From a clinical standpoint, the future for meniscal repair has 3 main challenges, according to Dr. Spindler. The first is a more complete understanding of the unique roles of the medial versus lateral meniscus, which can affect clinical outcome. Second, there is a need for longer-term data from prospective cohorts to drive improved healing following medial meniscus surgery and to identify replacements for lost medial meniscus. Third, improvements in the evaluation of meniscus repair are necessary. Improvements should include validated patient-reported outcomes and assessments of the performance and appearance of the repaired cartilage.

Rehab and Secondary Prevention Following ACL Injury

Written by Maria Vinall

The Department of Physical Therapy at the University of Delaware has a specific rehabilitation and training program for athletes to prevent secondary injury following an initial anterior cruciate ligament (ACL) tear. Lynn Snyder-Mackler, ScD, PT, University of Delaware, Newark, Delaware, USA, discussed the program.

Dr. Snyder-Mackler reviewed the scientific data that served as the impetus for her department's rehabilitation program. In a 24-month follow-up study among athletes who played sports that required cutting or pivoting movements and who had ACL reconstruction, 29.5% with a history of ACL reconstruction and 8.5% of the controls suffered an ACL injury; 30.4% were injured in < 20 athlete-exposures and 52.2% in < 72 [Paterno MV et al. *Am J Sports Med* 2014]. Female athletes were more than twice as likely to suffer a contralateral ACL injury as an ipsilateral injury. Similar data were reported in an Australian study [Webster KE et al. *Am J Sports Med* 2014]. The odds for sustaining an ACL graft rupture or contralateral injury increased 6- and 3-fold, respectively, for patients aged < 20 years. Odds of sustaining a graft rupture increased by a factor of 3.9 and contralateral rupture by a factor of 5 among those returning to cutting or pivoting sports.

Dr. Snyder-Mackler recommends early treatment following an ACL injury, with cold, compression, elevation, and active motion to decrease effusion. To restore and preserve passive and active knee extension, stretching, patellar mobilization, and quadriceps strengthening are recommended. This is followed by progressive exercises and neuromuscular electrical stimulation (NMES) to increase muscle and quadriceps strength and maintain muscle mass. A number of sessions of neuromuscular training should be employed to restore normal movement patterns and gait.

Rehabilitation programs should entail early techniques (ie, first week following ACL reconstruction) that control inflammation, improve patellar mobility, strengthen quadriceps, and improve gait. NMES can be used for selective muscle retraining, control of edema, and pain. The 1996 guidelines from the University of Delaware, updated in 2012 [Adams D et al. *J Orthop Sports Phys Ther* 2012], emphasized an 8-level progressive running regimen over 3 to 12 months following injury, but only for those athletes with full range of motion, no effusion, and a quadriceps index > 80%. A score of ≥ 90% on the return-to-activity (RTA) criteria determines progression through the running levels. The tests includes quadriceps strength index, 4 single-legged hop tests, the Knee Outcome Survey–Activities of Daily Living Scale, and the Global Rating Score of Perceived Knee Function. Passing the RTA exam and running progression means a graded return to activity, not a return to sports.

In addition to the rehabilitation program, a preventive ACL reinjury program has been developed. Nordic hamstring curls, standing squat exercises, drop jumps, triple single-legged hops, and tuck jumps are performed as part of the ACL-SPORTS Training protocol. Agility drills, quadriceps strengthening, and perturbation training are also part of the program.

Dr. Snyder-Mackler noted that the median time to RTA is 10 months but that it is getting increasingly longer.

ACL Injury Dynamics and Prevention in Female Athletes

Written by Maria Vinall

Anterior cruciate ligament (ACL) injuries in athletes are common, especially among females, who are at a 2- to 10-times greater risk than males. The causes are multifactorial but can be avoided with proper training. Timothy E. Hewett, PhD, The Ohio State University Medical Center, Columbus, Ohio, USA, discussed the mechanics of ACL injuries in terms of neuromuscular, anatomical, biomechanical, hormonal, and growth and development risk factors. The study of these form the groundwork for a prevention program developed at The Ohio State University Medical Center.

Female athletes have a greater risk of ACL because of increased dynamic valgus and high abduction loads during landing. Other biomechanical and neuromuscular risk factors identified include dynamic trunk instability, proprioception, history of low back pain, and greater knee joint laxity [Myer GD et al. *Am J Sports Med* 2008;

Zazulak BT et al. *Am J Sports Med* 2007; Hewett TE et al. *Am J Sports Med* 2005].

For those at high risk for a first ACL rupture, studies have shown a body-knee connection to injury where there is uncontrolled trunk or core motion coupled with knee abduction. To make female athletes less vulnerable to ACL tear, Dr. Hewett recommended training that addresses the mechanisms leading to knee abduction: not allowing the knee to cave in and training to increase hamstring and quadriceps recruitment, single-leg balance and symmetry, and dynamic core stability. This training identifies the neuromuscular imbalances—ligament, quadriceps, leg, and trunk dominance—that make the knee vulnerable to ACL injury.

Females diverge in ACL injury rates from males at ~12 years, the time that the majority of females begin puberty. ACL injuries peak in females at age 16. During females' adolescent growth spurt, their landing motion patterns are considerably different from those of males. Female athletes display greater total medial motion of the knees and a greater maximum lower extremity valgus angle than do male athletes on landing. Flexor torque decreases, and there is an increase in dynamic valgus angulation of the knees after maturation [Hewett TE et al. *J Bone Joint Surg Am* 2004].

In a study that examined longitudinal risk factors of ACL in females during maturity, incremental increases in height, body mass index, and anterior knee laxity were associated with decreased hip abduction and knee flexor strength and increased knee abduction loads after each year of growth. These changes increased the risk of ACL injury [Myer DG et al. *J Athl Train* 2009]. In females, increased body mass and height of the center of mass, without matching increases in hip and knee strength, may underlie increased knee abduction loads. Peak height velocity and high load coincide in females but not males.

Combined biomechanical and epidemiologic studies and video analysis provide evidence that sex-specific mechanisms of ACL injury may occur, with women sustaining injuries by a predominantly valgus collapse mechanism. ACL injury preventive programs should focus on the reduction of high-risk valgus, the reduction of loads, and the stability of sagittal-plane movements.