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Optimizing Hip Care: Mayo's Narrow Yet Wide Approach

At Mayo Clinic, orthopedic surgeons often specialize in a single joint, allowing them to develop expertise in the range of procedures used to address problems in that area. That simultaneously narrow and wide focus helps to optimize patients' outcomes.

"Having a practice focused on a single joint allows us to home in on the problems that are causing our patients' pain," says Luke S. Spencer Gardner, M.D., an orthopedic surgeon at Mayo Clinic in Jacksonville, Florida.

Historically, hip specialists have had either advanced orthopedic training in open surgery, or sports medicine training in arthroscopy. Mayo's hip specialists have expertise in both (Figure). "We're able to diagnose a range of different pathologies that could be causing hip pain and to offer the correct procedure for that individual patient," Dr. Spencer Gardner says.

Patients range in age from adolescents to older adults. Their conditions range from pre-arthritic causes of pain — including soft tissue damage, labral tears, femoroacetabular impingement and hip dysplasia — to arthritic degeneration requiring joint replacement.

"Our in-depth knowledge of the hip also allows us to differentiate problems in that joint from problems arising elsewhere," Dr. Spencer Gardner says. The experience of subspecialized musculoskeletal radiologists and the wider expertise of Mayo's musculoskeletal physicians and orthopedic surgeons allow for precise diagnosis.

Matching patients to procedures

Mayo Clinic is able to manage hip conditions ranging from mild to severe. "Hip pain that is not caused by arthritis can often be addressed arthroscopically," Dr. Spencer Gardner says. "But sometimes, these patients also have larger structural problems that need to be addressed — for example, hip dysplasia with an associated labral tear. In that case we can do both an arthroscopic and an open surgery in a single stage."

A B C

Figure. A. Preoperative X-ray shows acetabular dysplasia. The blue line indicates abnormal alignment of the acetabulum. B. X-ray after periacetabular osteotomy demonstrates normal alignment of the acetabulum. C. Intraoperative image during hip arthroscopy shows suture passage through a torn labrum during labral repair.

Luke S. Spencer Gardner, M.D.

In addition to avoiding a second round of anesthesia and postoperative recovery, a combined procedure can improve outcomes."You get better visualization of a labral tear arthroscopically, which allows you to repair the labrum with less dissection than would be possible with an open surgical approach,"Dr. Spencer Gardner says."Being facile in both arthroscopic and open surgery allows us in a single stage to address each part of a patient's pathology in the optimal manner."

For all patients with hip conditions, Mayo can provide specialized physical and occupational therapy to aid in the recovery process.

Continuous improvement is a cornerstone of Mayo Clinic's approach to care. A study of outcomes from combined open and arthroscopic orthopedic procedures at Mayo Clinic is underway.

"The keys to good surgical outcomes are making the right diagnosis, performing the procedure that appropriately addresses that individual patient's problems and providing a high level of ongoing care,"Dr. Spencer Gardner says."At Mayo, we are committed to every one of these stages because ultimately they translate to improved patient outcomes."

Rotator Cuff Repair: Working Toward a Biologic Treatment

John M. Tokish, M.D.

Despite recent improvements in surgical techniques and materials, approximately 25% of rotator cuff injuries fail to heal. Mayo Clinic is pursuing a regenerative medicine approach for improved treatment of these debilitating injuries.

"We have come a long way over the last 20 years from a mechanical engineering standpoint, with new kinds of anchors, suture materials and surgical techniques. But now we're realizing that the problem isn't mechanical — it's biologic," says John M. Tokish, M.D., an orthopedic surgeon at Mayo Clinic's campus in Scottsdale, Arizona.

Mayo's Center for Regenerative Medicine is working to develop electrospun fibers that, when surgically inserted, can promote tendon healing. Having created fiber structures in the laboratory that mimic the native tendon, the researchers are using animal models to investigate ways to embed growth factor products in those patches (Figure).

Figure. Photograph of a laboratory model shows Mayo Clinic's experimental rotator cuff reconstruction using an electrospun patch.

"Because of the orthobiologics revolution, we're beginning to understand the basic science behind what exactly signals a tendon to heal," Dr. Tokish says. "We've learned that we can add adjunctive materials that provide the necessary biochemical environment to get that tendon to regenerate. That used to be science fiction. But for now, at least in the lab, it's reality."

Promoting tendon healing and regeneration

Electrospinning is used to create fibers that, like a tendon's fibers, are measured on the nanolevel. The fibers can be arranged in varying directions.

"We know that the ability of tissues to regenerate often depends on the direction of their fibers," Dr. Tokish says. "Electrospinning allows us to place materials that are commonly used, and biologically accepted, within a magnetic field. Depending on the magnet's field strength and the direction of its spin, we can create nanofibers to be layered parallel to each other or intersecting, or really in any shape and direction we want. In the laboratory we can use a number of these different complementary fields to create a structure that mimics the native tendon."

Various combinations of fibers are being tested in rat models developed in conjunction with Arizona State University. Before insertion into the models, the fiber patches are imbued with various growth factor products.

"What's really exciting is that we can pre-soak the patch in factors complementary to the individual tendon zones that we need," Dr. Tokish says. "If it's muscle, we can embed factors that promote muscle growth in that area of the patch. If it's the calcified

cartilage layer on the bone, we can embed factors that encourage that sort of regeneration into that portion of the patch."

In addition to providing necessary growth factors, the adjunctive materials may well be able to change the tendon's biochemical environment. "We've learned that these materials can encourage the body's own medicinal signaling cells to be recruited to the area of injury or degenerative tearing and provide the necessary environment for the tendon to regenerate," Dr. Tokish says. "When we are eventually able to insert the patch into human patients, it may act as a scaffold to encourage not only healing but also regeneration."

The goal is to apply the system to the treatment of both irreparable tears and severe tendinopathy. "In patients with irreparable tears, the patch by itself or in conjunction with other technologies we currently use may help that new tendon to be incorporated in the body and patients to regain previous function," Dr. Tokish says.

For patients with severely damaged yet repairable tendons, the biologic system might boost healing and safeguard the surgical repair. "We see a lot of patients in the younger demographic — between the ages of 40 and 60 — who have large rotator tears that are difficult to heal. Unfortunately, the reverse shoulder arthroplasty, which has revolutionized care for older patients, isn't a good option for younger people," Dr. Tokish says. "We are some ways away yet from human trials. But we feel that augmenting tendon healing through the regenerative medicine field may be the missing key that will help us to better treat rotator cuff tears."

Patient-Specific Instrumentation for Shoulder Arthroplasty

Mayo Clinic uses the latest technology for shoulder replacement surgery, including analytical tools that provide understanding of an individual patient's glenoid wear pattern. Sophisticated preoperative planning and the use of patient-specific instrumentation are key to optimizing glenoid component choice and position and maximizing surgical outcomes.

"We've learned over time that understanding the glenoid bone's three-dimensional anatomy is enormously helpful in planning shoulder replacement surgery," says John W. Sperling, M.D., an orthopedic surgeon at Mayo Clinic in Rochester, Minnesota. "These tools allow us to develop a surgical plan based on the individual patient's anatomy and then to accurately execute that plan once we get to the operating room."

With the highest-volume shoulder replacement practice in the United States, Mayo Clinic is at the forefront of advances in this complex procedure. In addition to implementing 3D surgical guides based on an individual patient's anatomy, Mayo's orthopedic surgeons use recently developed depth controls for glenoid reaming (Figure 1).

John W. Sperling, M.D.

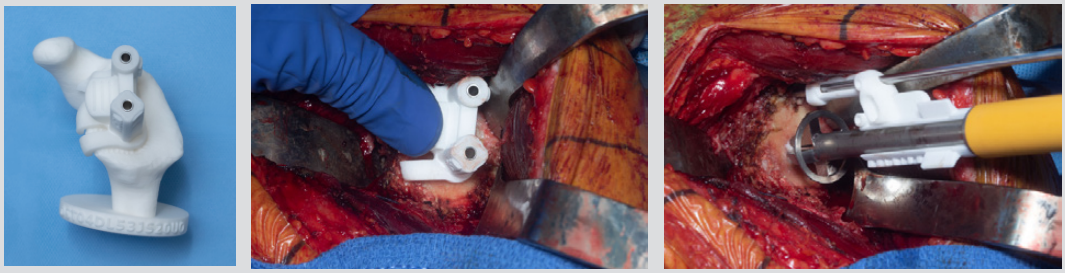

Figure 1. On the left, photograph shows a 3D glenoid model with a patient-specific guide. In the center, perioperative photograph shows the patient-specific guide matching the patient's glenoid surface. On the right, perioperative photograph shows a depth control guide for glenoid reaming, to maximize the preservation of glenoid bone.

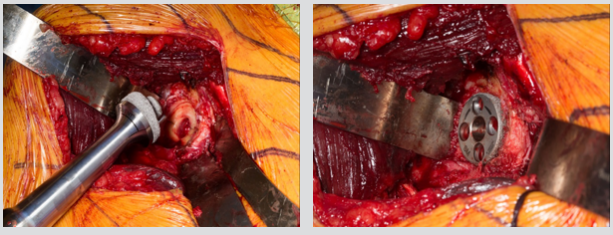

Figure 2. Perioperative photographs show the use of an augmented glenoid baseplate. On the left, an augmented glenoid baseplate is placed in a patient. On the right, the augmented baseplate's ability to create tilt and provide lateralization are demonstrated.

"A 3D-printed guide attached to the reamer allows for precise preparation of the glenoid surface and maximizes glenoid bone preservation," Dr. Sperling says. "During surgery, the depth control helps us prepare the glenoid in the manner that we planned preoperatively."

Initially, patient-specific instrumentation was reserved for patients with complex anatomy, including dysplasia, bone deficiency or deformity secondary to prior trauma. "But due to the benefits we've seen, we are broadening our use to the full range of conditions, from minimal glenoid deformity to highly complex underlying shoulder pathologies," Dr. Sperling says.

Mayo Clinic's team approach facilitates this individualized orthopedic care. The CT scans needed for pre-surgical planning and patient-specific instrumentation can be pre-scheduled to coordinate with surgical and medical appointments. "The patient experience here is very time efficient," Dr. Sperling says.

The CT scans are uploaded to a system that uses advanced software to allow the surgeon to plan the orthopedic procedure and order patient-specific surgical guides. "In the operating room, the preoperative plan and patient-specific instrumentation increase the procedure's efficiency," Dr. Sperling says. "We can execute our plan to preserve bone and optimize the positioning of the implant."

Augmented baseplate for reverse shoulder arthroplasty

To preserve glenoid bone in patients who have reverse shoulder arthroplasty, Dr. Sperling uses an augmented glenoid baseplate (Figure 2, see page 3).

"The augmented component minimizes bone removal compared with eccentric reaming, preserves the best-quality cortical bone and allows for longer screw fixation," Dr. Sperling says. "Recent research has shown that the routine use of augmented baseplates in reverse arthroplasty, along with preoperative planning, can result in over 50% preservation of glenoid bone compared with the use of a standard glenoid baseplate."

As the major shoulder arthroplasty center in the United States, Mayo Clinic is committed to continued innovation. "In the future, as preoperative planning and patient-specific instrumentation continue to evolve, we will be able to further customize our procedures for individual patients," Dr. Sperling says.

Pedicle Screw Placement: Robotic Assistance for Greater Precision

Accurate placement of pedicle screws is key to avoiding the potential complications of spinal fusion surgery and improving overall spinal fixation. Mayo Clinic uses the latest robot-assisted technology when indicated to enhance surgical precision in these procedures (Figure).

"Robot-guided surgery is a well-choreographed process that can help ensure reliable and accurate placement of spinal implants," says Brett A. Freedman, M.D., an orthopedic surgeon at Mayo Clinic in Rochester, Minnesota. "We find that this system offers distinct advantages compared with not only freehand placement but also standard stereotactic navigation."

Figure. Mohamad Bydon, M.D., a neurosurgeon at Mayo Clinic in Rochester, Minnesota, leads a team performing spinal surgery using new robot-guided technology.

Mayo Clinic was an early adopter of robot-assisted technology for spinal fusion surgery. As an orthopedic center of excellence, Mayo is committed to new technology that provides clinical benefits and adds value. "Robot-assisted surgery is just one example," Dr. Freedman says. "We continually look for validated innovations that help our patients."

Ideal paths and trajectories

Robot-assisted spine surgery uses CT imaging and navigational software to determine the optimal pathway for inserting pedicle screws. Finding that pathway is made challenging by the lack of clearance around the spine and the presence of surrounding neurological structures.

"Robotic assistance gives us real-time imaging that reliably depicts complex anatomy," Dr. Freedman says. "That's very important when a patient has not only deformity that changes the shape of bone but also poor-quality bone. We can actually find a path that goes through the patient's best bone as opposed to softer bone."

During surgery, the system's software guides the robotic arm into position, translating the surgical plan onto the surgical field. "The robotic arm

places the guidance tube in the preferred alignment, and each screw can then be placed to a depth and in an alignment that matches its mates, which makes for a better overall construct," Dr. Freedman says. "A system that robotically aligns the screws' trajectories makes it easier to insert the spinal rods and induces less stress on the screws we placed."

In addition, the robotic arm's stability overcomes problems inherent with standard stereotactic navigation. "Stereotactic navigation requires the surgeon's hands to be held in a specific position that is mapped to the imaging. However, our hands move — especially when we are preparing and inserting screws — while the robot holds a rock-steady trajectory," Dr. Freedman says. "Our arms and other appendages are also in the way of the tracking camera that watches the various surgical instruments move. The robot-assisted system gives us an enhanced path of navigation."

Mayo Clinic continuously assesses new technologies to determine their benefits for patients. "As spine surgeons, we want to innovate to solve problems, validate these solutions, and research the impact they have on clinical outcomes and value-based care," Dr. Freedman says. "Robotic assistance offers real advantages for the accurate placement of pedicle screws."

Brett A. Freedman, M.D.

Mayo Surgeons' Deployments: Benefits for Military and Civilian Patients

A sizable number of Mayo Clinic's orthopedic surgeons are active duty veterans or reservists who have been deployed overseas. Mayo's military connections serve not only members of the armed forces but also civilian patients once the surgeons return to Mayo.

"The acuity of injuries we see at Mayo, and our patient volumes, make us well prepared for deployment. We also can take new techniques from our military experience back home," says Nicholas A. Pulos, M.D., a hand surgeon at Mayo Clinic in Rochester, Minnesota, who recently returned from deployment to Kandahar, Afghanistan.

Figure. Photograph shows the hand of a wounded serviceman following treatment in Afghanistan by Nicholas A. Pulos, M.D., a Mayo Clinic hand surgeon on deployment with the United States Navy Reserve. A blasting cap injury had mutilated the hand. Working with military colleagues, Dr. Pulos harvested a groin flap to cover the palmar defect.

Mayo's ties to military service stretch back to Dr. William Worrall Mayo, who began his medical practice in Rochester in 1864 as an examining physician for Civil War enlistees. Dr. Pulos, who serves in the United States Navy Reserve, notes that hand surgery emerged as a medical specialty after World War II due to the wartime need for reconstructive surgeries. In addition to hand surgeons, orthopedic surgeons at Mayo Clinic specializing in the spine and hip, as well as plastic surgeons and other specialists, have military experience.

As a salaried organization with a strong founding culture, Mayo Clinic pursues a team-based approach to care. "We put our patients' interests first and work together as a team rather than as individuals to deliver the care they need," says Brett A. Freedman, M.D., an orthopedic surgeon at Mayo's campus in Minnesota, and a decorated United States Army veteran. "We take our Mayo values with us on deployment, and they blend perfectly well with the military."

With a large orthopedic practice, Mayo Clinic can transition patients to care from other experienced specialists when staff are deployed. "Even though all Mayo employees aren't able to serve in a combat zone, they do contribute by helping their colleagues and families while the deployed physicians are overseas," says Paul M. Huddleston, M.D., an orthopedic surgeon at Mayo's campus in Minnesota and a decorated United States Arm veteran who has served several deployments in Iraq and Afghanistan.

"Mayo is very supportive of deployment," Dr. Pulos adds. "As an all-volunteer force, the military relies on reservists, including physicians at Mayo Clinic, to go out on active duty and help service members."

Nicholas A. Pulos, M.D.

Paul M. Huddleston, M.D.

Peter C. Rhee, D.O.

Trauma-related expertise

Improved body armor has helped service personnel survive injuries that might have been fatal in previous conflicts. "A lot of the injuries we see on deployment involve the extremities because the body armor is so good," Dr. Pulos says. "About 50% of the surgeries I did in Afghanistan involved the hand."

Mayo Clinic has a sizable orthopedic trauma practice. "The Mayo expertise is really helpful in thinking of creative ways to do orthoplastics (Figure, see page 5) on deployment," Dr. Pulos says. "We have experience using regional flaps and soft tissue transfers to reconstruct upper extremities after traumatic injuries."

That expertise facilitates immediate definitive treatment for service members. "Typically, service members with serious injuries in Afghanistan are stabilized and then sent back to the United States," says Peter C. Rhee, D.O., a hand surgeon at Mayo's campus in Minnesota and a United States Air Force reservist. "Military physicians are very skilled. But for a majority of trauma-related injuries out there, the Mayo surgeon may be the only person who can provide definitive treatment."

That capability is especially beneficial for local citizens who become injured while helping the United States military. "We can't send those local nationals to the United States for care," Dr. Rhee says. "But those patients can have a Mayo Clinic-trained surgeon, in the most austere environment, where normally they wouldn't have access to any surgeon."

At the same time, Mayo's surgeons learn new skills on deployment that can ultimately benefit patients back in the United States. Dr. Pulos cites the military's use of perioperative tranexamic acid and tourniquets to control bleeding.

"Tourniquets weren't as popular in civilian practice," he says. "But their use in military practice has trickled down to medical practice in the civilian sector."

Mayo Clinic physicians have also published extensively on the orthopedic issues encountered on deployment. "As military surgeons, our work contributes to knowledge of lifesaving developments supporting the war effort," Dr. Huddleston says. "Our experience with combat-related spinal fractures and injuries helps us understand and treat these issues today."

Dr. Freedman's military service led to published research on topics including spinal care, compartment syndrome diagnosis and wound healing. As a first-year resident at Walter Reed Army Medical Center, he was motivated by the traumatic injuries he saw in Pentagon personnel after the attack on Sept. 11, 2001, and in soldiers and sailors who returned from war with catastrophic spine and limb injuries.

"The extremity injuries we have seen in war today have really pushed the envelope," he says. "The use of biologics and enhanced methods of bone healing, and the development of new implants and wound care devices all owe something to those experiences. We are always looking to innovate and find a better way."

Dr. Freedman notes that Mayo Clinic is exploring further ties with the military through a program that would bring military medical personnel to a Mayo campus to work alongside Mayo specialists. "The idea is to give the military personnel the Mayo experience," he says. "The benefits for Mayo and the military are definitely bidirectional. As Mayo surgeons, we give to the military but we also take back the experience of how a team can work together in an austere location when you don't have all the resources you want."

Multidisciplinary and Coordinated Approach to Limb Lengthening Care

Stephen (Andy) A. Sems, M.D.

The causes of limb deformities are variable and often complex. Mayo Clinic's Limb Lengthening and Regeneration Clinic in Minnesota takes a multidisciplinary approach aimed at maximizing function while managing any underlying disorders.

"Many of these patients require attention from more than just an orthopedic surgeon, because many limb deformities involve more than just bone. Access to the resources of multiple specialists in multiple fields is really beneficial," says Stephen (Andy) A. Sems, M.D., an orthopedic surgeon at Mayo Clinic in Rochester, Minnesota.

Managing care for both children and adults, the limb lengthening clinic brings together experts in several orthopedic surgery subspecialties, including orthopedic trauma, pediatric orthopedics and orthopedic oncology. Plastic and reconstructive surgeons, medical geneticists, endocrinologists and radiologists also are part of the team. Individualized treatment recommendations are made based on the combined input of all team members. The treatment options are as varied as the sources of the deformities (Figure, see page 7), and external or internal fixation can be provided, depending on the individual patient's needs.

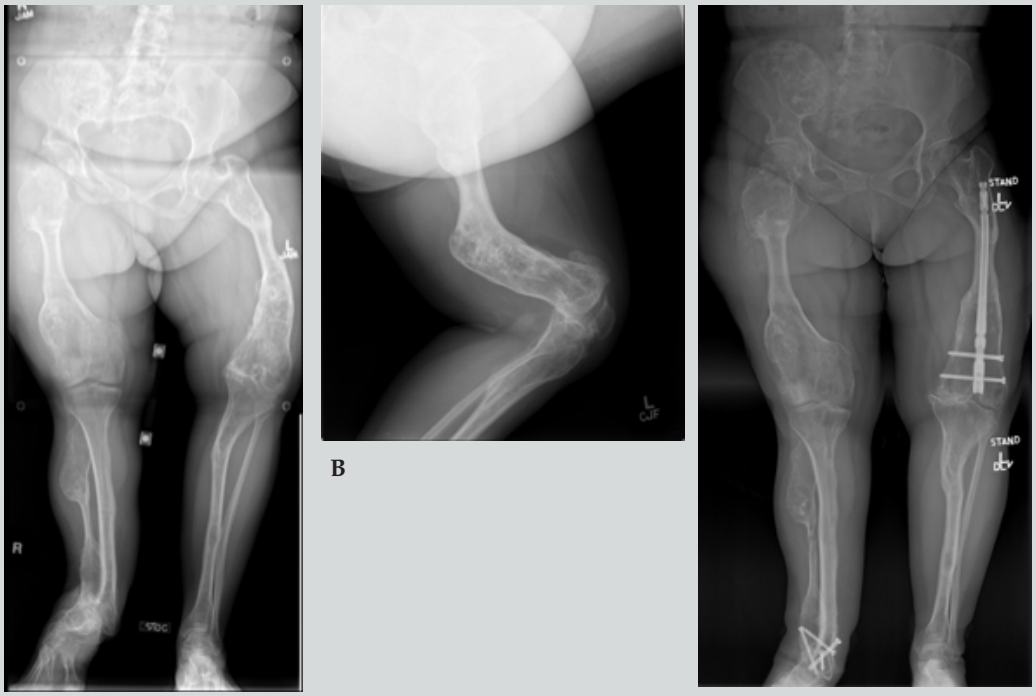

Figure. X-rays illustrate the treatment of a 55-year-old woman with Ollier's disease at Mayo Clinic's Limb Lengthening and Regeneration Clinic in Minnesota. A and B. The patient presented with left knee pain, bilateral deformities of the lower extremities including the right foot and ankle, and leg length discrepancy. A foot and ankle specialist, an orthopedic oncologist, and an orthopedic limb deformity specialist worked together to coordinate her surgical treatment. C. She was treated with left femoral and tibial osteotomies using intramedullary nail fixation of the femur and multiplanar ring fixation of the tibia, followed by right tibial lengthening and right hindfoot osteotomy and fusion.

The patient experience

Mayo requests referring physicians to send as much information as possible about patients before they are seen at the limb lengthening clinic. "We gather a group of specialists, based on a patient's individual situation, to review that information," Dr. Sems says. "We then try to set up a flow of consultations with individual specialists, to minimize the patient's trips to Mayo."

For example, a patient with an underlying metabolic disorder would see an endocrinologist as well as various surgeons. "The limb deformity might require soft tissue procedures, such as flaps or nerve releases, which would need the involvement of a microvascular surgeon," Dr. Sems says. "Depending on where the deformity occurs, we have foot and ankle surgeons, and hand and upper extremity surgeons. If the deformity involves a residual amputation, we have a specialist with experience in those conditions."

Each of these specialists routinely sees patients in the limb lengthening clinic. Having a core group of specialists helps ensure that the team has experience with patients' varied conditions, even rare disorders.

"We don't just put in a referral to endocrinology. For example, there are two endocrinologists we typically work with, along with two specific hand surgeons, one foot and ankle surgeon, two pediatric surgeons, and one geneticist," Dr. Sems says. "Our familiarity with one another creates a sense of teamwork and an understanding of these patients."

As a major tertiary center, Mayo Clinic offers the full range of treatment options. These include lengthening rods, external fixation, and other implantable devices made from metals or polyether ether ketone (PEEK) polymers that can change limb angles.

"New technology has revolutionized how limb lengthening is approached," Dr. Sems says. "Many of our patients tell us after treatment that this is the first time they've had a functioning or well-aligned limb in as long as they can remember. Allowing our surgeons to focus on their areas of expertise contributes to giving patients the best possible outcomes."

For more information

Limb Lengthening and Regeneration Clinic in Minnesota. Mayo Clinic.
https://www.mayoclinic.org/departments-centers/limb-lengthening-regeneration-clinic-minnesota/overview/ovc-20472088.

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Orthopedic Surgery Update

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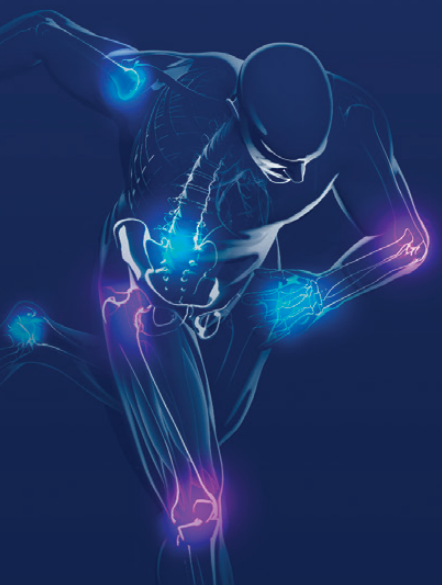

Education Opportunities

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*.

Controversies in Wrist Surgery 2021 and Pre-Conference Advanced Wrist Arthroscopy Lab

April 22-25, 2021

This course is designed for orthopedic and plastic surgeons with significant hand practices, and covers the spectrum of disorders of the wrist and distal radioulnar joint. The format will be case oriented, covering topics in areas including 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.

Orthopedic Infectious Diseases — LIVESTREAM

May 21-22, 2021

Designed for infectious disease practitioners, this course is dedicated entirely to the challenges of managing orthopedic infections. It will feature highly interactive, case-based modules delivered by subject matter experts addressing diagnostic and therapeutic challenges.

9th Annual Comprehensive Sports Medicine Update and Board Review 2021

June 16-19, 2021

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

30th Annual Mayo Clinic Symposium on Sports Medicine — 2021

Nov. 5-6, 2021

This course features evidence-based and 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.

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