readers of this summary are strongly urged to consult the full guideline and evidence report for this information. The AAOS work group is confident that those who read the full guideline and evidence report will see that the recommendations were developed using systematic evidence-based processes designed to combat bias, enhance transparency, and promote reproducibility.

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

Anterior Cruciate Ligament (ACL) History and Physical

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

ACL Radiographs

In the absence of reliable evidence, it is the opinion of the work group that in the initial evaluation of a person with a knee injury and associated symptoms (giving way, pain, locking, catching) and signs (effusion, inability to bear weight, bone tenderness, loss of motion, and/or pathological laxity) that the practitioner obtain anteroposterior (AP) and lateral knee x-rays to identify fractures or dislocations requiring emergent care. Strength of Recommendation: Consensus *

ACL Magnetic Resonance Imaging (MRI)

Strong evidence supports that the MRI can provide confirmation of ACL injury and assist in identifying concomitant knee pathology such as other ligament, meniscal, or articular cartilage injury. Strength of Recommendation: Strong ****

ACL Pediatric

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

ACL Young Active Adult

Moderate evidence supports surgical reconstruction in active young adult (18-35) patients with an ACL tear. Strength of Recommendation: Moderate ***

ACL Meniscal Repair

There is limited evidence in patients with combined ACL tears and reparable meniscus tears, but it supports that the practitioner might repair these meniscus tears when combined with ACL reconstruction because it improves patient outcomes. Strength of Recommendation: Limited **

ACL Recurrent Instability

There is limited evidence comparing non-operative treatment to ACL reconstruction in patients with recurrent instability, but it supports that the practitioner might perform ACL reconstruction because this procedure reduces pathologic laxity. Strength of Recommendation: Limited **

ACL Conservative Treatment

There is limited evidence to support non-surgical management for less active patients with less laxity. Strength of Recommendation: Limited **

ACL Surgery Timing

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

ACL Combined Medial Collateral Ligament (MCL)

There is limited evidence in patients with acute ACL tear and MCL tear to support that the practitioner might perform reconstruction of the ACL and non-operative treatment of the MCL tear. Strength of Recommendation: Limited **

ACL Locked Knee

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

ACL Single or Double Bundle Reconstruction

Strong evidence supports that in patients undergoing intra-articular ACL reconstruction the practitioner should use either single bundle or double bundle technique, because the measured outcomes are similar. Strength of Recommendation: Strong ****

ACL Autograft Source

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

ACL Autograft vs Allograft

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

ACL Femoral Tunnel Technique

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

ACL Post-op Functional Bracing

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

ACL Prophylactic Braces

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

ACL Neuromuscular Training Programs

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

ACL Post-op Physical Therapy

For those undergoing post-operative rehabilitation after ACL reconstruction, moderate evidence supports early, accelerated, and non-accelerated protocols because they have similar outcomes. Strength of Recommendation: Moderate ***

ACL Return to Sports

Limited strength evidence does not support waiting a specific time from surgery/ injury, or achieving a specific functional goal prior to return to sports participation after ACL injury or reconstruction. Strength of Recommendation: Limited **

Definitions:

Strength of Recommendations Descriptions

Strength	Overall Strength of Evidence	Description of Evidence Strength	Strength Visual
Strong	Strong	Evidence from two or more "High" strength studies with consistent findings for recommending for or against the intervention.	****
Moderate	Moderate	Evidence from two or more "Moderate" strength studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention.	***
Limited	Low Strength	Evidence from one or more "Low" strength studies with consistent findings or evidence from a	**

Strength	Overall Strength of Evidence	Description of Evidence Strength	Strength Visual
	Evidence or Conflicting Evidence	single "Moderate" strength study for recommending for against the intervention or diagnostic or the evidence is insufficient or conflicting and does not allow a recommendation for or against the intervention.	
Consensus†	No Evidence	There is no supporting evidence. In the absence of reliable evidence, the work group is making a recommendation based on their clinical opinion. Consensus recommendations can only be created when not establishing a recommendation could have catastrophic consequences.	*

†Consensus based recommendations are made according to specific criteria. These criteria can be found in Appendix VI in the original guideline document.

Clinical Algorithm(s)

None provided

Scope

Disease/Condition(s)

Anterior cruciate ligament (ACL) injuries

Guideline Category

Diagnosis

Evaluation

Management

Prevention

Rehabilitation

Treatment

Clinical Specialty

Emergency Medicine

Family Practice

Orthopedic Surgery

Pediatrics

Physical Medicine and Rehabilitation

Radiology

Sports Medicine

Intended Users

Advanced Practice Nurses

Allied Health Personnel

Health Care Providers

Health Plans

Hospitals

Managed Care Organizations

Nurses

Occupational Therapists

Patients

Physical Therapists

Physician Assistants

Physicians

Guideline Objective(s)

- To provide practice recommendations based on a systematic review of published studies on the treatment of anterior cruciate ligament (ACL) injuries in skeletally mature and immature patients
- To highlight gaps in the literature and areas that require future research
- To serve as an information resource for decision makers and developers of practice guidelines and recommendations
- To help improve treatment based on the current best evidence
- To serve 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

Target Population

Skeletally immature and skeletally mature patients with suspected or confirmed anterior cruciate ligament (ACL) injury

Interventions and Practices Considered

1. Relevant patient history and musculoskeletal exam of the lower extremities
2. Anterior cruciate ligament (ACL) radiographs
3. ACL magnetic resonance imaging (MRI)
4. ACL reconstruction in skeletally immature (pediatric) patients
5. ACL reconstruction in active young adults (age 18-35 years)
6. Meniscal repair combined with ACL reconstruction
7. ACL reconstruction in patients with recurrent instability
8. Conservative management for less active patients with less laxity
9. Consideration of ACL surgery timing
10. Reconstruction of the ACL combined with non-operative treatment of medial collateral ligament (MCL) tear
11. Treatment of locked knee
12. Single bundle or double bundle reconstruction techniques
13. Use of autograft or appropriately processed allograft tissue sources
14. ACL femoral tunnel techniques (tibial independent approach or transtibial approach)
15. Routine use of post-operative functional or prophylactic knee bracing (not recommended)
16. Neuromuscular training programs
17. Post-operative physical therapy
18. Return to sports after ACL injury or reconstruction

Major Outcomes Considered

- Knee pain
- Activities of daily living
- Quality of life
- Functional status
- Activity tolerance
- Self-reported physical function

Methodology

Methods Used to Collect/Select the Evidence

Hand-searches of Published Literature (Primary Sources)

Hand-searches of Published Literature (Secondary Sources)

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Study Selection Criteria

The American Academy of Orthopaedic Surgeons (AAOS) work group developed *a priori* article inclusion criteria for the review. These criteria are the "rules of evidence" and articles that did not meet them are, for the purposes of this guideline, not evidence.

To be included in the systematic reviews (and hence, in this guideline) an article had to be a report of a study that:

- 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, rehabilitation, bracing, prevention and magnetic resonance imaging (MRI).
- Study must be published in or after 1966 for x rays and non-operative 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 ≥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., SF-36), 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.

The work group will only evaluate surrogate outcomes when no patient oriented outcomes are available. The work group 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 the inclusion criteria. The work group recalled these documents, if the abstract suggested they might provide an answer to one of the recommendations, and searched their bibliographies for additional studies to supplement the systematic review.

Literature Searches

The work group began the systematic review with a comprehensive search of the literature. Articles considered were published prior to May 2012 in four electronic databases; PubMed, EMBASE, CINAHL, and The Cochrane Central Register of Controlled Trials. The medical librarian conducts the search using key terms determined from the work group's preliminary recommendations.

The work group supplemented the electronic search with a manual search of the bibliographies of all retrieved publications, recent systematic reviews, and other review articles for potentially relevant citations. Recalled articles are evaluated for possible inclusion based on the study selection criteria and are summarized for the work group who assist with reconciling possible errors and omissions.

The study attrition diagram in Appendix IV of the original guideline document provides a detailed description of the numbers of identified abstracts and recalled and selected studies that were evaluated in the systematic review of this guideline. The search strategies used to identify the abstracts are contained in Appendix V in the original guideline document.

Number of Source Documents

156 articles were included after full text review and quality analysis.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Methods for Evaluating Evidence

Studies of Intervention/Prevention

Quality

The American Academy of Orthopaedic Surgeons (AAOS) judges quality based on *a priori* research questions and uses an automated numerical scoring process to arrive at final ratings. Extensive measures are taken to determine quality ratings so that they are free of bias.

The quality of evidence is evaluated separately for each outcome reported in every study using research design domains suggested by Grading of Recommendations Assessment, Development and Evaluation (GRADE) work group members and others. The GRADE evidence appraisal system is used in the Cochrane Collaboration and has been developed for studies evaluating matched control groups. A coding scheme adaptable to all research designs is incorporated that involves incremental increases or decreases based on the following criteria:

- The study was prospective (with prospective studies, it is possible to have an *a priori* hypothesis to test; this is not possible with retrospective studies)
- The statistical power of the study
- The assignment of patients to groups was unbiased
- There was sufficient blinding to mitigate against a placebo effect
- The patient groups were comparable at the beginning of the study
- The treatment was delivered in such a way that any observed effects could reasonably be attributed to that treatment
- Whether the instruments used to measure outcomes were valid
- Whether there was evidence of investigator bias

Each of the above quality domains is rated for possible flaws based on up to four indicator questions that define them. See Appendix V in the original guideline document for a discussion of the AAOS appraisal system. Domains are considered "flawed" if one indicator is coded "No" or at least two defining questions are "Unclear." The Statistical Power domain is considered flawed if sample size is too small to detect at least a small effect size of 0.2.

If there are flawed domains then the evidence quality is downgraded according to the reductions shown in the table below. As an example, the evidence reported in a randomized controlled trial (RCT) for any given outcome is rated as "High" quality if zero or one domain is flawed. If two or three domains are flawed, the rating is reduced to "Moderate." If four or five domains are flawed, the quality of evidence is downgraded to "Low." The quality of evidence is reduced to "Very Low" if six or more domains are flawed. As indicated above, very low quality evidence is not included in this AAOS guideline.

Relationship between Quality and Domain Scores for Interventions

Number of Domains with No More Than One "Unclear" Answer	Strength of Evidence
0	High
1-2	Moderate
3-4	Low
>5	Very low

Some flaws are so serious that the evidence is automatically termed as being of "Very Low" quality if a study exhibits them. These serious design flaws are:

- Non-consecutive enrollment of patients in a case series
- Case series that gave patients the treatment of interest AND another treatment
- Measuring the outcome of interest one way in some patients and measuring it in another way in other patients
- Low statistical power

Conversely, the quality of research articles may be upgraded if the research is of high applicability or if providing the intervention decreases the potential for catastrophic harm, such as loss of life or limb. The criteria, based on the GRADE methodology, which can be used to upgrade the quality of a study, are as follows:

- The study has a large (>2) or very large (>5) magnitude of treatment effect: used for non-retrospective observational studies;
- All plausible confounding factors would reduce a demonstrated effect or suggest a spurious effect when results show no effect;
- Consideration of the dose-response effect.

Quality is one of two dimensions that determine the strength of the final recommendations.

Applicability

The applicability (also called "generalizability" or "external validity") of an outcome is one of the factors used to determine the strength of a recommendation. Outcomes are categorized according to whether their applicability is "High", "Moderate", or "Low." As with quality, the applicability for each outcome a study reports is separately evaluated.

The applicability of a study is evaluated using the pragmatic-explanatory continuum indicator summary (PRECIS) instrument. The instrument was originally designed to evaluate the applicability of randomized controlled trials, but it can also be used for studies of other design. For example, the existence of an implicit control group in a case series (see above) make it useful for evaluating outcomes from these latter studies.

This instrument is comprised of the 10 questions that are briefly described in Table 2 in the original guideline document. All 10 questions are asked of all studies, regardless of design. The questions are divided into four domains. These domains and their corresponding questions are given in Table 2 in the original guideline document.

Each study is assumed to have "High" applicability at the start, and applicability is downgraded for flawed domains as summarized in the table below.

Relationship between Applicability and Domain Scores for Studies of Treatments

Number of Flawed Domains	Applicability
0	High
1,2,3	Moderate
4	Low

A study's applicability is "High" if there is only one "Unclear" answer in one domain and the answers to all of the questions for all other domains is "Yes." A study's applicability is low if there is one "Unclear" answer in one domain and the answers to all of the questions for all other domains is "No." A study's applicability is "Moderate" under all other conditions.

Refer to Section III in the original guideline document for a description of the methods used to determine the quality and applicability of evidence for the following types of studies:

- Studies of screening and diagnostic tests
- Studies of prognostics

Final Strength of Evidence

To determine the final strength of evidence for an outcome, the strength is initially taken to equal quality. An outcome's strength of evidence is increased by one category if its applicability is "High", and an outcome's strength of evidence is decreased by one category if its applicability is "Low." If an outcome's applicability is "Moderate", no adjustment is made to the strength of evidence derived from the quality evaluation.

Methods Used to Analyze the Evidence

Meta-Analysis

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

Best Evidence Synthesis

When determining the best available evidence, the highest-strength studies available for the outcomes examined are included first. If there are two or more high-strength studies, the recommendation grade is strong. In this case, moderate- and low- strength evidence do not influence the grade of the recommendation. If there is one high- or at least two moderate-strength studies, the recommendation grade is moderate. If there is one moderate- or at least one low-strength studies, the recommendation grade is limited. Consensus based recommendations are established only when the rules for consensus recommendations apply. A summary of the evidence that met the initial inclusion criteria, but was not best available evidence was created for each recommendation and can be viewed by recommendation in Appendix XII in the original guideline document.

Statistical Methods

Analysis of Diagnostic Data

Likelihood ratios (LR), sensitivity, specificity and 95% confidence intervals were calculated to determine the accuracy of diagnostic modalities based on two by two diagnostic contingency tables extracted from the included studies. When summary values of sensitivity, specificity, or other diagnostic performance measures were reported, estimates of the diagnostic contingency table were used to calculate LR. LR indicate the magnitude of the change in probability of disease due to a given test result. For example, a positive LR of 10 indicates that a positive test result is 10 times more common in patients with disease than in patients without disease. LR are interpreted according to previously published values, as seen in Table 11 in the original guideline document.

Analysis of Intervention/Prevention Data

When possible, the results reported in individual studies are recalculated and compiled to answer the recommendations. The results of all statistical analysis conducted by the American Academy of Orthopaedic Surgeons (AAOS) Clinical Practice Guidelines Unit are conducted using STATA 12. STATA was used to determine the magnitude, direction, and/or 95% confidence intervals of the treatment effect. For data reported as means (and associated measures of dispersion) the mean difference between groups and the 95% confidence interval was calculated and a two-tailed t-

test of independent groups was used to determine statistical significance. When published studies report measures of dispersion other than the standard deviation the value was estimated to facilitate calculation of the treatment effect. In studies that report standard errors or confidence intervals the standard deviation was back-calculated. In some circumstances statistical testing was conducted by the authors and measures of dispersion were not reported. In the absence of measures of dispersion, the results of the statistical analyses conducted by the authors (i.e., the p-value) are considered as evidence. For proportions, the proportion of patients that experienced an outcome along with the percentage of patients that experienced an outcome is reported. The variance of the arcsine difference was used to determine statistical significance. P-values <0.05 were considered statistically significant.

Meta-analyses were performed using the random effects method of DerSimonian and Laird. A minimum of four studies was required for an outcome to be considered by meta-analysis. Heterogeneity was assessed with the I-squared statistic. Meta-analyses with I-squared values less than 50% were considered as evidence. Those with I-squared larger than 50% were not considered as evidence for this guideline. All meta-analyses were performed using STATA 12 and the "metan" command. The arcsine difference was used in meta-analysis of proportions. In order to overcome the difficulty of interpreting the magnitude of the arcsine difference, a summary odds ratio is calculated based on random effects meta-analysis of proportions and the number needed to treat (or harm) is calculated. The standardized mean difference was used for meta-analysis of means and magnitude was interpreted using Cohen's definitions of small, medium, and large effect.

Methods Used to Formulate the Recommendations

Expert Consensus

Description of Methods Used to Formulate the Recommendations

This guideline and systematic review were prepared by the American Academy of Orthopaedic Surgeons (AAOS) Anterior Cruciate Ligament (ACL) Injuries guideline work group (clinical experts) with the assistance of the AAOS Evidence-Based Medicine (EBM) Unit in the Department of Research and Scientific Affairs (methodologists) at the AAOS. To develop this guideline, the work group held an introductory meeting on June 11-12, 2011 to establish the scope of the guideline and the systematic reviews. The clinical experts defined the scope of the guideline by creating preliminary recommendations (Questions) that directed the literature search. When necessary, these clinical experts also provided content help, search terms and additional clarification for the AAOS Medical Librarian. The Medical Librarian created and executed the search(es). The supporting group of methodologists and statistician (AAOS EBM Unit) reviewed all abstracts, recalled pertinent full-text articles for review and evaluated the quality of studies meeting the inclusion criteria. They also abstracted, analyzed, interpreted, and/or summarized the relevant evidence for each recommendation and prepared the initial draft for the final meeting. Upon completion of the systematic reviews, the work group participated in a three-day recommendation meeting on October 4-6, 2013. At this meeting, the clinical experts and methodologists then evaluated and integrated all material to develop the final recommendations. The final recommendations and rationales were edited, written and voted on at the final meeting. The draft guideline recommendations and rationales received final review by the methodologists to ensure that these recommendations and rationales were consistent with the data. The draft was then completed and submitted for peer review on February 28, 2014.

Formulating Preliminary Recommendations

The work group began work on this guideline by constructing a set of preliminary recommendations. These recommendations specify [what] should be done in [whom], [when], [where], and [how often or how long]. They function as questions for the systematic review, not as final recommendations or conclusions. Preliminary recommendations are almost always modified on the basis of the results of the systematic review. Once established, these *a priori* preliminary recommendations cannot be modified until the final work group meeting.

Defining the Strength of the Recommendations

Judging the strength of evidence is only a stepping stone towards arriving at the strength of a guideline 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 there is data 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 case series. Consequently, recommendations based on the former kind of evidence are given a high strength of recommendation and recommendations based on the latter kind of evidence are given a low strength.

To develop the strength of a recommendation, AAOS staff first assigned a preliminary strength for each recommendation that took only the final strength of evidence (including quality and applicability) and the quantity of evidence (see the "Rating Scheme for the Strength of the Recommendations" field).

Wording of the Final Recommendations

To prevent bias in the way recommendations are worded, the American Academy of Orthopaedic Surgeons (AAOS) uses specific predetermined language stems that are governed by the evidence strengths. Each recommendation was written using language that accounts for the final strength of the recommendation. This language, and the corresponding strength, is shown in Table 9 in the original guideline document.

Voting on the Recommendations

The recommendations and their strength were voted on by the work group members during the final meeting. If disagreement between the work group occurred, there was further discussion to see whether the disagreement(s) could be resolved. Up to three rounds of voting were held to attempt to resolve disagreements. If disagreements were not resolved following three voting rounds, no recommendation was adopted. Lack of agreement is a reason that the strength for some recommendations can be labeled "Limited."

Rating Scheme for the Strength of the Recommendations

Strength of Recommendations Descriptions

Strength	Overall Strength of Evidence	Description of Evidence Strength	Strength Visual
Strong	Strong	Evidence from two or more "High" strength studies with consistent findings for recommending for or against the intervention.	****
Moderate	Moderate	Evidence from two or more "Moderate" strength studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention.	***
Limited	Low Strength Evidence or Conflicting Evidence	Evidence from one or more "Low" strength studies with consistent findings or evidence from a single "Moderate" strength study for recommending for against the intervention or diagnostic or the evidence is insufficient or conflicting and does not allow a recommendation for or against the intervention.	**
Consensus†	No Evidence	There is no supporting evidence. In the absence of reliable evidence, the work group is making a recommendation based on their clinical opinion. Consensus recommendations can only be created when not establishing a recommendation could have catastrophic consequences.	*

†Consensus based recommendations are made according to specific criteria. These criteria can be found in Appendix VI in the original guideline document.

Cost Analysis

A formal cost analysis was not performed and published cost analyses were not reviewed.

Method of Guideline Validation

External Peer Review

Internal Peer Review

Description of Method of Guideline Validation

Peer Review

Following the final meeting, the guideline draft undergoes peer review for additional input from external content experts. Written comments are provided on the structured review form (see Appendix VIII in the original guideline document for an example of the structured review form)

adapted from the Appraisal of Guidelines for Research and Evaluation (AGREE) instrument. All peer reviewers are required to disclose their conflicts of interest.

To guide who participates, the work group identifies specialty societies at the introductory meeting. *Organizations*, not *individuals*, are specified.

The specialty societies are solicited for nominations of individual peer reviewers approximately six weeks before the final meeting. The peer review period is announced as it approaches and others interested are able to volunteer to review the draft. The chair of the American Academy of Orthopaedic Surgeons (AAOS) Committee on Evidence Based Quality and Value reviews 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 AAOS 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 peer 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 manager of the evidence-based medicine unit drafts the initial responses to comments that address methodology. These responses are then reviewed by the work group chair and vice-chair, who respond to questions concerning clinical practice and techniques. The director of the Department of Research and Scientific Affairs provides input as well. All comments received and the initial drafts of the responses are also reviewed by all members of the work group. All changes to a recommendation as a result of peer review are based on the evidence and undergoes majority vote by the work group members via teleconference. Final revisions are summarized in a detailed report that is made part of the guideline document throughout the remainder of the review and approval processes.

The AAOS believes in the importance of demonstrating responsiveness to input received during the peer review process and welcomes the critiques of external specialty societies. Following final approval of the guideline, all individual responses are posted on the AAOS website 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, AAOS responses, and their COI disclosures are still posted.

Review of the Management of Anterior Cruciate Ligament Injuries guideline was requested of 26 organizations and 18 external content experts were nominated to represent them. Thirteen individuals (nine organizations) returned comments on the structured review form (see Appendix XI in the original guideline document).

Public Commentary

After modifying the draft in response to peer review, the guideline was subjected to a thirty day period of "Public Commentary." Commentators may consist of members of the AAOS Board of Directors (BOD), members of the Council on Research and Quality (CORQ), members of the Board of Councilors (BOC), and members of the Board of Specialty Societies (BOS). The guideline is automatically forwarded to the AAOS BOD and CORQ so that they may review it and provide comment prior to being asked to approve the document. Members of the BOC and BOS are specifically solicited for interest as well as organizations with representatives on the multidisciplinary panel. In addition to announcements that are sent out, a notice is posted on the AAOS website announcing that the draft guideline is available for public comment. Upon request, the document is forwarded to interested individuals along with a structured review form adapted from the AGREE instrument. For this guideline, four members returned formal public comments.

AAOS Guideline Approval Process

This final guideline draft must be approved by the AAOS Committee on Evidence-Based Quality and Value, the AAOS Council on Research and Quality, and the AAOS Board of Directors. These decision-making bodies are described in Appendix II in the original guideline document and are not designated to modify the contents. Their charge is to approve or reject its publication by majority vote.

The guideline was adopted by the American Academy of Orthopaedic Surgeons Board of Directors on September 5, 2014.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The type of supporting evidence is specifically stated for each recommendation (see the "Major Recommendations" field).

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

- A thorough history and physical exam will assist the practitioner in prompt and accurate diagnosis of anterior cruciate (ACL) injuries and concomitant pathology.
- ACL radiographs: Potential early recognition of clinically important knee injury enhances patient care.
- Potential benefits of pediatric surgical reconstruction include improving knee stability and functional outcomes in skeletally immature patients with ACL injury.
- The benefit of ACL conservative treatment is that lower risk patients, based on activity and/or index laxity criteria, may tolerate an ACL deficient knee, and therefore may be spared exposure to the risks of surgical intervention such as infection, risks of anesthesia, arthrofibrosis, etc.
- Reconstruction of the ACL and non-operative treatment of the medial collateral ligament (MCL) tear: Potential benefits include reduction of surgery with decreased operating room time and less likelihood of motion limitation.
- The benefit of knee bracing may be a decrease in the overall cost of ACL reconstruction and rehabilitation.
- The benefits of a neuromuscular training program implementation as part of a sports competition regime include a reduced risk of sustaining a sports related ACL injury.
- The benefit of early accelerated post-op physical therapy rehabilitation is that patients may be able to return to full, unrestricted activity sooner.

Potential Harms

Most treatments are associated with some known risks, especially invasive and operative treatments. A particular concern when treating anterior cruciate ligament (ACL) injuries is routine surgical complications such as infection, deep vein thrombosis (DVT), anesthesia complications, etc. Other complications associated with ACL surgery include: post-operative loss of motion or arthrofibrosis, ongoing instability episodes, neurovascular injury, 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.

Potential Harms of Specific Interventions

- ACL radiographs involve exposure to x-rays
- Potential harms of pediatric ACL reconstruction include physeal injury, graft failure and surgical complications.
- As with all surgical procedures, there are patient risks with ACL reconstruction in young active adults including but not limited to infection, anesthetic complications, phlebitis, and neurovascular injury.
- As with all surgical procedures, there are patient risks with combined ACL meniscal repair including but not limited to infection, anesthetic complications, phlebitis, neurovascular injury, meniscal repair failure, and ACL reconstruction failure.
- As with all surgery procedures, there are surgical risks and complications with ACL reconstruction in patients with recurrent instability including but not limited to graft failure, arthrofibrosis, infection, neurovascular injury, and anesthetic complications.
- Despite ACL conservative treatment being categorized as low risk, patients may still require late ACL reconstruction and/or meniscal surgery and could sustain further damage to the ACL deficient knee.
- The decision to perform early ACL reconstruction could lead to loss of motion, joint stiffness, and reoperation if sound history and physical examination is not performed.
- Potential harms of combined reconstruction of the ACL and non-operative treatment of medial collateral ligament (MCL) tear include the late loss of function or recurrent ACL injury from the residual valgus laxity.
- As with all surgical procedures, there are patient risks with ACL reconstruction and locked knee including but not limited to infection, anesthetic complications, phlebitis, neurovascular injury, meniscal repair failure, and ACL reconstruction failure.
- As with all surgery procedures, there are surgical risks and complications with ACL single or double bundle reconstruction including but not limited to, graft failure, arthrofibrosis, infection, neurovascular injury, and anesthetic complications.
- Risks of ACL autograft source (bone-patellar tendon-bone or hamstring-tendon) include possible graft failure in either graft is possible and

reported.

- As with all surgery procedures, there are surgical risks and complications with ACL autograft and allograft including but not limited to graft failure, arthrofibrosis, infection, neurovascular injury, and anesthetic complications. With ACL reconstruction using autograft tissue, there are specific additional risks of donor site morbidity, including risk of patellar fracture and long-term kneeling pain (with autograft bone-patellar tendon-bone) as well as risk of saphenous nerve trauma and long-term knee flexor strength deficit (with autograft hamstring tendon). With ACL reconstruction using allograft tissue, there are specific additional risks of potential for disease transmission and limited availability.
- As with all surgical techniques, there are potential complications with ACL femoral tunnel technique such as malposition of the femoral tunnel or femoral tunnel blowout.
- The impact on long term outcomes (e.g., progression of osteoarthritis) of the timing and intensity of rehabilitation programs is currently unknown. For example one study noted that biomarkers of articular cartilage metabolism remained elevated well after the completion of both rehabilitation programs and the time interval that most individuals will return to full, unrestricted physical activity. Cleavage of Type II collagen returned to normal after 12 months, while synthesis of Type II collagen and turnover of aggrecan approached normal but remained at 24 months.
- As individuals heal and recover at different rates and each injury has its own unique circumstances, it is difficult to assign a specific endpoint that would favor return to sport. Each patient should be treated individually and functionally advanced to the level of their ability. Premature return to full activity may cause injury to a reconstructed ligament, surrounding structures, or the contralateral knee. Early return in those individuals who elect non-operative management may lead to further injury of surrounding tissues and further decline. Current evidence is lacking as to the long-term consequences of premature return to sport on joint homeostasis, dynamic function, and risk of secondary injury.

Qualifying Statements

Qualifying Statements

- This Clinical Practice Guideline was developed by an American Academy of Orthopaedic Surgeons (AAOS) multidisciplinary volunteer Work Group based on a systematic review of the current scientific and clinical information and accepted approaches to treatment and/or diagnosis. This Clinical Practice Guideline is not intended to be a fixed protocol, as some patients may require more or less treatment or different means of diagnosis. Clinical patients may not necessarily be the same as those found in a clinical trial. Patient care and treatment should always be based on a clinician's independent medical judgment, given the individual patient's clinical circumstances.
- The summary of recommendations is not intended to stand alone. Treatment decisions should be made in light of all circumstances presented by the patient. Treatments and procedures applicable to the individual patient rely on mutual communication between patient guardian, physician, and other healthcare practitioners.
- Some drugs or medical devices referenced or described in this Clinical Practice Guideline may not have been cleared by the U.S. Food and Drug Administration (FDA) or may have been cleared for a specific use only. The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or device he or she wishes to use in clinical practice.
- Musculoskeletal care is provided in many different settings by many different providers. This guideline was created as an educational tool to guide qualified practitioners 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 of treatment must be made in light of all circumstances presented by the patient and the needs and resources particular to the locality or institution.
- Clinician input based on experience increases the probability of identifying patients who will benefit from specific treatment options. The individual patient and the patient's family dynamic will also influence treatment decisions therefore, discussion of available treatments and procedures applicable to the individual patient rely on mutual communication between the patient and the patient's guardian (when appropriate for minor patients) and physician, weighing the potential risks and benefits for that patient. Once the patient and patient's guardian has been informed of available therapies and has discussed these options with the patient and guardian (if appropriate), an informed decision can be made.

Implementation of the Guideline

Description of Implementation Strategy

Guideline Dissemination Plans

The primary purpose of the guideline is to provide interested readers with full documentation about not only the work group's recommendations, but also about how the work group arrived at those recommendations. This document is also posted on the American Academy of Orthopaedic Surgeons (AAOS) website .

Shorter versions of the guideline are available in other venues. Publication of guidelines is announced by an Academy press release, articles authored by the work group and published in the Journal of the American Academy of Orthopaedic Surgeons (JAAOS), and articles published in AAOS *Now*. A summary will be submitted for publication in the Journal of Bone and Joint Surgery (JBJS). With funding from the Agency for Healthcare Research and Quality (AHRQ), AAOS is also developing a mobile application, Orthoguidelines, to enhance dissemination efforts. Most guidelines are also distributed at the AAOS Annual Meeting in various venues.

Selected guidelines are disseminated by webinar, an Online Module for the Orthopaedic Knowledge Online website, Radio Media Tours, Media Briefings, and by distributing them at relevant Continuing Medical Education (CME) courses and at the AAOS Resource Center.

Other dissemination efforts outside of the AAOS will include submitting the guideline to the National Guideline Clearinghouse (NGC), the Guidelines International Network database, and distributing the guideline at other medical specialty societies' meetings. The work group chair, vice chair and work group members will seek appropriate speaking opportunities at professional meetings to disseminate the findings in the guideline and encourage the implementation and adoption of the recommendations.

Implementation Tools

Quick Reference Guides/Physician Guides

For information about availability, see the *Availability of Companion Documents* and *Patient Resources* fields below.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

IOM Domain

Effectiveness

Patient-centeredness

Identifying Information and Availability

Bibliographic Source(s)

American Academy of Orthopaedic Surgeons (AAOS). American Academy of Orthopaedic Surgeons clinical practice guideline on management of anterior cruciate ligament injuries. Rosemont (IL): American Academy of Orthopaedic Surgeons (AAOS); 2014 Sep 5. 619 p. [132 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

2014 Sep 5

Guideline Developer(s)

American Academy of Orthopaedic Surgeons - Medical Specialty Society

Source(s) of Funding

This Clinical Practice Guideline was funded exclusively by the American Academy of Orthopaedic Surgeons who received no funding from outside commercial sources to support the development of this document.

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Financial Disclosures/Conflicts of Interest

In accordance with American Academy of Orthopaedic Surgeons (AAOS) policy, all individuals whose names appear as authors or contributors to 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. See Appendix XI in the original guideline document for individual work group members' conflicts of interest.

Guideline Endorser(s)

American Academy of Physical Medicine and Rehabilitation - Medical Specialty Society

American Orthopaedic Society for Sports Medicine - Professional Association

National Academy of Sports Medicine - Professional Association

National Athletic Trainers' Association - Professional Association

Guideline Status

This is the current release of the guideline.

This guideline meets NGC's 2013 (revised) inclusion criteria.

Guideline Availability

Electronic copies: Available from American Academy of Orthopaedic Surgeons Web site .

Print copies: Available from the American Academy of Orthopaedic Surgeons, 9400 West Higgins Road, Rosemont, IL 60018-4262. Telephone: (800) 626-6726 (800 346-AAOS); Fax: (847) 823-8125; Web site: www.aaos.org .

Availability of Companion Documents

The following is available:

- Management of anterior cruciate ligament injuries. Summary of recommendations. Rosemont (IL): American Academy of Orthopaedic Surgeons; 2014. 13 p. Electronic copies: Available from the American Academy of Orthopaedic Surgeons Web site .

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI Institute on October 21, 2014. The information was verified by the guideline developer on November 14, 2014. This summary was updated by ECRI Institute on February 15, 2017 following the U.S. Food and Drug Administration advisory on general anesthetic and sedation drugs.

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