Basic and Clinical Science of Meniscal Repair: Present and Future

Written by Brian Hoyle

An examination of the current and future states of the basic and clinical science of meniscal repair was presented by 2 US researchers. Steven P. Arnoczky, DVM, Michigan State University, Lansing, Michigan, USA, opened the session by discussing what the future may hold in the basic science of meniscal repair.

Even a small amount of meniscus resection changes the function of the meniscus in terms of load transmission, which can overload the articular cartilage, leading to degeneration. The basic concept of successful meniscus repair has remained the same since the late 1970s, requiring healthy meniscal tissue, access to reparative cells, access to bioactive factors (a robust blood supply), and a favorable healing environment (a stable and noncatabolic knee). Although there are well-known factors that represent the "ideal" candidate for meniscal repair (Table 1), anywhere from 69% of medial and 88% of lateral meniscal tears may be deemed unrepairable, even in patients with stable knees [Fetzer GB et al. *J Knee Surg* 2009].

Table 1. Ideal Candidate for Meniscal Repair

Young (< 40 y)
Peripheral, longitudinal tear > 10 mm (red-red, red-white)
Healthy meniscal tissue
Anterior cruciate ligament stable joint
Good axial alignment
Minimal articular cartilage lesions
Rehabilitation compliant

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A study that assessed nearly 1500 patients (mean age, 46 years; 69% men, 31% women) with isolated meniscal tears in otherwise stable knees (73% medial, 19% lateral, and 8% both) revealed a poor success rate of repair, with only 7.3% of medial tears and 12.7% of lateral tears being repairable [Metcalf MH, Barrett GR. *Am J Sports Med* 2004]. This may have occurred because of damage to the meniscus, as many patients had complex or horizontal degenerative lesions that increased as they grew older.

Dr. Arnoczky then discussed new strategies to treat the "biologically challenged" patient with a damaged meniscus. Such patients include those patients aged > 40 years with (1) meniscal tears in the white-white zone, (2) chronic meniscal tears, or (3) complex tears. Three particularly innovative and potentially valuable meniscal repair strategies that may reduce repair failure in these challenging patients (and all patients) have been devised, which Dr. Arnoczky summarized as all-biologic repair, advanced repair, and scaffold replacement.

Biologic repair, which can eliminate the need for sutures of implants, is one strategy for repairing bucket handle and longitudinal tears in the vascular region of the menisci. Advanced repair—which uses the addition of cells, bioactive factors, or both to optimize the healing environment—might be successfully utilized to repair formerly irreparable bucket handle and longitudinal tears in the avascular zone or even horizontal cleavage lesions. Vascular enhancement techniques include creating vascular access by means of channels, trephine-created cores, or slits; stimulating enhancement through deliberate abrasion of the synovium; adding bioactive factors, such as fibrin clot, platelet-rich plasma, and the injection of recombinant proteins; and performing bone marrow stimulation techniques. One promising targeted therapy is the injection

Table 2. Predictors of Outcome Following ACL Reconstructive Surgery at 6 Years (p Values)

		Knee injury and Osteoarthritis Outcome Score					
Structure	IKDC	Symptoms	Pain	ADL	Sports/Rec	QoL	Marx
Meniscus							
Medial	0.004	0.001	0.001		0.005	0.025	
Lateral	0.028	0.001	0.002	0.001	0.001	0.023	
Articular cartilage							
MFC	0.011		0.021			0.002	0.01
LFC	0.002	0.03					
MTP	0.002	0.03	0.021		0.018	0.025	
LTP			0.034				
Patella							
Trochlea				0.032			

ADL=activities of daily living; IKDC=International Knee Documentation Committee; LFC=lateral femoral condyle; LTP=lateral tibial plateau; MFC=medial femoral condyle; MTP=medial tibial plateau; QoL=quality of life.

of mesenchymal stem cells (MSCs) into the knee joint rather than having the patient undergo surgery [Pak J et al. *Biomed Res Int* 2014].

Scaffold replacement utilizes bioinductive scaffolds or meniscal prostheses to regenerate chondroprotection function. This is a potential repair strategy for patients with irreparable complex, oblique, radial, or horizontal tears. MSCs may also have potential value as the basis of meniscal regeneration, with recent published data suggesting that up to 24% of patients who received an intra-articular injection of allogeneic MSCs 7 to 10 days after meniscectomy achieved a ≥ 15% increase in meniscal volume over meniscectomy controls at 12 months [Vangsness CT Jr et al. *J Bone Joint Surg Am* 2014]. Natural scaffolding in the form of allografts and xenografts, synthetic materials (eg, Actifit, Menaflex, MeniscoFix), and prostheses (eg, NUsurface) have potential merit for the repair of complex, oblique, and degenerative tears. In the future, custom-designed meniscal implants based on baseline magnetic resonance imaging may also be available. Dr. Arnoczky closed his session with a reminder that despite an array of new tools and techniques, the goal of meniscal surgery is, first and foremost, chondroprotection.

Kurt P. Spindler, MD, Cleveland Clinic, Cleveland, Ohio, USA, then reviewed the present and future clinical aspects of meniscal repair.

The 3 primary options for meniscus tears are excision, repair, or no treatment. The decision that proves best for the patient requires clinical consensus of the severity of the meniscal injury [Anderson AF et al. *Am J Sports Med* 2011; Dunn WR et al. *Am J Sports Med* 2004]. A clear understanding of what constitutes successful meniscal repair is crucial. The traditional view of success is no further surgery; follow-up studies have reported appreciable failure rates (14% to 27%) for this approach [Nepple JJ et al. *J Bone Joint Surg Am* 2012]. Patient-reported outcomes for aspects including pain and activities of daily living—such as the International Knee Documentation Committee subjective knee evaluation score, Knee injury and Osteoarthritis Outcome Score, and the Marx sports activity scale—are reportedly useful, particularly for medial meniscus repair [Cox CL et al. *Am J Sports Med* 2014; Barenius B et al. *Knee Surg Sports Traumatol Arthrosc* 2013].

In contrast, a lateral meniscus repair was shown by patient-reported outcomes to be as good as the normal lateral meniscus [Cox CL et al. *Am J Sports Med* 2014]. The study reported in a 6-year follow-up of 1307 of 1512 (86%) patients (Table 2).

More recently, visualization of articular cartilage changes using specialized radiography views and magnetic resonance imaging has been adopted. A caveat with these visualization approaches is that repair is based mainly on the type of tear and the vascularity of the site of injury; a decision to excise is based on the arthroscopic appearance and the relationship to the blood supply—thus, excision versus repair is not interchangeable. A degenerative meniscus tear from lack of blood supply usually eliminates the option of subsequent repair.

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;