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Current management approaches for anterior cruciate ligament tears in young athletes

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ABSTRACT

Anterior cruciate ligament (ACL) tears are among the most frequent serious knee injuries in young athletes and often lead to prolonged time away from sport and elevated risk of re-injury. Purpose was to synthesize contemporary evidence (2015-2025) on diagnosis, operative and non-operative management, rehabilitation, and return-to-sport (RTS) in adolescents and young adults with ACL tears. Narrative review informed by a structured search of PubMed/Medline and Google Scholar using MeSH terms ("anterior cruciate ligament/injuries", "anterior cruciate ligament/surgery", "athletes", "rehabilitation", "platelet-rich plasma", "anterolateral ligament"), limited to english language and human studies. Current guidelines recommend individualized treatment; when surgery is indicated, reconstruction is favored over primary repair due to lower revision risk. Graft choice should consider sport demands and age; evidence suggests slightly lower failure with bone-patellar tendon-bone (BTB) versus hamstrings in some cohorts, though patient-reported outcomes are comparable. Adjunct procedures such as anterolateral augmentation (ALL/LET) may reduce graft failure and pivot shift in high-risk patients. PRP shows mixed benefits, with possible modest improvements in early pain and stability but inconsistent long-term effects. Criteria-based rehabilitation with delayed RTS (≈9-12 months) and psychological readiness assessment lowers second-injury risk. Management of ACL tears in young athletes should be individualized, balancing surgical technique, biologic adjuncts, and rigorous criteria-based RTS testing that integrates strength, hop performance, movement quality, and psychological readiness.

Keywords: Anterior cruciate ligament, Young athletes, Reconstruction, Rehabilitation, Return to sport, Anterolateral ligament

INTRODUCTION

ACL tears disproportionately affect adolescents and young adults engaged in pivoting and contact sports. Clinical decision-making spans non-operative rehabilitation, surgical reconstruction, biologic augmentation, and structured RTS testing. Authoritative guidance and high-quality trials published in the last decade have refined indications for surgery, graft selection, adjunct procedures, and rehabilitation milestones.[1,2] This review summarizes contemporary evidence and provides pragmatic recommendations for clinicians managing young athletes with ACL injuries.

LITERATURE RESEARCH

A structured search of PubMed/Medline and Google Scholar (January 2015 to August 2025) was conducted using combinations of the following MeSH terms and keywords: "Anterior cruciate ligament/injuries", "anterior cruciate ligament/surgery", "anterior cruciate ligament/rehabilitation", "athletes", "return to sport", "platelet-rich plasma", "anterolateral ligament", "lateral extra-articular tenodesis", "pediatrics", and "adolescents". Inclusion criteria were English language, human subjects, and clinical trials, cohort studies, meta-analyses, systematic reviews, guidelines, or consensus statements

relevant to athletes ≤30 years. Seminal earlier studies (pre-2015) were retained when foundational (e. g., randomized trials informing current practice). Reference lists of key reviews were hand-searched to identify additional eligible studies. Data were extracted on indications, surgical techniques, rehabilitation milestones, RTS criteria, and outcomes.

DIAGNOSTIC WORK-UP

Diagnosis relies on mechanism of injury, hemarthrosis, and examination tests (Lachman, anterior drawer, pivot shift). MRI confirms ACL disruption, evaluates concomitant meniscal and chondral pathology, and assists preoperative planning. Instrumented laxity and functional testing (single-leg hop and vertical hop) establish baseline asymmetry and inform rehabilitation goals.[11-13]

OPERATIVE VERSUS NON-OPERATIVE MANAGEMENT

Non-operative rehabilitation emphasizing early range of motion, swelling control, and progressive strength may be reasonable for low-demand patients willing to modify activities. However, in competitive youth athletes with symptomatic instability, reconstruction is commonly recommended to restore stability and reduce secondary meniscal injury. The AAOS guideline advises ACL reconstruction rather than primary repair when surgery is indicated, citing lower revision risk.[2] Randomized and observational evidence indicates that initial rehabilitation with optional delayed reconstruction can provide comparable long-term functional outcomes in selected adults; yet, younger athletes returning to pivoting sports often favor early reconstruction to minimize instability episodes.[1,14]

SURGICAL TECHNIQUE AND GRAFT CHOICE

Autograft remains the first-line choice in young athletes due to lower failure than allograft. BTB and hamstrings (HT) autografts yield similar patient-reported outcomes, with several analyses showing slightly lower graft failure with BTB, especially in high-risk, young cohorts.[3,4] Quadriceps tendon autograft provides comparable stability with potentially less anterior knee pain than BTB in some studies, and is increasingly used in adolescents. Technical pearls include anatomic tunnel placement and individualized notch management; graft diameter ≥8-8.5 mm for HT is associated with lower failure risk in youth.[15]

ANTEROLATERAL AUGMENTATION (ALL RECONSTRUCTION/LET)

Persistent rotational laxity and graft failure in high-risk athletes have renewed interest in anterolateral augmentation. Recent meta-analyses suggest that combining ACL reconstruction with ALL reconstruction or LET reduces rerupture, pivot-shift grade, and improves patient-reported outcomes compared with isolated ACLR in appropriately selected patients (e.g., high-grade pivot shift, generalized laxity, revision cases).[5,6,16,17]

BIOLOGIC AND MECHANICAL AUGMENTATION

Platelet-rich plasma (PRP) has been studied as an adjunct to ACLR. Systematic reviews indicate small short- to mid-term improvements in pain and early function, with inconsistent effects on graft maturation and long-term outcomes; recent analyses report possible gains in postoperative stability but call for higher-quality trials.[7,8,18,19] Internal brace (tape) augmentation and modern primary repair techniques are being explored. Systematic reviews indicate acceptable short-term outcomes for carefully selected proximal tears treated with repair plus internal bracing, but with higher failure rates than reconstruction in many series; reconstruction remains the standard for young, high-demand athletes.[20-22]

REHABILITATION PRINCIPLES

Contemporary rehabilitation is criteria-based rather than purely time-based. Early emphasis on quadriceps activation, progressive load, and restoration of symmetrical extension is critical. Evidence supports the judicious introduction of open-kinetic-chain quadriceps strengthening in a controlled arc after early healing, without increasing graft laxity.[23] Objective milestones include: limb symmetry index (LSI) ≥90% on strength and hop tests (with attention to movement quality), minimal effusion, full extension, and patient-reported readiness.[11,12,24] Movement-quality assessment during hop tests (e.g., valgus control, trunk stability) adds information beyond distance/time symmetry.[25]

RTS DECISION MAKING

Returning to pivoting sport too early markedly increases reinjury risk. Multiple studies and contemporary CPGs recommend delaying RTS to ≈9-12 months post-ACLR and only after meeting validated criteria. Failing to meet discharge criteria-not time per se-drives second-injury risk.[9,24,26] Psychological readiness, commonly measured by the ACL-RSI scale, correlates with outcomes and should be integrated with physical tests.[10,27,28] A pragmatic RTS battery for young athletes includes: isokinetic quadriceps and hamstring strength ≥90% LSI; single-leg vertical hop and horizontal hop battery ≥90% LSI; qualitative landing mechanics assessment; on-field/court change-of-direction progressions; and ACL-RSI thresholds consistent with lower reinjury risk.

SPECIAL CONSIDERATIONS IN CHILDREN AND ADOLESCENTS

In skeletally immature athletes, the risk of growth disturbance guides technique selection. Physeal-sparing and partial-transphyseal techniques demonstrate excellent stability with low rates of clinically meaningful deformity

when performed meticulously. Systematic reviews show variable graft failure (often higher than adults) and emphasize individualized technique by skeletal age and tear pattern.[29-32] Non-operative care may be considered for partial tears with stable knees in younger children, but persistent instability risks meniscal/cartilage injury; shared decision-making with the family is essential.[33,34]

DISCUSSION

This review synthesizes guideline statements and recent comparative studies to support individualized management for young athletes with ACL tears. Concordant with the AAOS CPG, reconstruction remains the benchmark when surgery is indicated, with BTB and HT autografts offering similar subjective outcomes but nuanced differences in failure risk across cohorts.[2-4] Adjunct anterolateral augmentation appears advantageous in high-risk phenotypes, reducing re-rupture and residual pivot shift.[5,6,16] Biologic adjuncts such as PRP may modestly aid early recovery, although long-term clinical benefits remain inconsistent and protocol-dependent.[7,8,18,19] Criteria-based rehabilitation that integrates strength, hop performance, movement quality, and psychological readiness is critical; delaying RTS to at least nine months and ensuring athletes meet discharge criteria substantially mitigate second-injury risk.[9,24,26,27] In pediatrics, physeal respect with age-appropriate techniques is essential; despite generally favorable function, failure rates remain non-trivial, underscoring the need for prevention programs and careful RTS decisions.[29-31] Future research should prioritize high-quality randomized trials of adjunct procedures and biologics, standardized RTS test batteries with validated risk thresholds, and long-term outcomes in skeletally immature athletes.

Participation in youth sport has risen worldwide, with year-round specialization and higher training loads. These changes have coincided with increased ACL injury rates in adolescents, particularly in sports with frequent cutting, deceleration, and unanticipated change of direction. Biomechanical risk factors include faulty landing mechanics (dynamic valgus, limited hip and trunk control), reduced hamstring-to-quadriceps strength ratio, and fatigue-related neuromuscular deficits. Primary prevention with school- and club-based neuromuscular training reduces ACL injury rates, yet adoption remains suboptimal. Clinicians must therefore navigate rising injury burden while advocating prevention and ensuring that treatment plans reflect each athlete's sport, season timing, and psychosocial context.

BTB autograft is often preferred for collision and court/field athletes due to robust fixation and lower graft elongation; potential trade-offs include anterior knee pain and kneeling discomfort. Hamstring autografts avoid anterior knee symptoms and donor-site kneeling pain but may be vulnerable to smaller graft diameter in petite athletes; augmentation or quadriceps tendon autograft can be considered. Quadriceps tendon-with or without bone block-has gained popularity because of reliable diameter, favorable biomechanical properties, and comparable outcomes to BTB and HT in meta-analyses. Allograft is generally avoided in athletes <25 years given higher failure rates. Independent of graft choice, precise anatomic tunnel placement, maintenance of femoral posterior wall, and avoidance of roof/ PCL impingement are key determinants of stability.

Indications commonly proposed for concomitant augmentation include: grade-2/3 pivot shift, generalized ligamentous laxity, high-risk pivoting sports (soccer, basketball, handball), revision ACLR, young age, and increased posterior tibial slope. Modern LET techniques (e.g., modified Lemaire) and ALL reconstructions use small incisions and avoid over-constraint by fixing in neutral rotation at appropriate flexion angles. While the aggregate data show reduced failure and pivot shift, careful patient selection and surgical execution are required to prevent lateral compartment over-constraint or loss of internal rotation.

A contemporary rehabilitation framework progresses through phases: (1) acute recovery (pain/effusion control, extension restoration, quadriceps activation), (2) strength and neuromuscular control, (3) plyometrics and deceleration mechanics, (4) linear and multi-directional running progressions, and (5) controlled practice with graded contact. Early open-kinetic-chain quadriceps work in a limited arc (e.g., 90°→45° progressing to 90°→0°) can accelerate quadriceps recovery without compromising graft integrity when dosing and technique are appropriate. Objective testing every 6–8 weeks provides feedback and allows shared decision-making; persistent asymmetries should trigger targeted interventions rather than time-based progression.

RTS test batteries should be standardized and feasible in real-world settings. Strength assessment ideally uses isokinetic dynamometry; when unavailable, reliable handheld dynamometry with strict protocols is acceptable. Hop testing should include both horizontal and vertical tasks; however, clinicians must assess landing strategy, trunk/knee alignment, and inter-limb timing to avoid 'passing' on compensated mechanics. On-field/court progressions should simulate sport-specific constraints (reactive agility, unanticipated cutting) because laboratory symmetry may not capture real-world deficits. Psychological readiness (ACL-RSI) often lags behind physical recovery; incorporating graded exposure, mental skills training, and expectation setting improves confidence and adherence.

In skeletally immature athletes with substantial growth remaining, physeal-sparing techniques (e.g., iliotibial-band extra-articular/intra-articular reconstructions) avoid drilling across physes. Partial transphyseal or complete transphyseal techniques are reasonable in older adolescents with limited growth

remaining, minimizing tunnel size and avoiding hardware that could tether growth. Careful preoperative assessment of skeletal age, limb alignment, and family goals informs technique choice. Postoperatively, pediatric athletes require vigilant monitoring for alignment changes, leg-length discrepancy, and adherence to neuromuscular training to mitigate elevated rerupture risk.

Comparative data indicate small but clinically relevant differences between graft choices in failure risk; these differences are magnified in younger, high-exposure athletes. Similarly, augmentation strategies confer their greatest benefit in those same high-risk phenotypes. Where evidence remains equivocal-such as PRP protocols and optimal RTS cut-scores-clinicians should prioritize standardized testing, transparent shared decision-making, and individualized load management rather than relying solely on time since surgery.

CONCLUSION

Young athletes with ACL tears benefit from individualized, evidence-guided care. When surgery is indicated, anatomic autograft reconstruction is preferred, with graft and augmentation strategies tailored to risk. A rigorous, criteria-based rehabilitation program culminating in validated RTS testing-typically no earlier than 9-12 months-can reduce reinjury risk and optimize long-term participation.

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