Determining the Optimal Approach for Proximal Humeral Fractures

Mayo Clinic has the breadth of expertise to individualize treatment of proximal humeral fractures. With experience in the full range of treatment modalities, Mayo’s orthopedic surgeons are able to provide a treatment approach—sling, repair or replacement—based on the needs of each patient.

“Our No. 1 goal is figuring out who needs an operation, and which operation. We have all options available to us at all times,” says Jonathan D. Barlow, M.D., an orthopedic surgeon at Mayo Clinic in Rochester, Minnesota.

The management of proximal humeral fractures has evolved rapidly, allowing for improved patient treatment. However, decisions about managing care are sometimes based on a surgeon’s background, with trauma-trained orthopedic surgeons opting for repair and shoulder surgeons choosing reverse total shoulder replacement.

“Mayo is bridging this gap, to optimize surgical management of these fractures,” Dr. Barlow says. “We know from our research and our experience treating patients that certain people are better off with reverse total shoulder repair (Figure), while others can be reliably treated with proximal humeral fracture plates.”

With training in both trauma and shoulder orthopedics, Dr. Barlow is part of an orthopedics team with multimodal expertise. “Mayo Clinic has always been at the forefront of new and different modalities. We’ve established our expertise with reverse total shoulder repair and also evolved the mechanics of how plate fixation is applied, to substantially lower complication rates,” he says.

The right surgery at the right time
Mayo’s approach to these fractures depends on such factors as the patient’s age, bone quality and source of injury. Patients younger than 60 to 65 are often candidates for surgical repair. “They tend to have good bone and to have experienced high-energy trauma from motor vehicle accidents or falls from heights. We have shown that we can successfully treat those patients with plates and screws,” Dr. Barlow says.

Patients older than 65 or with lower bone quality are less likely to have good outcomes from surgical repair and typically have shoulder replacement. “We have a robust shoulder arthroplasty division,” Dr. Barlow says. “Our outcomes have been reliably good, with most patients regaining overhead motion, and complication
The sacroiliac (SI) joint is a common but underrecognized source of continuing back pain in patients who have surgical fusions for the treatment of back pain. Mayo Clinic has developed new techniques for the diagnosis and treatment of patients with SI joint dysfunction.

“The SI joint is often glossed over as a pain generator, especially in people who have had spinal fusion and experience continued pain,” says William W. Cross III, M.D., an orthopedic surgeon at Mayo Clinic in Rochester, Minnesota. “As with joints involved in cranial adjacent segment disease, the SI joint can respond adversely to increased forces. In our clinic we routinely see patients who have had one, two or even three spinal fusions but develop or continue to have SI joint pain.”

Proximal humeral fractures are especially debilitating for older patients, who often rely on their upper extremities to ambulate and to push themselves out of chairs. Surgical treatment is sometimes avoided with the assumption that it remains an option if nonsurgical treatment fails. “But functional outcomes are lower if a patient is initially treated without surgery and then has a shoulder replacement later,” Dr. Barlow says. “If we don’t make the right decision the first time, we’re subjecting older patients to repetitive surgeries with the potential for morbidity and the need for hospitalization and use of skilled nursing facilities.”

To learn more about optimal treatment approaches for proximal humeral fractures, Mayo Clinic is planning a randomized trial comparing nonsurgical treatment to reverse total shoulder replacement. A 2015 trial in the U.K., published in JAMA in 2015, found no significant difference in outcomes between patients who had surgical repair and nonsurgical treatment for these fractures. The U.K. study, which had a two-year follow-up period, didn’t investigate reverse total shoulder replacement.

“We think this area warrants further investigation using modern shoulder replacement techniques,” Dr. Barlow says. “There’s tremendous uncertainty among many physicians about the optimal approach for an individual patient. Mayo Clinic is committed to individualized treatment.”

**For more information**


---

**Back Pain After Back Surgery: The SI Joint and Adjacent Segment Disease**

The sacroiliac (SI) joint is a common but underrecognized source of continuing back pain in patients who have surgical fusions for the treatment of back pain. Mayo Clinic has developed new techniques for the diagnosis and treatment of patients with SI joint dysfunction.

“The SI joint is often glossed over as a pain generator, especially in people who have had spinal fusion and experience continued pain,” says William W. Cross III, M.D., an orthopedic surgeon at Mayo Clinic in Rochester, Minnesota.

“As with joints involved in cranial adjacent segment disease, the SI joint can respond adversely to the increased forces. In our clinic we routinely see patients who have had one, two or even three spinal fusions but develop or continue to have SI joint pain.”

Research has established that the SI joint is the source of pain in nearly half of patients who experience new or continued low back pain after fusion surgery. Dr. Cross notes that SI joints normally move less than 1 millimeter. “But with force transfer after spinal fusion, the SI joints can move a couple of millimeters,” he says. “For some patients, that’s exquisitely painful.”

Persistent abnormal motion in the SI joint can lead to premature degenerative changes. “We have seen patients ranging in age from their mid-30s to their 80s who have had degenerative changes in the SI joint after spinal fusion,” Dr. Cross says. “This is not just age-related degeneration. Anybody who has fusion surgery can develop SI dysfunction. It is important to note, however, that the absence of degenerative changes in the SI joint does not eliminate the SI joint as a potential pain generator.”

**Finding and fixing the source of pain**

The diagnosis of SI joint dysfunction requires an extensive patient history and comprehensive physical examination. “No single test can perfectly diagnosis the condition,” Dr. Cross says. “The imaging can look normal (Figure 1), and the reliability of common physical exam techniques can be poor.”
Mayo Clinic’s physical evaluation combines the flexion, abduction and external rotation (FABER) test and a posterior superior iliac spine (PSIS) distraction test. “The maneuver, what I have termed the Mayo SI test, manipulates the SI joint in such a way that it can cause extreme pain in some patients,” Dr. Cross says. “It is interesting to note that this test is often normal during postoperative follow-up, making it a great marker for diagnosis and successful treatment.”

First line treatment for SI joint dysfunction consists of nonoperative management, such as physical therapy, an SI joint belt, injections and anti-inflammatory medication. SI joint fusion surgery is considered only after those options have been exhausted.

“If there’s no hardware in or across the SI joint from a previous surgery, a steroid might give some durable pain relief,” Dr. Cross says. “However, if the steroid doesn’t work and SI fusion is anticipated, we wait three months because of the potential increased risk of infection with steroid use.”

When surgery is indicated, Mayo Clinic uses a new, minimally invasive SI fusion implant (Figure 2) developed by researchers at Mayo Clinic and CoorsTek Medical and approved by the Food and Drug Administration. The device entered clinical use in late 2017.

So far, the outcomes are promising. Measured with the visual analog of subjective pain assessment, patients’ pain scores decline by roughly five points after implantation of the new device. Average scores on the single assessment numeric evaluation (SANE) exam are 80%, 91% and 96% at eight weeks, six months and 12 months after surgery, respectively.

The SI fusion system follows the principles of arthrodesis: aggressive joint preparation, enhanced compression and stability. “We designed this system because we think no other system fits the true philosophy of how the SI joint should be fused,” Dr. Cross says. “SI joint fusion should be no different from any other fusion surgery. You have to employ these principles to achieve durable, long-term outcomes that are going to return patients to a much greater quality of a life.”

---

### EMG With Motion Analysis Optimizes Care for Upper Motor Neuron Syndrome

Mayo Clinic’s unique use of dynamic electromyography (EMG) with motion analysis helps provide sophisticated care for people with upper motor neuron syndrome. Comprehensive evaluations performed in the Motion Analysis Laboratory at Mayo Clinic in Rochester, Minnesota, provide insight into which muscles are viable for transfer, aiding Mayo Clinic orthopedic surgeons in their efforts to restore upper-body function and decrease patients’ pain.

“In our lab, we assess patients while they perform specific movements related to activities of daily living. Motion capture and data analysis help us to identify muscles that could be moved to augment a function that the patient is missing,” says Kenton R. Kaufman, Ph.D., the laboratory’s director.

The testing is ordered by Mayo Clinic orthopedic surgeons for patients who might benefit from surgical treatment of upper motor neuron syndromes. Patients with spinal cord injuries, traumatic or anoxic brain injuries, or brain injuries due to stroke or cerebral palsy might be candidates for this preoperative testing.
“Dynamic testing is invaluable because for many patients, using clinical exams alone makes it very difficult to get an accurate assessment of the muscles that are viable,” says Peter C. Rhee, D.O., a hand surgeon at Mayo Clinic in Rochester, Minnesota. “The results of dynamic EMG not only can confirm what we believe is happening with a muscle but also can sometimes give us new information that directly influences the surgical plan — details that otherwise might have led to a poor surgical outcome.”

The Motion Analysis Laboratory began performing pre-surgical testing for upper motor neuron syndrome in late 2018. The testing generally takes about four hours. As well as detecting functional muscles, dynamic functional assessment can identify pathologic motor groups that are causing spastic deformities.

“This truly is precision medicine, because it analyzes an individual’s muscles to help us determine what we can do to give that person optimal function. Every patient is unique,” Dr. Kaufman says.

**Animation techniques with enhanced software**

Mayo Clinic’s dynamic EMG uses motion-capture technology similar to that used in animated motion pictures, although with more-sophisticated analytical software. Before testing starts, about a dozen reflective markers are attached to the patient’s upper body (Figure 1).

“Most of the muscles we want to record cannot be accessed by surface EMG. They require deep, fine-wire electrodes for recording,” says Krista A. Coleman Wood, Ph.D., P.T., who performs the lab’s dynamic testing. “Patients might feel the needle prick when we insert the wire, but there is no pain when they are asked to perform various tasks.”

Guided by Dr. Coleman Wood, patients attempt various upper-body movements. Ten infrared cameras in the laboratory capture the motion and measure muscle activation (Figure 2, see page 5). Each four-hour test requires several hours of data analysis.

“We go through every movement to determine if each muscle we tested is doing what it should be doing, interfering with the patient’s movement or just not doing anything,” says Kathie A. Bernhardt, a biomechanical engineer in the Motion Analysis Laboratory. “If a muscle is firing inappropriately, we can identify if it’s a spastic muscle or just a muscle that’s on all the time.”

Testing can also identify muscles that aren’t yet candidates for transfer but might be if the patient succeeds in obtaining greater control over them through techniques such as biofeedback. “We have instrumentation on a scale that gives us the precision we need to visualize even small-amplitude muscle activity,” Dr. Coleman Wood says.

The underlying techniques used by the Motion Analysis Laboratory were developed decades ago by the late Jacquelin Perry, M.D., with whom Dr. Kaufman previously worked. Technological advances have facilitated the adoption of dynamic EMG for research. The clinical application of these techniques requires close collaboration between laboratory scientists and physicians.

“This service can be performed only in a center where a dynamic EMG motion lab works closely with surgeons, and where scientists and clinicians meet regularly to discuss patients and guide their treatment,” Dr. Rhee says.

“Patients with upper motor neuron syndrome have very complex issues that require precise testing and a high level of surgical talent,” Dr. Kaufman adds. “Mayo Clinic devotes the time and effort needed to provide the best care we can for these patients.”

**For more information**

Motion Analysis Laboratory. Mayo Clinic. https://www.mayo.edu/research/labs/motion-analysis/overview.
Mayo Clinic’s orthopedic surgeons have the breadth of experience to manage the full range of foot and ankle surgeries, from the repair of routine sports injuries to correction of complex deformities. That expertise, combined with Mayo Clinic’s commitment to individualized care, helps to ensure optimal outcomes and, for athletes, a return to play as soon as possible.

“Even a common sports injury, such as a stress fracture or chronic lateral ankle instability, can be devastating to a young athlete or anybody who wants to return to exercise. We work with our patients to help them achieve their goals safely,” says Daniel B. Ryssman, M.D., an orthopedic surgeon specializing in foot and ankle procedures at Mayo Clinic in Rochester, Minnesota.

As a high-volume tertiary center, Mayo Clinic has the capability to surgically correct complex deformities caused by trauma or a neurological disorder such as Charcot-Marie-Tooth disease. But patients with more-common sport injuries also benefit from the expertise of an orthopedic surgeon with fellowship training in the foot and ankle.

“An athlete might face certain circumstances — pressure to get back on the team and in shape for the next season — that don’t necessarily match a one-size-fits-all approach,” Dr. Ryssman says. “Without cutting corners or taking chances, we tailor our approach to the specific patient.”

The individualized approach begins with diagnosis. Mayo Clinic starts with a detailed history and physical examination. “The history and physical exam are key. Too often nowadays, there can be an overreliance on the MRI when determining a treatment plan. But what we see on MRI may not precisely correlate with what is causing the patient’s pain,” Dr. Ryssman says.

Mayo Clinic focuses on the patient’s chief complaint. “We ask, ‘Where do you hurt?’ and ‘What’s keeping you from doing the things you want to do?’ We then use imaging to help us better understand the patient’s needs and to plan treatment,” Dr. Ryssman says.

Accurate diagnosis might point patients toward physical therapy or other nonsurgical treatment first. If surgery is indicated, Mayo Clinic’s orthopedic surgeons have broad experience with surgical procedures to address...
Soft Tissue Sarcoma: Technology and Expertise to Improve Care

Wound complications are a major source of morbidity in patients undergoing radiation therapy and surgical resection for soft tissue sarcoma. Mayo Clinic is conducting a prospective clinical trial of intraoperative fluorescence angiography to evaluate whether it can reduce the risk of wound-healing complications in patients undergoing sarcoma reconstruction.

The clinical trial will compare the outcomes of sarcoma reconstructive surgery using a new fluorescence imaging device with outcomes for patients having the same surgery without fluorescence angiography. The device assesses blood flow and tissue perfusion after the intravenous administration of indocyanine green in patients undergoing surgery (Figure). Tissue that is identified as nonviable can be surgically removed.

“Historically, patients having this procedure have faced about a 35% chance of developing a wound complication. We hope that using this technology will significantly reduce that risk,” says Courtney E. Sherman, M.D., an orthopedic surgeon at Mayo Clinic’s campus in Florida.

Soft tissue sarcoma poses challenges throughout the process of diagnosis and treatment. The disease is rare — many orthopedic surgeons will see only one or two cases during their careers — and frequently misdiagnosed.

“Most sarcomas are painless. The masses are often noticed following an incidental trauma. The differential for soft tissue masses is large, but sarcoma must be considered,” Dr. Sherman says. A delay in diagnosis can result in unnecessary amputation. In addition, the unplanned excision of a soft tissue sarcoma can result in high morbidity and possibly amputation. “If there is any doubt about the diagnosis, a biopsy is in order,” Dr. Sherman says.

As a large tertiary center, Mayo Clinic has experience with the diagnosis and treatment of soft tissue sarcoma, including high-grade tumors. “We have a multidisciplinary approach. Our orthopedic surgeons, radiation oncologists, medical oncologists, radiologists and pathologists work as a team. That allows us to provide the complex management that these patients need, and the most up-to-date treatment options,” Dr. Sherman says.

Figure. A. Image shows a posterior thigh myxoid liposarcoma in a 38-year-old woman treated at Mayo Clinic. She underwent radiation therapy followed by surgical resection with complex closure. After surgical closure, intraoperative fluorescence angiography demonstrated excellent blood flow to the skin edges. B. The patient healed with no postoperative wound issues.
Mayo Clinic radiologists use ultrasound and advanced MRI imaging, including fat-suppression sequences and gadolinium enhancement, to aid the diagnosis of soft tissue sarcoma. The utility of this imaging for soft tissue sarcoma is highly technique dependent. Mayo Clinic surgeons also use the latest techniques, including minimally invasive surgery, limb-sparing surgery and intraoperative radiation therapy.

The prognosis for patients with soft tissue sarcoma depends on tumor type. Patients with low-grade tumors have a five-year survival rate of 90%; for patients with metastatic lesions, that rate is 15%. Through research and multidisciplinary diagnosis and treatment, Mayo Clinic is working to improve the management of soft tissue sarcoma.

“Our goal is to give our patients expertise from multiple specialties, to provide them with the optimal treatment options,” Dr. Sherman says.

### Spinal Care: Team Approach at the Bedside and in the Lab

As a fully integrated center, Mayo Clinic follows a multidisciplinary team approach for complex spinal oncology surgery. Orthopedic surgeons routinely work with neurosurgeons, ENT surgeons and other specialists as needed to provide optimal surgical outcomes.

“We have a team with multiple people, deep at every position,” says Michael J. Yaszemski, M.D., Ph.D., a spinal surgeon at Mayo Clinic in Rochester, Minnesota. “It’s like an orchestra. When it’s your turn, you do what you need to do. When your part is done, you step back and someone else leads. Everyone here just tucks the ego away and does what’s best for the patient.”

The team approach is followed throughout the process of diagnosis and treatment. “When you come to Mayo Clinic for a sarcoma evaluation, for example, you see the surgeons, a medical oncologist and a pediatric oncologist if the patient is a child,” Dr. Yaszemski says. The team also includes radiation oncologists, pathologists who specialize in bone cancer, musculoskeletal radiologists and chemotherapy specialists.

Dr. Yaszemski cites the case of a patient with a highly challenging chondrosarcoma in the cervical spinal canal. The patient’s initial evaluations involved two orthopedic surgeons, a head and neck surgeon, and a neurosurgeon.

“Together we made a plan,” Dr. Yaszemski says. “We decided that our head and neck colleague should start the procedure, to provide maximum precision and safety for the patient. Orthopedic surgeons planned the osteotomy — we knew we wanted to get through the bone at a specific location. We practiced the tumor removal beforehand. It took just three minutes during the procedure, even though nerves VI and VII were stuck to the tumor. Our spinal neurosurgery colleague separated the sixth and seventh cervical nerves from the tumor, and then we asked our peripheral nerve neurosurgeon for an evaluation to reconstruct those resected nerves.”

The peripheral nerve neurosurgeon recommended waiting three months before attempting nerve transfer to restore function to the patient’s right arm. That surgery was successful. “Six years out, the patient has normal function. I can’t break her extension muscle strength. I can’t break her wrist flexion muscle strength. She’s doing very well,” Dr. Yaszemski says.

### Regenerating bone and nerves

Mayo Clinic’s research laboratories follow a similar team approach. Under Dr. Yaszemski’s direction, the work of the Tissue Engineering and Biomaterials Laboratory ranges from basic science discoveries to the development of polymeric biomaterials for regenerative medicine treatments. “Everything we do in this lab has as its starting point an unmet clinical need,” Dr. Yaszemski says.

The long-term research goal is to fundamentally change treatment through the use of biodegradable polymers that act as scaffolds for the regeneration of bones and nerves. One current investigation involves the development of an electrically charged bone biomaterial that can act as both a bone scaffold and a protein delivery vehicle. In a study to be published in *Tissue Engineering Part A*, researchers in the lab demonstrated that a negative charge significantly enhances bone morphogenic protein-induced bone formation compared with a neutral or a positive charge in oligo[(polyethylene glycol) fumarate] (OPF) hydrogels.

“The use of polymer scaffolds in patients with chronic nonunion of bone fractures could have a major impact on healing and reduce the need for metal instrumentation,” Dr. Yaszemski says.

The biomaterials lab’s work on nerve scaffolds, done in conjunction with Mayo’s Regenerative Neurobiology Laboratory, holds similar
potential to revolutionize the treatment of patients with spinal injuries. In a study published in the January 2018 issue of the Journal of Tissue Engineering and Regenerative Medicine, Mayo Clinic researchers demonstrated that OPF scaffolds delivering Schwann cells genetically modified to secrete high concentrations of glial cell-derived neurotrophic factor can promote regional axonal regeneration, remyelination and functional improvement in lab animals after spinal cord transection.

To facilitate translation of laboratory work into clinical trials, Mayo Clinic has a biomaterials and biomolecules manufacturing facility that follows current good manufacturing practices (CGMP). The facility is directed by Dr. Yaszemski and Anthony J. Windebank, M.D., a neurologist at Mayo Clinic in Rochester, Minnesota. The Food and Drug Administration recently granted an investigational device exemption for Mayo Clinic’s nerve regeneration scaffold to be fabricated in the Mayo CGMP facility.

“This research moves forward because the different labs bring different perspectives,” Dr. Yaszemski says. “At Mayo, that teamwork just comes naturally to us.”

For more information
Tissue Engineering and Biomaterials Laboratory, Mayo Clinic. https://www.mayo.edu/research/labs/tissue-engineering-biomaterials/overview.


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

Opioid Conference: Evidence, Clinical Considerations & Best Practice 2019
Nov. 7-9, 2019, in Rancho Mirage, Calif.

This conference highlights the shift in guidelines and public concern regarding the use of opioids in medical practice, and provides up-to-date information regarding the appropriate indication for opioids in clinical practice. Specific topics include the basics of opioids, evidence-based guidelines for opioids, medication monitoring, tapering and legal considerations, and difficult patient conversations.

29th Annual Mayo Clinic Symposium on Sports Medicine 2019
Nov. 8-9, 2019, in Rochester, Minn.

This course features evidence-based, cutting-edge diagnostic and treatment strategies for sports-related and musculoskeletal conditions. The program is multidisciplinary, with expert lecturers representing a spectrum of sports medicine fields. Multiple educational formats used include case presentations, interactive question and answer sessions, and live demonstrations of physical examination, anatomy, ultrasound and arthroscopy.

Comprehensive Shoulder and Elbow Course: Current Concepts and Controversies 2020

This course provides information on the latest treatment options for shoulder and elbow arthroplasty, arthroscopy, fracture and reconstruction. The focus is on best current practice in diagnosis, treatment and new technology. Faculty with international expertise in shoulder and elbow surgery discuss how to optimize surgical techniques and avoid complications. Didactic sessions emphasize tips and pearls for approaching complex shoulder and elbow reconstruction. Attendees are encouraged to bring cases for discussion.