Safe Return to Play Following ACL Reconstruction in Young Athletes

Zachary S. Stinson, MD[1,2]; Jennifer J. Beck, MD[3]; Sasha Carsen, MD, MBA[4]; Allison Crepeau, MD[5]; Aristides I. Cruz, Jr., MD, MBA[6,7]; Matthew D. Ellington, MD[8]; Stephanie W. Mayer, MD[9]; Curtis D. VandenBerg, MD[10]

[1]Nemours Children's Hospital, Orlando, FL; [2]University of Central Florida, Department of Orthopedic Surgery, Orlando, FL; [3]David Geffen School of Medicine at UCLA, Los Angeles, CA; [4]Children's Hospital of Eastern Ontario, University of Ottawa, Ottawa, Ontario; [5]Connecticut Children's Hospital, Farmington, CT; [6]Warren Alpert Medical School of Brown University, Department of Orthopaedic Surgery, Providence, RI; [7]Hasbro Children's Hospital, Providence, RI; [8]Dell Medical School, The University of Texas at Austin; Central Texas Pediatric Orthopedics, Austin, TX; [9]Sports Medicine Center, Children's Hospital Colorado, Department of Orthopaedic Surgery, University of Colorado, Denver, CO; [10]Children's Hospital of Los Angeles, Keck School of Medicine of USC, Los Angeles, CA

Abstract: In order to reduce the risk of a second ACL injury following primary ACL reconstruction in young athletes, return to play (RTP) strategies are implemented that utilize temporal, psychological, and functional benchmarks. This strategy should be discussed with patients and their social support group prior to surgery in order to set proper expectations. Physiologically, time is needed for both graft maturation and incorporation as well as neuromuscular recovery. To monitor readiness for return to sport, validated measurement tools should be utilized along with functional assessments to address neuromuscular deficiencies. Patient reported outcome measures and psychological readiness should also be taken into account when assessing athletes' readiness to return to play. As athletes transition back to sport, ACL injury prevention training programs should be implemented on an ongoing basis. There remains insufficient evidence to support the routine use of functional ACL bracing to prevent ACL reinjury.

Key Concepts:

- Young athletes are at a high risk for a second ACL injury following a primary ACL reconstruction, with graft rupture or contralateral ACL tear occurring in up to one third of patients within 2 years after index ACL reconstruction.
- A return to play strategy should utilize not only temporal but also functional and psychological benchmarks.
- ACL injury prevention programs that incorporate neuromuscular training have been shown to reduce the rate of ACL tears and should be utilized to address functional deficiencies and for ongoing injury prevention.
- Functional assessments should be repeated at multiple time intervals to track progress and identify areas for improvement early on in the rehabilitation process.

Introduction

ACL reconstruction surgery in young athletes has become increasingly common and efforts to mitigate the risk of reinjury and optimize outcomes should include a careful return to play approach. This involves a multidisciplinary effort that begins prior to surgery. The following offers a review of the multiple factors that deserve consideration in improving the quality, safety, and value of this recovery process with a focus on the pediatric population.

Reinjury Risk Specific to Pediatric/Adolescent Population

Younger age is a well-established risk factor for reinjury risk following ACL reconstruction (ACLR)[1-5] and the reasons for this are likely multifactorial. Younger patients are more likely to have higher activity levels which may expose them to "at-risk" activities more frequently.[6,7] Pediatric and adolescent patients may still be relatively underdeveloped from a neuromuscular perspective, which may put them at risk not only for primary ACL injury but also for recurrent injury.[8] Finally, during the postoperative rehabilitation phase of recovery, children, parents, and coaches may be more apt to return to play sooner than objective, functional measures and guidelines allow.[9,10]

Together, this suggests that pediatric patients may be at increased risk of failure for a prolonged period after their index surgery. This highlights a debate in the sports medicine community regarding when athletes should be allowed to RTP, attempting to balance early RTP with the risk of ACLR failure.[1,12] While there has been a trend for accelerated rehab as introduced by Shelbourne et al. to allow for rapid RTP (6-12 months),[13] newer data demonstrates this may not be enough time for biologic recovery of the joint and optimization of function, as further discussed below.

While the decision to return to play following an ACLR should be a joint decision-making process involving the athlete, the athlete's parents, coaches, and the involved athletic training staff, all parties should be aware of the risk of premature RTP. It may be prudent to encourage athletes who are earlier in their career that do not require rapid RTP to delay their return to full activity as much as possible until they have maximized their rehab and reinjury prevention potential.

Preoperative Discussion

The preoperative discussion is critical for setting realistic expectations that recognize the limitations of surgery while also emphasizing the importance of postoperative restrictions and rehabilitation efforts. Acknowledging the impact of an ACL injury on a young athlete can help to foster a relationship of trust and honesty. It is important to validate patients' feelings of sadness, anger, fear, and disappointment associated with the realization that they face a prolonged absence from sports or other activities they enjoy and the impact this may have on an athlete's identity.[14]

While patient age, gender, activity level, and skeletal maturity all play a role in the preoperative discussion regarding the technical aspects of surgery, a patient's preferences in regard to cosmesis and potential harvest site morbidity are also important considerations when making these decisions. Likewise, a patient's individualized preferences will help guide the discussion regarding a return to their desired activity level, and it is important to take into account the influences of family members, coaches, teammates, and other members of their support group when gaining insight into their individual circumstances. When discussing the potential complications of an ACLR, the increased risk of graft rupture or a contralateral ACL tear in young athletes, especially within the first 2 years following surgery, must be emphasized along with an explanation that an early return to high-risk activities prior to achieving adequate functional recovery, further exacerbates this risk. Having an individualized approach to this discussion helps limit comparisons to their teammates or friends who may have had a similar injury.

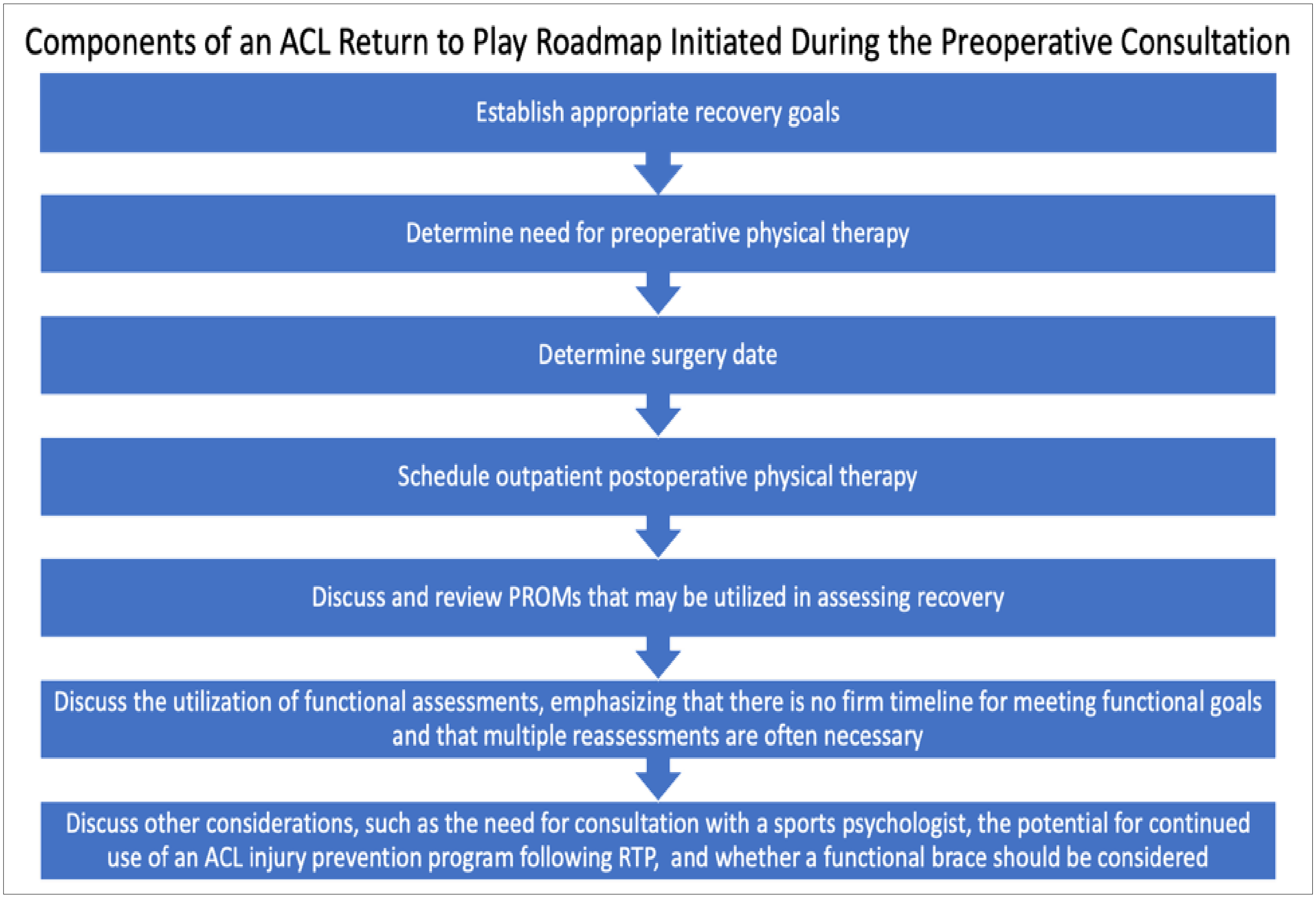

Figure 1*. Example of a preoperative return to play roadmap discussion*

After establishing realistic goals and expectations, it is helpful to provide the athlete with a roadmap of the rehabilitation process that includes a rough timeline in addition to functional benchmarks necessary for a safe return to play and how these functional criteria will be assessed (Figure 1). In addition to providing transparency and clarity, disclosing this information prior to surgery can help avoid future confusion and frustration as well as foster early engagement and buy-in from the patient and their support group. This also provides an opportunity to identify any financial or social barriers related to the postoperative recovery process that will need to be taken into consideration.

Time Requirement

Time has historically been the predictor for return sport following ACL reconstruction. A recent systematic review showed that 60% of studies utilized time as the main criterion for RTP, and only 13% utilized objective clinical criteria.[15] However, there is no consensus in the orthopaedic sports medicine community regarding a specific timeframe required after ACLR for young athletes to return to sports safely. Factors that may influence an athlete's readiness to RTP include biological as well as functional considerations. Previous literature advocated for accelerated rehab (6-12 months) following ACL reconstruction,[13] but more recent literature has suggested it may take approximately 2 years after ACL reconstruction for athletes to achieve baseline joint health and function.[16]

The biological recovery of the knee includes a process of graft "ligamentization" after ACLR in which the graft must undergo cellular proliferation, revascularization, and reinnervation as it restores native ligament properties.[17] During ACL graft "ligamentization," histological studies have demonstrated stages of ultrastructural differences in collagen fibril distribution, and no agreement exists on their timeframe, although this biological healing appears to occur over a longer period than when athletes commonly return to sport.[18,19] Additionally, the mechanoreceptors and sensory nerve fibers, which account for nearly 3% of the ACL's tissue volume, play an important role in dynamic joint stability and proprioception.[20,21] It has been demonstrated that sensory reinnervation leads to improved position sense.[22] The relative contribution of the loss of ACL sensory information and proprioception is difficult to measure and its impact on reinjury risk is unclear, but there is evidence to suggest that a minimum of 18 months after ACL reconstruction may be needed for complete restoration of this important function in knees.[23]

Earlier return to sport following ACL reconstruction in pediatric patients has been shown to be an independent risk factor for a second ACL injury.[1] An international, multidisciplinary group of ACL experts developed an evidence-based consensus statement regarding return to sport testing and decision-making. They concluded that purely time-based return to sports decision-making should be abandoned and that progression occurs along a return to sport continuum. The decision for return to sport should be multidisciplinary and incorporate objective physical examination data as well as validated return to sport testing, which should include both functional assessments and psychological readiness testing.[24]

Physical Exam

Many factors must be considered for return to sport following ACL reconstruction. One factor that must be included is an objective physical exam.[24] Qualitative assessment should include absence of a knee effusion, full range of motion equal to the contralateral uninjured side, normal patellar mobility, minimal patellar crepitus, no pain with all activities, and less than 3 mm of increased anterior-posterior tibial displacement on Lachman and anterior drawer testing or knee arthrometer testing.[15] In-office functional testing can be performed, including single-leg hop testing, in which less than 15% deficit in lower limb symmetry should be achieved. These tests include single hop, triple hop, crossover hop, and timed hop.[25]

Weakness in the lower extremities must be addressed after ACLR and quadriceps and hamstring strength and torque production should be equivalent to the contralateral limb prior to initiation of high-level sports activity.[16] Isokinetic dynamometer testing can be used as a way of objectively measuring concentric knee extensors and flexors, and reported data has shown improvement in extensor strength over time, regardless of graft type.[26] Isokinetic muscle strength deficits following ACL reconstruction may be graft dependent, with bone patellar tendon bone autograft exhibiting greater deficit in quadriceps strength and lower deficit in hamstrings strength as compared to hamstring autografts. These deficits may continue beyond 2 years postoperatively.[27]

Patient-Reported Outcome Measures

Patient-reported outcome measures (PROMs) can give surgeons an understanding of how the adolescent athlete feels about his or her progress through their postoperative rehabilitation and eventual readiness to return to sport. While there are multiple validated adult PROMs for ACL injuries, there are far fewer for the pediatric population. Child-reported outcome measures are typically valid in children >10 years old[28] while

Pediatric Patient Reported Outcome Measures

Pediatric PROMs	Measurement
Child Health Questionnaire, PedsQL, and Pediatric PROMIS	Health related quality of life
Pedi-IKDC and KOOS-Child	Condition and region specific
Pediatric Functional Activity Brief Scale	Activity assessment

Table 1. *PROMs currently used for pediatric patients*

parent proxy-reported outcomes are typically performed in children <10 years old, the latter having the potential for bias.[29] The recent 2018 IOC consensus statement on pediatric ACL injuries summarized the appropriate PROMS that should be used in pediatrics[30] (Table 1). For health-related quality of life measurements, the Child Health Questionnaire,[31] PedsQL,[32] and Pediatric PROMIS,[33] are the recommended PROMs. For condition-specific or region-specific PROMs, the Pedi-IKDC[34] and KOOS-Child[35] are recommended. Finally, for activity assessment, the Pediatric Functional Activity Brief Scale (Pedi-FABS)[36] is recommended.

There are three PROMs that have been specifically designed for pediatric patients with knee disorders. The Pedi-IKDC was modified from the adult IKDC and was found to be an acceptable outcome measure for psychometric performance in children from 10-18 years of age with various disorders of the knee.[34] Similarly, The KOOS-Child was modified based on feedback from children 10-16 years of age from the KOOS.[35] The HSS Pedi-Fabs can reliably and accurately evaluate activity level as a prognostic variable for research.[36]

PROMs such as the ACL-RSI[37] have also been associated with improved readiness for functional activities at 6 months and potentially earlier return to sports.[38] The ACL-RSI has not, however, been validated in pediatric patients. A recent systematic review found the IKDC to be the most commonly utilized PROM in 51% of studies, followed by the Lysholm (46%) and Tegner (37%), showing that the most commonly utilized PROMs in youth ACL reconstructions are not pediatric-specific.[39] They also found that only seven papers in their entire review utilized one of the pediatric-specific PROMs. Additional studies are needed to further elucidate the potential importance of PROMs both for research, as well as to possibly guide the postoperative rehab of the athletes.

Functional Assessment

Various functional milestones are utilized throughout the postoperative rehabilitation protocol to both ensure that the athletes are meeting their goals and to provide markers for advancement to the next phase of rehab. Assessment of single-limb power performance should be utilized in the decision to proceed with return to play, as persistent deficits have been shown to increase the risk of ipsilateral retear and contralateral tear.[9] The risk of ipsilateral ACL tear (4.4-10%) has been associated with younger age, higher activity level, and allograft usage, while the risk of contralateral ACL tears (3.5-20.5%) has been associated with younger age and higher activity level.[40] Achieving symmetrical quadriceps strength prior to return to sport has also been shown to significantly reduce the risk of reinjury.[41] Asymmetries in knee kinematics at the time of return to sport have been associated with decreased self-reported outcomes 2 years after surgery.[12]

Rehabilitation after ACL reconstruction has typically been performed in phases (Table 2). A 10 task-based

Phase Based ACL Rehabilitation Approach		
Phase	**Timing**	**Focus**
1 and 2	First 6 weeks	Range of motion as well as initiation of strengthening the quadriceps, gastrocsoleus, lateral hip, and hamstrings
3	6 to 12 weeks	Furthering strength, core/balance, and beginning single leg weight bearing drills. Jogging may begin once they can perform a single leg squat for 1 minute, jog in place for 1 minute, side-step for 1 min, and jog in the clinic without an antalgic gait
4	3 to 9 months (minimum)	Agility, heavier load single leg work, Sportsmetrics™ jump program, lower extremity weight training, and straight-line sprints at 4-5 months following surgery. Hop testing is then initiated at 9 months and passed if the athlete scores 90% or better. Retesting is performed at repeated intervals if the athlete fails.

Table 2. *Example of a phased-based approach to rehabilitation*

progression through ACL rehabilitation has also been recently proposed as an alternative to the time-based approach[42] (Table 3).

Balance remains an integral part of the functional assessment of the athlete. Historically, single-leg hop testing greater than 90% of the contralateral limb has been used in return to sport testing. There are other variations, including single-leg hop for distance, timed single-leg hop, triple hop for distance, and triple crossover hop for distance. Assessment of movement quality is equally as important as limb symmetry index (LSI). More objective tests can also be used in the postoperative assessment, including handheld dynamometer testing (Figure 2), which has been shown to be a reliable, low-cost means of determining asymmetries in quadriceps strength compared to the more expensive isokinetic dynamometer.[43]

Functional assessment of the hip and ankle are also important. Assessing ankle dorsiflexion during weight-bearing exercises including lunges can be very important, as a decrease in motion has been associated with an increased dynamic knee valgus, which is a known risk factor for ACL injury.[44,45]

The functional assessment of athletes participating in postoperative rehabilitation continues to evolve and no studies have definitively shown a specific test battery that has predictive validity for a successful return to sports following ACL reconstruction.[46] The goal is to find objective tests to both guide the athletes through the phases of rehabilitation and an eventual return to sports while steering away from time-based and more subjective measures, an approach that may ultimately lower the rate of reinjury (see additional resources and example videos of functional tests).

ACL Injury Prevention Programs

Many intervention programs have been designed to reduce the risk of primary ACL injury or reinjury in athletes. Programs differ in their focus on specific sports and also specific strength, plyometric, agility, and neuromuscular training. Many have been designed as warm-up drills, while others are additive to normal training routines. Some are focused on prevention of an initial injury, while others are focused on prevention of a reinjury.

Grimm et al. performed a systematic review and meta-analysis of nine level one RCTs regarding the utilization of injury prevention programs in soccer players specifically. They found that studies trended towards a significant effect on ACL injuries when pooled (P = 0.238). The relative risk was 0.66, which is consistent

Task Based ACL Rehabilitation Approach

	Task	Requirement
1	Walking	Good quadriceps recruitment to walk with no limp unaided
2	Bilateral foundation movements	Perform bilateral squats to 90 degrees with less than 20% asymmetry, requiring 50% body mass single limb leg press, full knee extension and flexion greater than 90 degrees
3	Unilateral foundation movements	Single leg squat to 90 degrees requiring 80% body mass single limb leg press and greater than 120 degrees of flexion
4	Bilateral landing	Sub maximal jump requiring 100% body mass single limb leg press and/or 150% body mass double limb leg press/squat as well as greater than 130 degrees of knee flexion
5	Running	125% body mass single limb leg press/squat and/or isometric knee extension greater than 70% limb symmetry index (LSI)
6	Bilateral plyometrics	Greater than 80% LSI knee extension and 125% body mass single limb leg press/squat or 200% body mass single limb leg press/squat
7	Unilateral jumping/landing	Single leg deceleration from forward and lateral running requiring greater than 80% LSI isokinetic knee extension and/or 150% body mass single limb leg press/squat
8	Unilateral plyometrics	Single leg drop requiring the same as task 7
9	Pre-planned multidirectional movements	90 degree cut maneuver and requiring the same as tasks 7 and 8
10	Sport-specific movements	Greater than 90% LSI isokinetic knee extension and/or 200% body mass single limb leg press/squat

Table 3*. Example of a task-based approach to rehabilitation*

with a protective effect.[47] Huang et al. performed a meta-analysis that found that ACL injury prevention programs reduced injury rates by 53% overall; however, each study had a slightly different protocol for plyometrics, strength, agility, and feedback, and specific components of the protocol were not analyzed.[48] Another meta-analysis found an odds ratio for injury of 0.4, suggesting effectiveness of injury prevention programs.[49] Subgroup analysis in this study found plyometrics and strength but not balance to be effective. Sadoghi et al. performed a systematic review, which compiled data from nine studies, and found a significant reduction in the risk of ACL rupture, with a risk reduction of 52% in female athletes and 85% in male athletes.[50] Compliance with the program has been noted in several studies to improve outcomes.[51] Improvement in not only quadriceps and hamstring strength but also hip flexion angles and moments were correlated with an improvement in knee biomechanics in "responders" to a prevention program suggesting that hip mechanics should be a part of these programs.[51] Recently, a compilation of available meta-analyses showed a 50% reduction in ACL injury in all athletes and a 67% reduction in non-contact injuries in females specifically.[52]

The ACL-Specialized Postoperative Return to Sports (ACL-SPORTS) training program was developed for athletes who have undergone ACL reconstruction, have regained full strength and range of motion, and are ready to perform high-level rehabilitation for return to sports. Several outcome measures from a randomized controlled trial using this protocol have been published with good results. Significant increases in a mixed group of men and women were seen in KOOS-Sport and KOOS-QOL, IKDC, and timed hop. Men, but not women, significantly increased quadriceps symmetry. Two-year postoperative data showed statistically significant and clinically meaningfully greater 2-year patient-reported outcomes in young, high-level female athletes who followed ACL-SPORTS protocol versus those who followed two other well-known protocols.[53] This program has also been shown to reduce contralateral ACL tears in female athletes at 2-year follow-up.[54]

Handheld Dynamometer Testing for the Post Op ACL Reconstruction Athlete

Allow athlete 1-2 practice trials then perform 3 formal trials per leg per muscle group. The average of the 3 trials is recorded and compared to uninvolved leg for decision making with progression through phases of rehabilitation or return to sport.

Quadriceps

Athlete Position: Sitting at edge of table with knee at approximately 70 degrees knee flexion. Both hips and back of thigh must remain on the table. Athlete is allowed to brace themselves with hands. Use towel roll as needed to cushion edge of table; however, be aware this will change knee flexion angle.

Belt/HHD Position: Belt on lowest point of anterior shin parallel to floor. HHD placed on bracing surface within belt loop.

Test Verbal Instructions: "Keeping both hips down, press shin into belt to straighten knee and hold maximum force."

Hamstring

Athlete Position: Seated at the front of a chair across from bracing surface with both hips in contact with chair and knee at approximately 70 degrees knee flexion.

Belt/HHD Position: Belt on lowest point of posterior shin parallel to floor. HHD placed on bracing surface within belt loop.

Test Verbal Instructions: "Keeping both hips down, pull into the belt to bend the knee and hold maximum force."

Hip Abductors

Athlete Position: Sidelying on table with bottom knee slightly bent for stability. Keeping hips perpendicular to surface, lift top leg keeping knee straight approximately 10 degrees above hip level.

Tester/HHD Position: Belt anchored around table with HHD placed just proximal to knee on the lateral side.

Test Verbal Instructions: "Keeping knee straight, lift your top leg up to press into the machine and hold maximum force."

Figure 2. *Examples of handheld dynamometer testing*

Another interesting finding across the ACL-SPORT literature is that the addition of perturbation training, thought to improve neuromuscular control, does not seem to have an effect on functional outcomes.[53, 55-57]

The FIFA 11 + injury prevention program was designed to reduce soccer-related injuries (not only ACL injuries) in youth athletes and is incorporated as a dynamic warm-up to try to improve compliance. It has been shown to reduce the rate of overall injuries in several studies.[58-60] It has also been shown to reduce the rate of ACL injury in male soccer players by 4.25 times.[61]

Pediatric and adolescent patients have been shown to demonstrate functional movement patterns that are associated with ACL injury, such as decreased knee flexion, knee valgus, and external tibial rotation.[62,63] The majority of studies regarding ACL prevention programs do not focus on pediatric patients specifically. Some portions of the protocols may be difficult for younger patients to understand or perform, and it has been shown that younger ages (<13 years old) do not respond with the same improvement to traditional programs as older adolescents and adults.[64] Modifications to a traditional program that gradually introduce activities, introduce a variety of activities, and allow more instruction and feedback time may improve sagittal and coronal plane knee biomechanical parameters.[65] Contrary to this finding, Thompson-Kolesar found that children aged 10-12 years of age showed more improvement than those aged 14-18 years of age with an 8-week program incorporating F-MARC 11+ twice weekly as part of a warmup program.[66] This program was shown again to reduce knee valgus moment in preadolescent female soccer athletes, a high-risk group for ACL injury.[67] This program shows promise to improve biomechanical risk factors in younger patients. A recent meta-analysis of studies including 11- to 20-year-old patients showed an injury risk reduction of 40% with injury prevention programs in this age group, although this was for overall injury rate and not ACL specifically.[68]

Psychological and Psychosocial Factors

Psychological and psychosocial factors have been found to play an important and integral role in the recovery of the injured athlete. Psychological readiness to return to play has a direct impact on a patient's safe return to sports and activities but may also be an indirect or secondary indicator of physical and physiological readiness. Understanding of the importance of psychological factors has grown significantly in recent years, with injury-related fear now thought to be a leading cause of failure to return to sports and activities in otherwise stable and "healed" patients post-ACL reconstruction.[69] Knee function and return to play can, in fact, be linked to psychological outcomes,[70] and psychological readiness to return has also been linked to reinjury rates upon return to sport in younger patients.[71] Injury-related fear has also been found to be directly related to self-reported knee function and has largely influenced patients' decisions to return to sport after ACL reconstruction.[72] Even after controlling for future knee self-efficacy as well as time from ACL reconstruction, injury-related fear has been associated with return to sport, and knee self-efficacy and knee-related quality of life scores have been associated with average step counts.[73] The psychological and emotional response to injury and the process of recovery is complex, and it has a significant impact on clinical and patient-reported outcomes.[74]

As discussed in the section dedicated to PROMs, it is important for both clinicians and researchers to find standardized means of measuring, comparing, and contrasting outcomes in patients. Both the Pedi-IKDC and KOOS-Child outcomes incorporate questions that may help shed light on a patient's psychological readiness, though neither score is dedicated to that function. The most commonly used psychological readiness score is likely the ACL-RSI scale, which is designed to incorporate psychological components believed to be associated with returning to activity after an injury, including emotions, confidence in performance, and risk appraisal.[37,75] Unfortunately, the ACL-RSI has not yet been validated or modified for a pediatric or adolescent population. Another commonly used measure is the Tampa Scale of Kinesiophobia-11,[76] but similar to the ACL-RSI, there is neither a pediatric version nor pediatric/adolescent validation.

A recent systematic review helped to clarify the evidence to date on the effect of psychological factors on return to play after ACL reconstruction,[77] as well as highlighting many of the other outcome measures that have been used to help measure and quantify psychological readiness. In addition to those mentioned previously, they include the Fear-Avoidance Belief Questionnaire,[78] the Knee Injury and Osteoarthritis Outcome Score,[79] the Knee Self-Efficacy Scale,[80] the Modified Disablement in the Physically Active Scale,[81] the Pain Catastrophizing Scale,[82] the Multidimensional Health Locus of Control scale (MHLC),[83] the Athletic Coping Skills Inventory,[84] and the Hospital Anxiety and Depression Scale (HADS).[85] There are clearly many different tools available; unfortunately, there is no agreement on a particular psychological or psychosocial standard. For the pediatric population, we must develop and validate population-specific measures focused on adolescence in particular as a period of rapid psychological and psychosocial change. As with other PROMs, adult psychological tools and associated evidence cannot necessarily be directly applied to the adolescent patient.[86]

Ideally, psychological and psychosocial assessment and treatment should not be thought of as being independent of functional rehabilitation but rather an integral part of it. There is no clinical agreement on specific strategies to address the psychological elements of return to play as we are still in the early stages of understanding the specific role they play in pediatric and adolescent patients. Practically though, it is important to acknowledge the importance of a patient's psychological, social, and emotional factors, and to consider that every patient has both unique psychological needs as well as unique available resources to address these needs. Psychosocial elements need to be incorporated into the patient assessment as well as the planning for recovery and rehabilitation.[87] Patients with inadequate support, resilience, coping strategies, and/or emotional outlets have been found to have inferior rehabilitation outcomes as well as higher rates of emotional instability, decreased confidence, inferior performance, and increased reinjury risk.[88,89] Some patients may get the support they need from their existing rehabilitation and coaching team and/or through community and family. Many others, however, may benefit from the assessment and services of a clinical psychologist with experience specific to sport and young athletes, or an applied sport psychology professional such as a mental performance consultant (see additional resources).

Functional Bracing

Functional braces are commonly prescribed for athletes returning to play following ACL reconstruction. Potential benefits include assistance with the optimization of athletic performance and athlete confidence, as well as protection of the ACL graft. However, there is limited evidence to support a reduced risk of reinjury or improved outcomes with the use of braces, and there is variation with regard to the recommended timing of brace wear and patient compliance.[90] Also, there are potential negative effects of decreased strength and increased risk of injury secondary to improper wear in addition to added cost.

From a biomechanical standpoint, functional braces are designed to try and reduce the force transmitted to the ACL graft in order to provide protection and minimize graft elongation. In vivo kinematic studies have demonstrated a reduction of anterior tibial translation, but these effects are not maintained at increased levels of force, suggesting that the stabilizing effect of braces diminishes at higher levels of activity.[91-93] Additionally, the static design of functional braces does not match the dynamic loading of the ACL at various flexion angles.[94,95] There is evidence that braces can help provide an improved sense of confidence,[90,96] which may be secondary to improved sensorimotor feedback. However, no studies have demonstrated improved proprioception with the use of braces.[97-99]

Overall, the use of functional braces has not been shown to improve functional outcomes or patient-reported outcomes.[100] Also, a majority of studies have not demonstrated a decreased risk of reinjury with the use of functional braces.[100,101] One exception is a decreased rate of reinjuries in skiers as demonstrated by Sterett et al.[102] In addition, a recent case series showed a decreased rate of graft tears in a braced cohort of adolescent patients when compared to an age and sex-matched historical control cohort of unbraced patients.[103] A prospective, randomized study focused on adolescent patients is needed to further investigate the use of functional braces in this patient population.

In studies evaluating the use of functional braces for return to sport following ACL reconstruction, brace compliance has been reported to range from 62% to 79%, with issues of discomfort, poor fit, slippage, and decreased performance, reported as reasons for not using them.[94] Proper fit and use are critical, as improper brace wear has been associated with an increased risk of injury.[10] Use of functional braces has also been shown to cause both flexion and extension strength deficits, as well as quadriceps atrophy.[97,98] Additionally, patients have reported a decreased perception of maximal performance and increased fatigability with the use of braces.[105,106]

While the benefit of functional bracing remains unclear, recent surveys found that 48% of fellowship-trained sports medicine surgeons and 50% of the members of the Pediatric Research in Sports Medicine (PRiSM) Society support their use for RTP.[107,108] Additionally, despite the conclusion from a recent systematic review that there is limited evidence that bracing decreases the rate of reinjury, Lowe et al. discussed that their preference is to recommend bracing for 6 to 12 months after return to sport.[100] This is in contrast to an earlier systematic review that determined bracing at any time following an ACL reconstruction is neither necessary nor beneficial.[101] Given the combination of limited supportive evidence, mixed expert opinion, and added cost, functional bracing is currently not routinely indicated as part of a safe return to play strategy. Additional studies, particularly in the pediatric and adolescent population, are needed to further define their role.

Conclusion

Secondary ACL injury rates, including graft tears and contralateral knee injury, are significantly higher in pediatric patients when analyzed separately from adult populations. Increasing research focused specifically on pediatric ACL surgery and recovery has proven that successful return to play is much more complex than simply following a calendar. Preoperative discussion of postoperative goals, surgeon expectations for recovery, and rationales for steps of recovery can guide team-based decision-making and improve patient outcomes. PROMs need to be pediatric-specific and validated in order to better understand their applicability with our young patient population. Advancement of physical exam techniques, beyond range of motion and graft specific testing, via functional return to sport testing provides objective data for reducing risk of reinjury upon return to sport. Increasing understanding about the psychological aspect of injury and recovery is warranted as the current research has solidified a direct correlation between psychological readiness and reinjury rates. Great attention has been placed in the past on ACL graft protection with functional bracing; however, evidence is lacking in its efficacy and value. Overall, recovery from an ACL injury should be approached in a multifaceted way in order to successfully and safely return young athletes to sports and activities.

Additional Resources

1. POSNA Tools
ACL Return to Play Toolkit

2. Sports Psychology Websites
appliedsportpsych.org
https://www.cspa-acps.com

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