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Redefining ACL Rehab

Surgical and therapy techniques bolster the body's weak link.

By Jonathan Bassett

If the human body is a masterful creation of structural engineering, then the anterior cruciate ligament (ACL) of the knee could be considered its weak link—the one tiny design flaw that can topple even the most physically gifted human specimens.

Leverage is the problem. A tough band of tissue that stretches vertically down the center of the knee, the ACL stabilizes the joint and prevents the shin and thigh bones from over-twisting. Its unique location makes it a critical component of the hinge between the two longest levers in the body.

When athletes generate enough rotational torque with the upper body while the foot remains fixed, as is the case with awkward landings and swift cutting moves in basketball and football, something has to give. Most often it's the ACL.

The frequency of this injury, coupled with the constant challenge of designing the best prevention and rehabilitation programs, have made ACL ruptures one of the most studied injuries in sports medicine. New research is arriving at a brisk pace, and if you don't stay current on the science you can find yourself treating athletes with outdated protocols.

Repairing the Damage

When an ACL ruptures, it unravels like a braided rope. It's an obstinate injury that doesn't heal on its own and usually requires intricate surgery. While there's generally no pain after the first few days, an untreated, unrepaired ACL tear compromises stability and causes the knee to "give out" during routine maneuvers.

Most patients opt to go under the knife to repair the ligament. However, older, less mobile patients can occasionally get by without surgery, relying instead on knee strengthening exercises and lifestyle modifications.

To replace a torn ACL, surgeons perform an allograft (using donated cadaver tissue) or autograft (using a section of the patient's own tissue). Despite a steady rise in allografts, autografts are still widely used. During an autograft, tissue is harvested from the patellar tendon (BPTB procedure) or a hamstring.

Each procedure has pros and cons. BPTB procedures have a longer track record, says Scott Holman, PT, OCS, clinic director at Rancho Physical Therapy in Temecula, Calif. BPTB grafts elicit good-to-excellent results in 90 percent of patients, and can return firm bone attachment up to 4 weeks earlier than hamstring grafts. Holman says. However, rehab compliance is important after a BPTB procedure, as knee pain, patella baja (low kneecap) and an increased risk of patellar fracture are possible complications.

Hamstring grafts saw a resurgence in the 1990s, due to improved soft tissue fixation techniques and a quicker return to activity. However, many surgeons and therapists report a higher degree of joint laxity and hamstring weakness, and Holman believes the current trend is to move away from this procedure.

In the last decade, autografts and allografts have benefited from improvements in surgical instruments, tissue preservation techniques and hardware materials. Still, the procedures aren't perfect and outcomes are frequently suboptimal—over one fourth of football players in the NFL never return to a game after an ACL injury.¹ In addition, the risk of complications is long if clinicians don't handle postoperative rehab correctly.

The Female Factor

Because of these setbacks, research is attempting to understand why ACL tears occur. And much of the focus is on female athletes, since women are two- to eight-times more likely to sustain an ACL injury than their male counterparts, according to the American Academy of Orthopaedic Surgeons (AAOS).

Theories abound about this frequency and center on the unique physiology of postpubertal females, such as lower musculoskeletal endurance, a narrower femoral notch, lower hamstring-to-quadriceps strength ratio and lower neuromuscular control of key muscle groups.

These factors contribute to problematic movement patterns, such as playing sports with the trunk and hips in a more erect posture, and moving the knee into valgus and extension when landing from a jump. As a result, the ability to absorb ground forces is compromised, which places the ACL in danger.

The interplay between female physiology and biomechanical patterns needs closer scrutiny. "That's the million dollar question in ACL research right now," says Christopher Powers, PhD, PT, associate professor and co-director of the musculoskeletal and biokinetics research laboratory at the University of Southern California. "Surprisingly little is known about women's sport-specific movement patterns and how they may contribute to knee injury."

Dr. Powers is leading a 3-year NIH-funded project to pinpoint specific movement disparities in young female soccer players. Motion analysis, force plates and sEMG data is tracking movement patterns during sport activity to determine what's happening on the biomechanical level that could account for the higher injury rate among female athletes.

Menstrual cycle phase is a compounding factor, adds Bruce Beynnon, PhD, associate professor of orthopedic rehabilitation at the University of Vermont in Burlington. Dr. Beynnon recently published a study that found female alpine skiers were three times more likely to sustain an ACL tear in their pre-ovulatory phase, compared with the post-ovulatory phase.²

Because this study was the first to rely on serum samples from injured and healthy athletes, rather than subjective self-reporting, Dr. Beynnon believes his research provides a clear picture of the importance of a menstrual cycle. "These findings remain a bit controversial, because we don't have a mechanism that that accounts for the disparity," says Dr. Beynnon.

Hormonal effects on joint laxity don't appear to be the culprit. Dr. Beynnon completed a separate study that showed no fluctuations in joint laxity throughout the menstrual cycle, although female athletes have looser joints than males. This information paves the way for future research into menstrual cycles, and provides valuable information for prevention programsscreening for ACL injury risk only needs to be done once, such as during preseason screenings.

An Ounce of Prevention

Regardless of an athlete's gender, experts agree that prevention and awareness can help minimize ACL injuries. The best way to implement proper conditioning programs is to capitalize on the expertise of physicians, athletic trainers, therapists, coaches and parents.

"There's a growing base of evidence that prevention programs work," says Dr. Powers, whose 3-year study is examining the effectiveness of the Santa Monica ACL prevention project (PEP).

The PEP protocol is a 15-to-20 minute, 3-day per week conditioning routine of stretching, strengthening, plyometrics and sport-specific agility drills. The protocol is designed to bolster stabilizing muscles, address deficits, and raise proprioceptive awareness and balance. Movements include slow jogs, shuttle runs, backward and diagonal running, targeted lower extremity stretches, lunges, toe raises and plyometric hops.

Early results are promising, especially with athletes who follow the program for at least 10 weeks. Dr. Powers hopes to isolate the beneficial components of the PEP program to determine why it works and whether it can "weed out" and alter problematic biomechanical behaviors in high-risk groups.

The PEP program is emblematic of the focus of most successful ACL prevention regimens. "If you look at the studies of prevention programs that have significantly reduced ACL injuries, every one of them has some combination of plyometrics, biomechanical analysis and a strengthening component," says Timothy Hewett, PhD, associate professor and director of the sports medicine biodynamics center at Cincinnati Children's Hospital Medical Center. "Clearly, these are the three components that must be present to achieve results."

Plyometrics are essential, Dr. Hewett says, to increase the dynamic stability of the knee joint, and provide key proprioceptive input and kinesthetic awareness. When working with young athletes, Dr. Hewett prefers single-leg decelerations, dynamic hopping and dynamic functional movements that focus on proper technique. For instance, athletes must land on the balls of their feet, with knees flexed, chest over the knees and no valgus shifting.

Even strengthening motions are dynamic and fast-paced. For example, instead of squatting with a bar, Dr. Hewett places an athlete on a rubber dome or pacer trainer to perform squats with dumbbells.

New research is changing the way coaches, trainers and therapists at the scholastic level view these injuries. "Nothing in sports medicine is accelerating as fast as ACL prevention and rehabilitation right now," says Ben Kivlan, PT, SCS, CSCS, director of rehab at Tri-State Orthopaedics and Sports Medicine in Pittsburgh. Based on these findings, Kivlan's clinic launched an ACL prevention program for a local girls' soccer team. Clinicians film the players from multiple angles and assess key movement markers, such as valgus knee angle and knee flexion on landing.

As a result, Kivlan can determine which athletes may be susceptible to injury, and start them on an exercise program that focuses on postural control and kinesthetic awareness. The program consists of balance and agility training, as well as core stabilization techniques, which include Pilates exercises that target hip and abdominal strengthening.

ACL Rehab's New Look

But even the best prevention program can't eliminate every injury. High-impact sports and the unique location of the ACL will always cause problems. Fortunately, rehab following ACL reconstruction has undergone a dramatic, much-needed facelift in the last 2 decades.

In the 1980s, a typical ACL protocol focused on immobility—casts, braces and avoiding any forces that could interfere with healing, says Mike Spitz, MSA, PTA, CSCS, an associate professor in the PTA program at Delta College in Bay City, Mich. Following a period of immobility, therapists adhered to more conservative timelines for rehab milestones. Clinicians rarely granted a return to full activity before 9 to 12 months.

"Today's programs are much more aggressive," says Spitz, and focus on immediate full weight bearing, early restoration of full knee extension and a heavy dose of closed-chain exercises, with a return to full activity in 4 to 6 months.

Accelerated protocols arose from knowledge that restricting movement of a postsurgical knee led to knee pain, capsular contractions, scar formation and articular cartilage effects, says Dr. Beynnon. Still, therapists and surgeons continue to differ in their preference between accelerated and conservative programs. Some clinicians feel that too much early movement stretches a new ligament graft and compromises stability; others feel that the earlier a patient can stand and walk, the better.

Much of the debate is unfounded, since patients generally arrive at the same endpoint. For instance, Dr. Beynnon randomized 25 subjects who received a bone-patellar tendon-bone graft into accelerated and nonaccelerated rehab programs. After 2 years, the athletes had no appreciable difference in knee laxity, clinical assessment, patient satisfaction, functional activity and collagen synthesis.³

Another debate exists between open- and closed-chain exercises during rehab. Again, it may not matter. Dr. Beynnon co-authored a study in 2005 that determined open-chain and closed-chain exercises "may not differ in their effects on the healing response of the ACL-reconstructed knee."

At Holman's facility, he usually sees a postsurgical patient for 16 to 24 visits. Athletes spend the first postop days on full weight bearing, passive range of motion and gentle strengthening and proprioceptive moves, such as quadriceps extensions while seated on a table with eyes closed. After several days, he adds step ups, heel raises, leg presses and quarter squats, along with gentle bicycling. Patients typically wear a transitional brace for 2 weeks after the operation.

In subsequent weeks, therapists can include transverse and lateral motions, backward running, plyometrics and weight lifting. Return to sports can occur at 16 to 24 weeks if isokinetic and strength tests are favorable, and the patient doesn't report pain or difficulty with exercise. Clinicians can also use modalities for pain and swelling, says Holman, such as cryo-cuffs, high-frequency electrical stimulation and interferential current.

Rehab doesn't differ much between hamstring grafts, BPTB grafts and allografts, says Kivlan, although some therapists prefer to progress more slowly after a hamstring graft, particularly with more demanding sport-specific movements, such as cutting and transverse running.

Long-term Complications

Surgery and rehab for ACL injuries are better than they were 20 years ago. Still, ACL surgery is invasive, and even the best post-surgical rehab programs may not be sufficient to prevent long-term side effects.

One such effect is bone loss. New research presented at the annual meeting of the American Academy of Orthopaedic Surgeons suggests that female athletes continue to suffer significant bone loss in their knees following ACL reconstruction, even after participating in an accelerated rehab program. Researchers followed 18 female athletes between the ages 16 and 40 through an aggressive, 2-year treatment program after ACL reconstruction. They noted "significant" bone loss in the femur, tibia and patella. Maximum bone loss occurred 3 to 6 months after surgery.

"We had hoped that with an early, accelerated rehabilitation program we could have reversed some of the bone loss during the recovery period," says lead author Diane Dahm, MD, assistant professor of orthopedics at the Mayo Clinic in Rochester, Minn. "These young, healthy women are at the age where they should be reaching peak bone mass, so having them achieve only partial recovery is concerning."

Women with a higher body-mass index experienced more bone loss, which led researchers to postulate that lower physical activity could contribute to the problem. "Women who undergo ACL reconstruction may need to be concerned about osteoporosis and their susceptibility to fractures later in life," says Dr. Dahm.

The challenge facing the sports medicine community is twofold: to learn more about the cause of ACL injuries, and to transfer this information to the parents, coaches, clinicians and trainers who work with at-risk athletes every day. Fortunately, progress is being made on both fronts, and rehabilitation researchers are making significant strides to strengthen one of the body's weak links.

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Return of a Champion

A boating accident in July 2005 destroyed golfer Ernie Els' left knee, and raised doubts about his future on the professional circuit. Els, then-ranked No. 3 in the world, sustained a ruptured anterior cruciate ligament (ACL), a stable tear of the medial meniscus, and significant bruising of the medial collateral ligament attachment. Post-surgical recovery from a hamstring graft usually takes 6 months. But armed with an uncompromising work ethic and a skilled therapy team, Els returned to competitive golf in less than 4 months. [Here's the winning formula his clinical team designed for an accelerated rehab program.](#)

July 28, 2005. Pre-op. Normal protocol before ACL surgery requires a "quiet knee"—full range of movement (ROM), minimal swelling and good function. It's critical for a patient to have full hypertension. If ROM is short of this goal, the patient stands a higher probability of stiff knee conditions. Sophie Dhenin, a physiotherapist at the Scorpio Clinic in Surrey, U.K., and colleagues develop an aggressive therapy plan that combines mobilizations, [active therapeutic movement \(ATM\)](#), soft tissue work, gentle stretches, exercises and kinesiotaping to ensure minimal swelling and full hypertension prior to ligament replacement.

August 8, 2005. Surgery. Orthopedic surgeon Andrew Unwin arthroscopically replaces the torn ACL with a strip of Els' own hamstring tissue and anchors it to the surrounding bone. "A great deal of physical and psychological effort is needed [after this surgery]," says Unwin, who's pleased with the results. "But there's absolutely no reason why professionals cannot return to their pre-existing standard of activity."

Dhenin begins treatment on the same day with passive flexion and extension, and mobilizations. The outcome is almost full flexion and hypertension, with substantial pain tolerance by Els.

August 10, 2005. The acute phase of the rehab team mobilizes and actively mobilize Els' newly reconstructed joint, and continue soft tissue mobilizations with passively steel instruments. The team puts him through a series of tough exercises, such as rocking back on the heels, straight-leg raises, static and inner range quadriceps contractions, and hamstring and calf work. Therapists track swelling and range of motion measurements as exercises become increasingly challenging. They also prescribe home cryotherapy to ease Els' persistent bone bruise pain and decrease swelling.

On day 8, Els returns to ATM treatment techniques and resistance exercises. The result is superb static quadriceps, terminal extensions and hip extensions, and good gluteal recruitment.

August 30, 2005. Powering up. The rehab team initiates a classic progressive strengthening program of closed-chain exercises and pool work to target individual muscle groups with brief, intense strength-training sessions. This includes a progressive ATM treatment technique and exercise protocol. The routine strengthens quadriceps, stretches posterior tissues and cues proprioception and coordination with standing toe, foot, knee and hip positioning. These daily activities involve using different combinations of hip and knee extensions, along with standing on cushioned disks for positional workouts. Therapists make sure that Els' pelvis, and low and upper back are stabilized during these exercises. This is the key to optimizing recruitment of central nervous system muscle activation strategies, says Dhenin.

A cross-training machine and a stationary bike help boost Els' cardiovascular output. The goal is to recapture—or even surpass—his previous form, says Josh Salzman, director of fitness at the Wentworth Club in England. "When he comes back to playing golf, the world is going to see a different Ernie Els."

September 22, 2005. Golf-specific drills. Els begins sport-specific drills to fine-tune his game. Swinging a club while standing on two disks sharpens his balance, and ATM neuromuscular retraining on a stabilization device continues to improve strength, coordination and proprioception across multiple planes. "We're now gearing things toward his golf swing," Dhenin says.

November 28, 2005. Teeing off. Els is back playing competitive golf at the Nedbank Golf Challenge in South Africa, 2 months ahead of the initial target date for returning to the game. He finishes ninth out of 12 and calls his outing a "disaster."

But just a week later, Els wins the Dunhill Championship with a score of 14 under par, which is punctuated by a dramatic eagle on the final hole of the Saturday round. "To win so soon after coming back to tournament golf is like a dream come true," says Els, who continues to work on his long-term rehab and hopes to be one of the top players in 2006.

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Sophie Dhenin contributed to this article.

ACLs in the Next Generation

As biotechnology gears up for the new millennium, investigators are examining the potential of new technology to curb the number of anterior cruciate ligament (ACL) injuries. Here are two main areas.

● Collagen gels. At Children's Hospital in Boston, researchers are looking at the potential of collagen gel to make traditional ACL replacement surgery obsolete. Working with animal models, a research team led by Martha Murray, MD, inserted a collagen gel that was mixed with platelet-rich blood plasma into partially torn ACLs. Gel-treated knees showed greater ligament repair at 6 weeks (43 percent vs. 23 percent) and a 26-percent greater increase in mechanical strength.

The body works hard to heal an ACL injury, says Dr. Murray. Cells migrate to the wound, growth factors are secreted and blood vessels grow to nourish new tissue. What's missing is a blood clot to act as a temporary "scaffold" to fuse the ligament ends back together. Fluid in the knee joint dissolves this potential.

The gel provides the bridge. "This is a first important step in showing that the ACL can heal if we give it the right conditions," says Dr. Murray, who believes certain ACL repairs in the future can be handled as outpatient procedures.

● Radio frequency. Researchers at Navarre University Hospital in Spain have found encouraging results by delivering arthroscopic radio frequency to partially torn and slack ACLs.

Because ligamentous tissue contains water and collagen fibers, it retracts (tenses) when subjected to heat at a precise radio frequency. Researchers followed 30 patients with MRI studies for a year after treatment and noted shorter recovery times in 90 percent of patients. The work captured the University of Oviedo's national prize for research in sports medicine.

Researchers feel that this technique can be beneficial to athletes and active middle-aged patients.

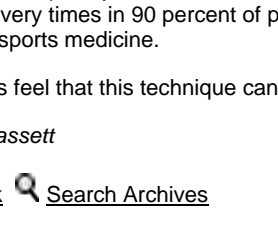
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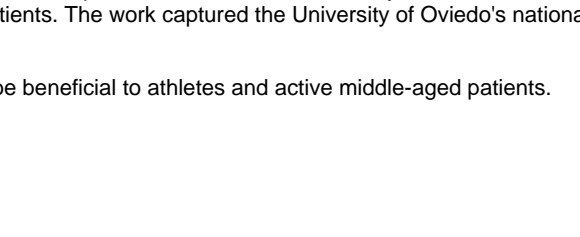
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