Hip disorders pose significant challenges for young adults, limiting activities and potentially resulting in long-term degenerative joint changes. Complex cases often require both arthroscopy to repair tears inside the hip joint and osteotomy to correct deformities that lead to the recurrence of tears.

To care for increasing numbers of patients with complex hip conditions, Mayo Clinic in Rochester, Minnesota, has a Young Hip Clinic, where orthopedic surgeons with expertise in hip arthroscopy and in open-hip surgery collaborate to treat young people. “Often we see patients who have had extensive outside work-ups involving multiple physicians in multiple specialties over three to six months. This is costly, inconvenient and unnecessary for patients,” says Aaron J. Krych, M.D., a consultant in Orthopedic Surgery at Mayo’s campus in Minnesota. “The Young Hip Clinic provides a streamlined evaluation for painful hip pathology in young and active patients.”

“Especially for patients with the more complex deformities — such as acetabular retroversion, acetabular hip dysplasia or femoral structural abnormalities — our combined subspecialty approach allows us to deliver the best care,” adds Rafael J. Sierra, M.D., a consultant in Orthopedic Surgery at Mayo’s Minnesota campus.

In selected patients, Mayo Clinic orthopedic surgeons can perform arthroscopy and osteotomy in a single procedure, sparing those patients a second round of anesthesia and postoperative recovery (Figure). Over 150 of these combined procedures have been performed in patients who would have otherwise had an arthroscopic approach to their hip disease prior to femoral or acetabular osteotomy.

“This combined approach is done swiftly by two orthopedic teams,” Dr. Sierra says. “The arthroscopic approach allows us to improve the recovery of these patients, as performing labral repairs and femoral head and neck osteochondroplasties through an open approach would require more soft tissue dissection, and potentially prolonged rehabilitation.”

Matching patients to procedures
Mayo Clinic is able to treat patients of all ages with hip conditions ranging from mild to severe. Imaging tests can be quickly scheduled and results are typically available within 24 hours, allowing for efficient and accurate diagnosis. Orthopedic surgeons can then collaborate to determine the most beneficial treatment plan for each individual patient.

“There are many factors to consider, involving the degree of correction and
amount of arthroscopy work that may be needed,” says Bruce A. Levy, M.D., a consultant in Orthopedic Surgery at Mayo’s Minnesota campus. “For patients with a very subtle labral tear but who need a significant amount of joint correction, we might do just the osteotomy. For somebody who has a malpositioned socket and also problems on the femoral neck and with the labrum, we might decide to stage the surgeries — fix the labral tear and correct the bony abnormalities on the femoral side, and then do a second-stage osteotomy on the socket.”

That level of experience also allows for shorter operating times in selected patients. At Mayo Clinic, pelvic osteotomy can be done in an hour, compared with the four hours typically required. “We’re a little bit unique at Mayo Clinic,” says Robert T. Trousdale, M.D., a consultant in Orthopedic Surgery at Mayo’s Minnesota campus. “Having done many pelvic osteotomies, we can do them well in less time.”

Matching patients to the right procedures helps optimize outcomes. In a study published in the October 2016 issue of the American Journal of Sports Medicine, Mayo Clinic researchers found that among patients under the age of 55 who had primary hip arthroscopy for femoroacetabular impingement at Mayo Clinic, modified Harris Hip Score (HHS) improved from a mean score of 59 preoperatively to 81 at one year postoperatively. The mean age of patients studied was 37 years.

A study published in the March 2016 issue of the American Journal of Sports Medicine found improved clinical outcomes for young patients who had reverse (anteverting) periacetabular osteotomy performed at Mayo Clinic to treat isolated acetabular retroversion or retroversion in the setting of dysplasia. Average HHS improved from 58 preoperatively to 93 postoperatively among patients with isolated retroversion, and from 49 to 92 in the dysplastic group. The patients’ mean age was 26 years.

“If patients are selected properly for various procedures and the procedures are performed well, the vast majority of both arthroscopies and open surgeries result in dramatic improvement in pain, function and activity levels,” Dr. Trousdale says.

**Long-term outlook**

Although structural hip deformities are thought to predispose patients to degenerative joint changes, little is known about the natural history of these conditions. Mayo Clinic researchers are working to shed light on the long-term outlook for young people with hip deformities.

In a study published in the February 2017 issue of Clinical Orthopaedics and Related Research, the researchers found that, after mild degenerative change develops in the hip, patients with developmental hip dysplasia have a higher probability of progressing to end-stage osteoarthritis or total hip replacement compared with patients with femoroacetabular impingement or normal morphology.

“Early intervention for patients with dysplasia seems likelier to positively influence the natural history of their hips, compared with patients with impingement,” Dr. Trousdale says.

Plans are underway to offer patient appointments at the Young Hip Clinic during designated periods of the week, to further expedite decision-making and patient care. “Because we’re all together in one location — as opposed to having an arthroscopist in one hospital and an open surgeon across town, and trying to coordinate two surgeons’ schedules — we’re able to provide very efficient and effective care,” Dr. Levy says. “It’s really unique to have surgeons with varied expertise seeing patients together.”

“The advantage is harnessing the team approach with experts in multiple areas of intra-articular and extra-articular hip disorders,” Dr. Krych adds. “That allows us to perform a timely evaluation to arrive at the correct treatment plan, individualized for each patient.”

**For more information**


unusual in providing the full complement of care with a high degree of specialization. Our surgical teams are orthopedic pediatric teams, not general pediatric teams,” says A. Noelle Larson, M.D., a consultant in pediatric Orthopedic Surgery at Mayo Clinic’s campus in Minnesota. “For any type of spine deformity, we have the resources and staff to provide the highest level of patient experience in terms of safety, comfort and outcomes,” adds William J. Shaughnessy, M.D., a consultant in pediatric Orthopedic Surgery at Mayo’s Minnesota campus.

**EDF casting**

Elongation, derotation, flexion (EDF) casting — also known as Mehta casting — is used to treat early-onset scoliosis in infants and children up to age 4. The treatment utilizes a custom-made thoracolumbar cast that acts simultaneously in the frontal, sagittal and coronal planes.

Early-onset scoliosis can sometimes spontaneously resolve. “But based on criteria such as the severity of the curve and the rib vertebra angle difference, we can identify kids whose curves are going to get worse and who can benefit from this casting,” says Todd A. Milbrandt, M.D., a consultant in pediatric Orthopedic Surgery at Mayo’s Minnesota campus.

About half the children who have EDF casting achieve a curve of less than 20 degrees after two years of treatment. Occasionally, outcomes are dramatic. Dr. Larson cites the example of a Mayo Clinic patient with a 75-degree curve who had EDF casting from age 12 months to 3 years. “She’s now 7, she’s not in a brace and her curve is under 20 degrees,” Dr. Larson says.

More frequently, EDF casting allows surgery to be postponed until the child is older. “Often scoliosis will progress 20 to 30 degrees per year without treatment,” Dr. Larson notes. “So even if we start with a 70-degree curve and with casting we get it down to 40 degrees, that’s a success.”

**Magnetic growing rods**

Growing rods have become the mainstay of treatment for children with scoliosis. After initial surgical implantation, patients typically must undergo several additional surgeries to lengthen the rods to accommodate growth.

Magnetically controlled growing rods can be adjusted externally, avoiding the need for repeated surgeries. The rods incorporate small, magnetic gear mechanisms; a magnetic actuator is passed over the rods to lengthen them (Figure 1).

“Adjusting traditional rods may be an outpatient procedure or might require an overnight hospital stay. But it’s still surgery that’s needed every six to nine months,” Dr. Larson says. The procedures are especially problematic for children with poor heart or lung function due to conditions such as spinal muscle atrophy.

In a study published in the December 2015 issue of *Spine*, Dr. Larson and colleagues found that although magnetic rods are initially more costly than conventional rods, the costs equalize after about three years, due to the lack of repeat surgeries. “The magnetic rods have a relatively high revision rate, like regular rods,” Dr. Larson says. “But this new technology has been a real game-changer in terms of patient comfort.”

**EOS**

Exposure to diagnostic radiation during childhood poses enhanced risk of breast cancer in female patients with scoliosis, and has been associated with other cancers. Mayo Clinic was among the first centers in the United States to offer EOS, a low-radiation imaging technology.

In a study of skeletally immature patients with scoliosis published in the March 2015 issue of *Spine Deformity*, the pediatric orthopedic group worked closely with Mayo Clinic’s radiation physicist to determine that an EOS posteroanterior (PA) radiograph results in four times less radiation to the thyroid and eight times less radiation to the breasts than conventional X-rays. Radiation to the breast and thyroid is higher with the anteroposterior view, so the researchers recommend using the PA view in the EOS machine for standard imaging protocols.

In addition to low radiation, EOS provides high-quality images (Figure 2). “EOS images are more uniform than our previous low-dose filtered X-rays and provide us with more-accurate measurements,” Dr. Shaughnessy says. “And by reducing radiation doses, we can in theory reduce that risk of cancer for our patients.”

**Intraoperative imaging and navigation**

For complex spinal surgeries, Mayo Clinic orthopedic surgeons can use intraoperative CT-guided navigation (Figure 3). The system provides real-time,
Total hip arthroplasty is a common surgery, with more than 330,000 procedures performed in the United States every year. However, there is significant controversy over the optimal muscle-sparing approach: mini-posterior approach (MPA) or direct anterior approach (DAA).

In a prospective, randomized study, researchers at Mayo Clinic in Rochester, Minnesota, found that Mayo Clinic patients who underwent DAA (Figures 1 and 2) had objectively faster recovery than patients who had MPA hip arthroplasty. The study used advanced, quantitative monitoring of activity to measure the recovery of 101 patients with end-stage unilateral hip osteoarthritis who were randomized to receive DAA or MPA surgery. Participants were evaluated preoperatively, and at two weeks, eight weeks and one year postoperatively.

“We found that functional milestones — such as discontinuing use of the walker, and walking half a mile — occurred about five days earlier with the anterior approach,” says Michael J. Taunton, M.D., Orthopedic Surgery and assistant professor of orthopedics at Mayo Clinic’s campus in Minnesota. “In experienced hands, DAA can provide faster functional recovery in the short term after surgery.”

Mayo Clinic has orthopedic surgeons with expertise in both anterior and posterior hip multidimensional intraoperative imaging of a patient’s anatomy. In a study published in the April 2016 issue of Clinical Spine Surgery, Mayo Clinic researchers found that intraoperative image-guided navigation resulted in a 97.8 percent rate of accurate screw placement in patients ages 10 years or younger. Previous studies have noted that up to 15 percent of free-hand pedicle screws in children are reported to be malpositioned.

“These technical innovations in intraoperative imaging and navigation are very helpful for placing screws more safely and efficiently,” says Anthony A. Stans, M.D., a consultant in pediatric Orthopedic Surgery at Mayo’s Minnesota campus.

To minimize radiation exposure from intraoperative CT, Mayo Clinic developed a protocol for pediatric patients using a lower radiation dosage than that recommended by the manufacturer. In the September 2016 issue of Journal of Pediatric Orthopaedics, Mayo researchers reported that the pediatric protocol reduces radiation from intraoperative CT to less than one-fourth the mean annual natural background radiation. “We can obtain an intraoperative CT scan for about the same radiation as two scoliosis X-rays, with acceptable quality of images,” Dr. Larson says.

3-D models
Utilizing CT scans and 3-D printing technology, Mayo Clinic has the capability to construct precise 3-D models of patients’ spines. “We use these models for patients with unusual abnormalities that are difficult to understand even with a 3-D image on a screen,” Dr. Stans says.

Additional software allows surgeons to place virtual screws in a screen image of a patient’s spine and then print a 3-D model of the spine incorporating those screw placements. “This helps us to do the surgery more safely and efficiently, with shorter time under anesthesia and better outcomes,” Dr. Stans says.

Expertise through teamwork
Mayo Clinic’s broad expertise allows it to provide innovative patient care. Radiologists are key members of the treatment team, providing images and at times physical models that guide treatment plans and surgery. Anesthesiologists have devised a special protocol for pediatric spinal surgeries.

“Our collaborative approach provides maximum safety, improves our patients’ comfort postoperatively and markedly reduces their length of hospital stay,” Dr. Stans says. “At Mayo Clinic, we have like-minded people working together on complicated cases to meet the needs of patients.”

For more information


replacement. Participants in the study were initially seen by one of four Mayo Clinic surgeons. After randomization to DAA or MPA, patients had surgery performed by a Mayo Clinic surgeon with expertise in the assigned procedure, regardless of whether the surgeon had consulted on the patient initially. Postoperative care was provided by patients’ initial consulting surgeons.

“That cross-randomization was a unique aspect of our study,” Dr. Taunton says. “We also were able to perform DAA for these patients with the necessary level of experience. That is key because there is a learning curve with the anterior approach. Serious complications can come from inappropriate execution.”

Another unique aspect of the study was the use of a gait monitor developed at Mayo Clinic. The monitor — which patients wore at home preoperatively and at two weeks, eight weeks and one year postoperatively — has five sensors and is significantly more sensitive than commercial activity-monitoring devices.

“Consumer activity monitors don’t typically measure your activity if you’re moving slowly — for example, with a walker,” Dr. Taunton says. “Our monitor can register the number of steps taken and percent of day active at activity levels ranging from very slow ambulation to running. It also measures entropy, a measure of the complexity of gait. At two weeks after surgery, we were able to see that our anterior patients not only walked more but also had better quality of gait.”

Among other data, the study documented quicker recovery by DAA patients compared with MPA patients in:

- Discontinuing use of a walker (10 days after surgery versus 14.5 days)
- Discontinuing use of all gait aids (17.3 versus 23.6 days)
- Discontinuing use of narcotics (9.1 versus 14 days)
- Ascending stairs with gait aid (5.4 versus 10.3 days)
- Walking six blocks (20.5 versus 26 days)

There was no difference in monitored activity levels between the two groups preoperatively, and at two months and one year after surgery. The study also found no postoperative in-hospital complications in either group. Further studies comparing long-term outcomes are planned.

Meeting patients’ expectations

Although recovery rates appear to equalize by eight weeks after hip replacement, the faster short-term recovery that’s possible with DAA can be important for patients. “Their expectations have changed,” Dr. Taunton says. “Patients who are losing the ability at age 72 to hike mountains or to bicycle want to regain those abilities. They want faster pain relief and as little interruption of life as possible.”

DAA is often performed with fluoroscopy, to re-create as precisely as possible the patient’s hip biomechanics. Precision is further increased at Mayo Clinic through the use of 3-D models of patient anatomy before surgery and of robotics during surgery that guide the implant’s positioning. “The robot helps us understand down to the degree or millimeter the exact position for the implant or for the leg length and offset,” Dr. Taunton says.

The faster recovery achieved after anterior hip surgery might even benefit patients with more-severe hip conditions. Dr. Taunton and colleagues are planning a randomized study comparing standard and anterior surgical approaches for femoral neck fractures.

“Those patients tend to be elderly and more debilitated,” Dr. Taunton says. “But we might someday be able to provide better care for a 95-year-old who falls and breaks a hip. If we can fix the hip and get the patient up and moving more quickly, there may be less risk of pneumonia, narcotic-related delirium or any of the other conditions that can cause cascading deterioration for these patients.”

Figure 1. Illustration of the right hip demonstrates the location and size of the incision for the direct anterior approach. The approach continues between the sartorius and tensor fascia lata muscles, an internervous plane, avoiding the risk of denervation of the involved muscles.

Figure 2. Anteroposterior and lateral radiographs of the hip demonstrate the acetabular component, femoral head and femoral stem in appropriate positions after surgery using the direct anterior approach.
Shifting the Paradigms for Complex Shoulder Surgery

For patients with complex shoulder problems involving paralysis and instability, treatment options have been sparse. Mayo Clinic is pioneering new surgical techniques — muscle transfers that can restore some deltoid function as well as tendon transfers for massive rotator cuff tears, brachial plexus injury (BPI), trapezius paralysis and subscapularis tears — that provide options for patients with debilitating shoulder conditions.

“Mayo Clinic can manage very complex cases that often cannot be treated elsewhere,” says Bassem T. Elhassan, M.D., a consultant in Orthopedic Surgery at Mayo Clinic in Rochester, Minnesota. “When a patient has multiple problems with instability, bone defects and muscle paralysis, we are able to perform not only implantation and bone grafts but also complex transfers of muscles and tendons to restore shoulder function.”

Re-creating the deltoid

Reverse shoulder arthroplasty is contraindicated in patients with deltoid paralysis, as the implant’s biomechanics and stability require a functional deltoid. Thus, surgical treatment options for patients with arthritis and deltoid paralysis have been limited.

Dr. Elhassan and colleagues have developed a procedure for reverse shoulder arthroplasty that transfers a pedicled pectoralis muscle to reconstruct the anterior deltoid. Local tendon transfers can be performed in addition to provide shoulder rotation.

“This surgery gives improved shoulder function to patients who have been told that there’s no solution to their problems. It is a procedure done only at Mayo Clinic,” Dr. Elhassan says. In a study to be published in the Journal of Shoulder and Elbow Surgery, Mayo researchers found that among 31 patients who had reverse shoulder arthroplasty and a pedicled pectoralis transfer, 29 had significant improvement of pain, shoulder subjective value, and Disabilities of the Arm, Shoulder and Hand (DASH) score. Flexion improved to a mean 83 degrees and external rotation to a mean 15 degrees. “This procedure re-creates the anterior deltoid in a close-to-anatomic fashion,” Dr. Elhassan says.

Solutions for severe rotator tears and BPI

Standard treatments for irreparable rotator cuff tears and for BPI often result in minimal or no improvement. Mayo Clinic’s innovation — lower trapezius transfer (Figure) — has demonstrated effectiveness for both conditions.

Among 33 patients with a symptomatic massive irreparable rotator cuff tear who underwent lower trapezius transfer at Mayo, 32 had significant improvements in pain and function, according to a study published in the August 2016 issue of Journal of Shoulder and Elbow Surgery. Improvements were documented in patients’ DASH scores and in flexion, abduction and external rotation. The Mayo procedure included Achilles tendon allograft to reinforce the lower trapezius.

“Although patients with greater than 60 degrees of preoperative flexion had more significant gains in range of motion than other patients in the study, all patients had improved shoulder external rotation, regardless of their preoperative loss of motion,” Dr. Elhassan says.

Among 12 patients with severe BPI who underwent a new Mayo Clinic procedure — contralateral lower trapezius origin transfer (CLTOT) — 10 improved from no shoulder external rotation motion preoperatively to an average external rotation of 110 degrees from the abdomen. A report of these treatments in the April 2016 issue of the Journal of Hand Surgery noted improvements in patients’ Constant shoulder scores, simple shoulder values and DASH scores. None of the patients studied had changes in contralateral shoulder function and strength after surgery.

Five of the 12 patients had additional tendon transfers to manage painful symptomatic inferior shoulder subluxation in the absence of shoulder abduction-flexion. “These additional transfers have been shown to have no direct functional consequences for external rotation, so any gains in shoulder rotation would be due to the lower trapezius transfer,” Dr. Elhassan notes.

Figure. A. Photograph shows arthroscopic lower trapezius transfer procedure. B. Drawing illustrates lower trapezius transfer open procedure.
**Improved surgery for trapezius paralysis**

The Eden-Lange procedure, described in the first half of the 20th century, has been the standard approach for patients with trapezius paralysis who don’t respond to conservative treatment. But the original Eden-Lange procedure potentially creates an internal rotation torque on the chest wall instead of the trapezius’s normal external rotation torque.

To re-create the trapezius’s line of pull, Mayo Clinic orthopedic surgeons have modified the Eden-Lange procedure. Mayo’s triple-tendon (T3) transfer involves transferring the levator scapulae, rhomboid minor and rhomboid major, including all muscles’ bony insertions.

A study of T3 transfers in 22 patients with a history of persistent trapezius paralysis secondary to spinal accessory nerve injury showed the procedure is effective in stabilizing the scapulothoracic articulation and restoring trapezius function. As reported in the August 2015 issue of the *Journal of Shoulder and Elbow Surgery*, winging was corrected in all patients. In addition, all patients had significant improvement of pain and range of motion, including active shoulder abduction and shoulder flexion.

“The main reason for these good outcomes with T3 transfer is the ability to restore the line of pull of the trapezius. Careful rehabilitation also is important,” Dr. Elhassan says. “The levator scapulae, rhomboid major and rhomboid minor are much smaller than the trapezius, so it’s critical to allow time for full healing of the transfer before strengthening begins.”

**Subscapularis breakthrough**

Laboratory research is the foundation for Mayo Clinic’s surgical innovations. A cadaveric study described in the April 2014 issue of the *Journal of Shoulder and Elbow Surgery* demonstrated the feasibility of transferring latissimus dorsi or teres major tendons or both to reconstruct irreparable subscapularis tears, paving the way for better outcomes than achieved with the typical approach of pectoralis major transfer.

“At Mayo we have incredible access to the Motion Analysis Laboratory, where we can do research on a biomechanical or anatomic level that allows us to say that a new procedure is possible,” Dr. Elhassan says. “The best part of Mayo is the teamwork that ultimately benefits patients.”

**For more information**


**Wrist Replacement: An Option for Advanced Arthritis**

Early-stage wrist arthritis can often be managed with medication, splinting and modification of activities. If these nonoperative treatments fail, wrist fusion has been the treatment of choice to alleviate pain and improve joint function. However, patients frequently report limitations after fusion involving daily activities that benefit from motion, such as perineal care and button fastening.

Orthopedic surgeons at Mayo Clinic in Rochester, Minnesota, offer the option of wrist replacement (Figure). Although performed less commonly than hip or knee replacement, wrist replacement can provide relief from pain and instability while preserving the range of motion needed for daily activities.

“Wrist replacement can be an option for patients who are reluctant to have a wrist fusion. At Mayo Clinic we are seeing increasing referrals for this procedure,” says Marco Rizzo, M.D., a consultant in Orthopedic Surgery at Mayo Clinic’s campus in Minnesota. “As a major center for orthopedic surgery, we have the volume of patients and range of surgical subspecialties to ensure skills and experience with wrist replacement.”

Wrist replacement is most commonly performed on patients with rheumatoid arthritis, but it’s also used to treat osteoarthritis and post-traumatic arthritis. Dr. Rizzo notes that the most suitable candidates are older patients who have pancarpal arthritis and who don’t perform work
that requires heavy lifting, which can diminish the longevity of the implant.

“Our short- and midterm outcomes in terms of pain relief and the maintenance of joint function are generally very good,” he says. “The long-term outcomes unfortunately are not as strong as we would like. Additional surgery is often needed after about 10 years.”

**Preserving wrist function**

According to an analysis by Dr. Rizzo and colleagues of data from the National (Nationwide) Inpatient Sample, wrist fusion was performed four times more frequently than wrist replacement from 2001 to 2010. The researchers’ study, published in the August 2016 issue of *Journal of Wrist Surgery*, notes that the total complication rate was 10 percent among the 738 wrist fusions performed and 7 percent among the 199 wrist replacements.

The study further notes that newer wrist replacement systems have improved design and kinematics compared with those used before 2010. Designed to solve previous models’ complications with loosening of the distal component, these newer implants are mainly uncemented and have porous titanium surfaces to allow for osseous integration. With this new technology, wrist replacement systems are being offered to patients who are reluctant to forgo wrist function.

“We have patients who come to us for evaluation for contralateral treatment after having fusion on one wrist,” Dr. Rizzo says. “They express frustration with the limitations to movement in the fused wrist and are concerned about having a fusion in that other wrist. Patients who ultimately have wrist fusion on one side and wrist replacement on the other prefer the replacement.”

Mayo Clinic has a rich history of innovations in wrist replacement, through studies conducted in the Mayo Clinic Motion Analysis Laboratory. Mayo Clinic hand surgeons designed one of the new wrist implants that is now available. In a retrospective comparative study published in the November 2012 issue of *Journal of Wrist Surgery*, Mayo Clinic researchers found that newer resurfacing implants, including the one designed at Mayo Clinic, provided good pain relief and functional motion, and had lower Disabilities of the Arm, Shoulder and Hand (DASH) scores than an earlier design.

At Mayo Clinic, evaluation for wrist replacement involves testing of active and passive motion, as well as a detailed history and assessment of the patient’s daily activities, including pastimes and level of care at home. The duration of the wrist replacement system depends greatly on the physical demands placed on it.

“The temptation after wrist replacement is similar to having a set of new tires and wanting to give them a run up the highway,” Dr. Rizzo says. “But I tell patients that they must go gently.”

**Figure.** X-rays show the wrist of a 64-year-old man before and after wrist replacement surgery at Mayo Clinic. A. Preoperative anteroposterior view. B. Preoperative lateral view. C. Postoperative anteroposterior view. D. Postoperative lateral view.

For more information
