Novel Stem Cell Therapy for Repair of Knee Cartilage

Mayo Clinic offers a unique regenerative medicine approach for repairing knee cartilage, which can be completed in a single surgery. The Food and Drug Administration approved the use of this technique, known as RECLAIM, in a trial utilizing the stem cell bank in the Mayo Clinic Center for Regenerative Medicine.

“Mayo is unique in having an adipose-derived allogeneic stem cell bank. It provides us with donor mesenchymal stem cells, which we mix with recycled autologous cells to quickly obtain enough cells to fill the patient’s cartilage defect without operating twice,” says Daniel B. F. Saris, M.D., Ph.D., an orthopedic surgeon at Mayo Clinic in Rochester, Minnesota, who specializes in knee surgery and focuses on regenerative medicine.

Dr. Saris previously performed the RECLAIM cartilage repair technique (Figure) in Europe. “The results, about four years out, are very good — comparable to or better than other cell therapies, except these patients achieve normal function after surgery about six months more quickly,” he says.

Planning is underway for a clinical trial at Mayo Clinic. RECLAIM is used to repair symptomatic cartilage defects, usually resulting from trauma or an athletic injury. The procedure might be suitable for nonarthritic patients ages 18 to 50 who have fresh cartilage defects.

Recycling patient cells

Existing cell therapy to repair knee cartilage generally involves surgically debriding the cartilage...
Mayo Clinic uses a novel technique for extensor mechanism reconstruction following total knee arthroplasty. The results for a large series of patients with midterm follow-up suggest that the stepwise surgical technique with Marlex mesh provides substantial functional benefit.

“We’ve had excellent results for an otherwise unsolved problem. At year four of mean follow-up, 84 percent of the mesh reconstructions were in place. Moreover, the mean extensor lag decreased from 36 to 10 degrees in our series,” says Matthew P. Abdel, M.D., an orthopedic surgeon at Mayo Clinic in Rochester, Minnesota.

Disruption of the extensor mechanism after total knee arthroplasty is debilitating, and multiple methods of repair and reconstruction have had poor results. The key to Mayo Clinic’s technique, described in the Aug. 1, 2018, edition of The Journal of Bone and Joint Surgery, is the stepwise approach, which helps ensure that the mesh is properly incorporated into the host soft tissues. The new technique builds on the reconstruction approach developed at Mayo Clinic by Arlen D. Hanssen, M.D., an emeritus consultant in Orthopedic Surgery.

“The procedure works well for people who have a complete disruption. However, we often see people referred for extensor mechanism disruptions who actually have a flexion contracture,” Dr. Abdel says.

Ideally, patients should not have had previous surgery for extensor mechanism reconstruction.

Mayo Clinic’s multidisciplinary approach provides the range of care needed by patients at all stages of knee cartilage repair. Before surgery, advanced imaging helps pinpoint the cartilage defect. Our physiotherapists and athletic trainers also determine prior to surgery how we can optimize the patient’s musculoskeletal control and function, and then work with the patient on rehab after surgery,” Dr. Saris says.

Mayo Clinic also has the breadth of orthopedic expertise to manage problems that patients often experience alongside damaged knee cartilage, such as varus deformity and anterior cruciate ligament or meniscus lesions. “If a cartilage repair procedure fails, it’s generally because not enough attention was paid to other factors — the meniscus or the knee’s alignment or stability,” Dr. Saris says. “Our unique multidisciplinary team looks at all aspects of a patient’s care. Our chances of success for these complex biological reconstructions is therefore high.”

The cartilage repair technique illustrates Mayo Clinic’s commitment to applying regenerative medicine to orthopedic surgery. “We are focused on patient-centered progress,” Dr. Saris says. “We want to make sure there is a safe and efficacious portfolio of regenerative medicine therapies for musculoskeletal problems.”
Ensuring that soft tissue completely covers the mesh so that it doesn’t rub against the implant or beneath the skin (Figure 1)
Mobilizing the vastus lateralis and vastus medialis so that they cover the mesh (Figure 2)

“Equally important to the success of this procedure is the postoperative rehabilitation. The casting is the second part of the surgery,” Dr. Abdel says.

Patients have a full-length cast, which covers the foot, for three months. “The cast is changed every two to three weeks. We always change it here at Mayo Clinic, no matter where the patient is from,” Dr. Abdel says.

After three months of casting, the patient wears a hinged knee brace and starts three to four months of physical therapy. The brace is locked in extension while the patient is ambulating and not doing therapy. Physical therapy can be done locally.

“The therapy protocol is quite involved and proceeds very slowly,” Dr. Abdel says. “For the first month, we allow a maximum of 45 degrees of bend. In the second month, the maximum bend is 60 degrees; in the third, 75 degrees; and in the fourth, 90 degrees. For the next few months after that, patients can remove the brace, but I recommend that they use a walking aid so they don’t have a buckling episode.”

Future refinements of the technique might involve using a mesh with greater tensile strength, injecting stem cells to stimulate tissue growth of host tissues into the mesh and expanding the use of contemporary rotating-hinge prostheses to better stabilize the limb.

“Disruption of the extensor mechanism after total knee arthroplasty is rare, but the consequences for patients are catastrophic,” Dr. Abdel says. “Mayo Clinic is committed to continually improving its techniques for the benefit of its patients.”

For more information

Figure 1. The mesh is incorporated into host tissue distally. The goal is for the mesh to pass through the host tissue via a tunnel, but to keep host tissue ventral and dorsal to the mesh to avoid any portion of the mesh rubbing on the prosthesis.

Figure 2. The mesh is incorporated with the proximal tissue after aggressive ventral and dorsal mobilization of the vastus medialis obliquus and vastus lateralis.

Hip Arthroscopy: Focus on Underlying Abnormalities

Mayo Clinic takes a comprehensive approach to hip arthroscopy, going beyond repairing the labral tear to addressing the underlying abnormalities. “Our approach is evidence-based. It’s generally the underlying bony abnormalities that drive the process of labral tears, and we’re very focused on trying to correct those problems,” says Matthew M. Crowe, M.D., an orthopedic surgeon at Mayo Clinic in Jacksonville, Florida.

“Although these surgeries certainly aren’t a cure-all for every young patient with hip pain or hip problems, we’re finding that many patients are very good candidates for these procedures and benefit from them.”

Across Mayo Clinic’s three campuses, orthopedic surgeons perform hip arthroscopy in patients whose ages range from adolescence through their 60s. Mayo’s comprehensive approach begins with diagnosis. “It’s generally carried out in a multidisciplinary fashion, with a lot of help from our nonoperative sports medicine providers and our imaging experts,” Dr. Crowe says.

As a multidisciplinary practice, Mayo Clinic facilitates collaboration among specialists. “An MRI with contrast in the hip joint is a very nuanced image that requires expertise to analyze. I routinely walk down the hallway to review patient images with our fellowship-trained musculoskeletal radiologists,” Dr. Crowe says.
Diagnostic procedures often indicate that the patient will respond well to nonoperative treatments, including focused physical therapy or injection procedures. If surgery is indicated, Mayo Clinic offers both open and arthroscopic hip preservation options.

“A lot of people have unrecognized hip dysplasia or other chronic developmental abnormalities that aren’t optimally treated with arthroscopy. But these patients can benefit from other hip procedures,” Dr. Crowe says. “We are increasingly improving our understanding of which patients benefit from which procedures.”

After surgery, Mayo Clinic has specific protocols for rehabilitation, which patients can follow with their local providers. Dr. Crowe, who had hip arthroscopy at Mayo Clinic’s campus in Minnesota, has followed the protocol. “I have experience with this protocol as both a surgeon and a patient. This rehabilitation is a very important part of treatment,” he says.

**Surgical hamstring repair**

Hamstring injuries, which tend to occur in active people between the ages of 40 and 70, have generally been treated nonoperatively. Due to the persistent pain experienced by some patients, Mayo Clinic has begun treating more of these injuries surgically.

“On closer inspection, we’re now seeing that a lot of patients treated nonoperatively 10 or 15 years ago aren’t happy with the long-term outcomes. They experience weakness in the injured leg and aren’t able to resume their normal activities. As a result, we’ve started considering surgery for more of these patients,” Dr. Crowe says.

“Unlike most injuries in younger athletes, which are often located where the muscle and tendon meet and can be treated nonoperatively, many of our older athletes and patients who have complete or partial hamstring tears can experience a lot of pain and difficulty sitting, if they’re treated nonoperatively,” he says. “For those patients we now have good surgical options.”

Dr. Crowe notes that not everyone who has hip arthroscopy or hamstring surgery will be completely pain-free. “But the vast majority of patients have significant improvement from these surgeries and are able to return to doing what they like,” he says. “Overall, the improvement in people’s quality of life is significant.”

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**New Option for Massive Irreparable Rotator Cuff Tears**

Mayo Clinic uses a novel modification of the superior capsule reconstruction (SCR) technique for enhanced treatment of massive irreparable rotator cuff injuries. Early results of the surgical technique, offered to patients with Hamada grade 2 and 3 tears, are promising.

“We use an acellular human dermal allograft to perform an SCR. But we use the leftover allograft to resurface the undersurface of the acromion, which effectively doubles the thickness of the construct and may provide more-durable outcomes, especially for younger and more-active patients,” says John M. Tokish, M.D., an orthopedic surgeon at Mayo Clinic in Phoenix, Arizona.

Reverse shoulder arthroplasty can restore function and improve pain in older patients with severe rotator cuff injuries. But patients under age 65 may experience increased complications from the procedure compared with older patients.

“We have experience with this protocol as both a surgeon and a patient. This rehabilitation is a very important part of treatment,” he says.

**Thickness similar to autograft**

The original SCR technique used a fascia lata autograft, which was folded two or three times to obtain a graft thickness of 6 to 8 millimeters (mm). Clinical outcomes of these procedures were comparable to outcomes of complete rotator cuff repairs. But donor site morbidity associated with autograft led to the use of dermal allografts in SCR, which has been less successful.

“The maximum thickness of commercially available dermal allografts is about 3.5 mm — half that of the autografts used in the original SCR technique and below the thickness of the native capsule,” Dr. Tokish says.

Dermal allografts are significantly more expensive than autografts, making it financially unfeasible to use a second graft to achieve the desired thickness. But the allografts are usually large enough to provide two separate grafts,” Dr. Tokish says.

The first allograft is attached to the glenoid and greater tuberosity, as is typically done in SCR, and the second to the underside of the acromion (Figure). The grafts are positioned with the epidermal sides opposed, to create a healing
Often dubbed “the black box of the wrist,” ulnar wrist pain is a common, debilitating condition that frustrates both patients and practitioners. Mayo Clinic has developed a diagnostic algorithm designed to address the major components and enhance the management of distal radioulnar joint (DRUJ) conditions.

“The algorithm provides a systematic approach to ensure we characterize the most common elements of ulnar wrist pathology for complete treatment. In this way, we can hone in on the diagnosis or diagnoses and tailor the treatment to address the problem,” says Sanjeev (Sanj) Kakar, M.D., an orthopedic surgeon at Mayo Clinic in Rochester, Minnesota. The algorithm was developed in conjunction with Marc Garcia-Elias, M.D., Ph.D., a specialist in carpal instability at the Kaplan Hand Institute in Barcelona, Spain.

**The ‘4-Leaf Clover’ algorithm**

Ulnar wrist pathology is common and generally involves derangements to several structures. “Often only one component of the multiple pathologies is addressed, and the issue is that these aren’t mutually exclusive. Continuing problems often frustrate patients and their treating providers,” Dr. Kakar says.

As described in the April 2016 issue of the *Journal of Hand Surgery*, the Four-Leaf Clover algorithm (Figure 1) focuses on four key factors. Physicians should ask if the DRUJ dysfunction is influenced by:

- Bone deformity, such as distal radius malunion or radioulnar length discrepancy
- Cartilage defect, due to factors such as arthritis
- The nature of the static stabilizers of the DRUJ, such as triangular fibrocartilage complex (TFCC) injury

**Figure 1.** Venn diagram illustrates the questions in the Four-Leaf Clover algorithm.
Mayo Clinic uses advanced intraoperative monitoring to prevent neurological complications during complex cervical spinal surgery. As a multidisciplinary center, Mayo Clinic can provide the team approach required for successful intraoperative monitoring.

“We work closely during these surgeries with a neurologist or physiatrist as well as an electrophysiology team. Our routine use of somatosensory- and motor-evoked potentials as well as electromyography allows us to monitor nerve pathways and alter our technique, to proactively...”

Cervical Spine Surgery: Intraoperative Monitoring to Avoid Complications

The ‘calamari procedure’
For people with DRUJ arthritis, ulnar head replacement can relieve pain and restore functional anatomy and kinematics. However, up to 30 percent of patients may need revision surgery, mostly due to implant instability and persistent pain.

Mayo Clinic surgeons, building on the clinic’s tradition of innovation, have devised a technique that may help. Termed the “calamari procedure,” the technique involves an ulnar head partial replacement with DRUJ interposition arthroplasty using a lateral meniscal allograft as a stabilizer. The allograft is trimmed to match the size of the sigmoid notch; the two edges of the meniscus are sutured together to form a ring, deepening the concavity of the sigmoid notch and thereby providing stability to the implant (Figure 2).

“I had the pleasure of working with Bassem T. Elhassan, M.D., an orthopedic surgeon at Mayo Clinic’s campus in Minnesota, who, using the principles of shoulder surgery, devised this technique for the wrist,” Dr. Kakar says.

In the July 2017 issue of the Journal of Hand Surgery (European Volume), Mayo Clinic researchers described favorable outcomes of patients who underwent the procedure. After a mean follow-up of 20 months, all patients experienced a marked reduction in pain and had an increase in postoperative range of motion, with an average increase in grip strength of 43 percent to the unaffected extremity. No patient reported symptoms of implant instability.

“The technique is still in its infancy, but Dr. Elhassan and I have been impressed with the results so far,” Dr. Kakar says. “Patients with ulnar wrist pain can have difficulty with everyday things such as lifting a child out of a car seat. Sometimes the patients are labeled as having chronic pain and prescribed opioids. It can be souldestroying. At Mayo, working together, we hope we can help these patients return to a better life.”

For more information

prevent these patients from going on to develop neurological deficits,” says Ahmad Nassr, M.D., an orthopedic surgeon at Mayo Clinic in Rochester, Minnesota.

Dr. Nassr estimates that intraoperative monitoring triggers an alert in about 25 percent of spinal surgeries. “The majority of these alerts may be subtle and related to limb positioning, not the surgery itself. However, failing to act on the alerts could result in significant harm to the patient,” he says. “In more-complex surgeries, such as those for spinal cord compression, tumors and deformity surgery, the use of this monitoring can alert us to an impending problem and allow us to change our technique so as to avoid a neurological complication.”

**Proactive approach at all stages**

The effort to prevent complications begins before surgery. Baseline neurological monitoring is performed to guide the positioning of the patient during the procedure. “We know that the position of the patient can impact his or her ability to undergo surgery safely,” Dr. Nassr says. “Without that baseline monitoring and optimal positioning, there’s a potential to injure the patient before we even start operating.”

The intraoperative monitoring can identify even peripheral causes of nerve compression that will impact patients. “For example, if we have the arm tucked too far at the patient’s side, the monitoring can indicate that we’re irritating the ulnar nerve at the elbow,” Dr. Nassr says. “Although that sounds fairly minuscule, if patients are in that position for three or four hours, they can wake up with a fairly bad neurological deficit that has nothing to do with the cervical spine but with how the arm was positioned during surgery.”

Cervical 5 (C5) palsy is less common, occurring in less than 10 percent of cervical spinal surgeries. But C5 palsy is usually detected only after surgery, as weakness in the deltoid and bicep become apparent.

Mayo Clinic routinely performs intraoperative C5 monitoring. “When we get an alert, we can do additional decompression around the C5 nerve root,” Dr. Nassr says. “If C5 palsy does develop after surgery, we identify it early. We’re recognizing its multiple causes and treating them aggressively to have more-favorable outcomes.”

Treatment protocols developed at Mayo Clinic include physical therapy, electrical stimulation of the shoulder muscles and elevation of the shoulder to ease pressure on the brachial plexus. “Those efforts generally result in faster recovery for patients who develop C5 palsy, which can be an inevitable complication of some cervical spinal surgeries,” Dr. Nassr says.

To further limit the risk of C5 palsy, Mayo Clinic resects the posterior longitudinal ligament (PLL) selectively. In a review published in the April 1, 2017, issue of *Spine*, Dr. Nassr and colleagues found that PLL resection is associated with a higher incidence of C5 palsy. “At Mayo, we try to resect the PLL only if it’s necessary as part of the decompression,” Dr. Nassr says.

Intraoperative monitoring is particularly important when patients aren’t able to communicate with surgeons. Dr. Nassr cites a recent patient whose care he managed with A. Noelle Larson, M.D., a pediatric orthopedic surgeon at Mayo Clinic’s campus in Minnesota. The 2-year-old patient had spinal cord compression (Figure) — an unusual condition at that age — and was too young to cooperate with an intraoperative wake-up test. During the surgery, intraoperative monitoring triggered a C5 nerve alert. Drs. Nassr and Larson were able to alter their approach and avoid complications.

“The risks for patients are high in this type of case,” Dr. Nassr says. “Outcomes like this aren’t possible without intraoperative monitoring.”

**For more information**

Education Opportunities

For more information or to register for courses, visit https://ce.mayo.edu/orthopedic-surgery/orthosurgery, call 800-323-2688 (toll-free) or email cme@mayo.edu.

3rd Annual Sports Medicine for the Primary Care Clinician 2019
March 1-3, 2019, in Orlando, Fla.

This conference allows participants to fill gaps in their residency training and to reinforce their knowledge of diagnosis and treatment for musculoskeletal conditions. Topics include procedural techniques that primary care clinicians can use to treat athletes and active individuals.

Mayo Clinic Course on Shoulder Tendon Transfers and Complex Rotator Cuff Repair 2019
April 25-27, 2019, in Rochester, Minn.

This course provides cutting-edge presentations, cadaver demonstrations and cadaver-based workshops on the management of complex rotator cuff tears and conditions affecting the scapulothoracic joint. The principles, surgical techniques and outcomes of tendon transfers around the shoulder joint and scapula will be highlighted, as well as advanced arthroscopically assisted tendon transfers and alternative salvage procedures such as reconstruction of the superior capsule, reverse shoulder arthroplasty and shoulder/scapulothoracic fusion.

Controversies in Wrist Surgery 2019
May 16-19, 2019, in Rochester, Minn.

This course is designed for orthopedic and plastic surgeons with a significant wrist practice. The course will cover the spectrum of disorders of the wrist and distal radioulnar joint, with a specific focus on injuries to the radial aspect of the wrist and radiocarpal joint. The format will be case-oriented, covering such topics as bony and soft tissue trauma, degenerative disease, and inflammatory arthritis. Videotaped surgery clips and cadaveric surgical dissection will be used to demonstrate complicated surgical procedures. Breakout sessions will provide in-depth coverage of specific wrist topics, including updates on advances in arthroscopy and arthroplasty from recognized experts in the field.

8th Annual Comprehensive Sports Medicine Update and Board Review 2019
June 19-22, 2019, in Minneapolis

This award-winning course is designed to provide a comprehensive review of all subjects contained in the sports medicine board examination. The course faculty includes internationally recognized experts in the field of sports medicine.