Orthopaedic Insights
A Physician Newsletter from the Department of Orthopaedic Surgery

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Dear Colleague,

Today’s research is tomorrow’s leading clinical practice — or so we hope if the right research questions are asked and addressed in thoughtful, meticulous ways.

These days we are asking a lot of research questions in Cleveland Clinic’s Department of Orthopaedic Surgery, as evidenced by the infographic on the back cover of this issue of Orthopaedic Insights. As detailed there, our department, through its collaborative relationship with Cleveland Clinic’s Lerner Research Institute, has 65 active externally funded research projects underway. These projects collectively represent nearly $50 million in total research support. More than $24 million of that total is National Institutes of Health (NIH) funding, which is spread across 23 active extramural NIH studies.

One of those NIH-supported research initiatives is profiled on page 6, where pediatric orthopaedist Dr. Tracy Ballock outlines in vitro research he’s conducting that may ultimately lead to strategies for regenerating physeal cartilage in vivo following serious growth plate injuries. The result of this research could have game-changing effects in pediatric orthopaedics.

Additionally, the issue opens by profiling a pair of other research initiatives that hold potential to contribute to our specialty in important ways:

• On page 3, Dr. Gregory Gilot of Cleveland Clinic Florida shares promising data on his team’s early use of an all-arthroscopic approach to augmenting rotator cuff repairs with extracellular matrix graft scaffolds. With encouraging biomechanical and retrospective in vivo data under their belts, they are ready to put their technique to the test in a prospective randomized trial.

• In a sidebar to Dr. Gilot’s article, we report on a recently FDA-approved reinforced allograft fascia lata patch developed in the lab of Kathleen Derwin, PhD. The patch has been cleared for use to reinforce repairs of tendons in a number of anatomic sites, and a first-in-human study is being planned.

Rounding out the issue is a collection of practical, insightful clinical contributions from the diverse reaches of our department, where our staff share how they are deploying the products of yesterday’s research in judicious ways to improve patient outcomes. And we conclude with a perennial favorite: the Orthopaedic Residency Update from Residency Program Director Thomas Kuivila, MD. In between his inspired musings, Dr. Kuivila welcomes our formidable lineup of new residents and sends off our accomplished 2013 grads to their next exciting endeavors. I am confident there are at least a few future research stars in the bunch.

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Going All Arthroscopic for Augmentation of Rotator Cuff Repairs:
Cleveland Clinic Florida Shares Some of the Earliest Data to Date

By Gregory J. Gilot, MD

Despite improved understanding of rotator cuff (RTC) tears, repair of these tears continues to be plagued by unsatisfactory postoperative healing rates and undesirable revision rates. There is a clear need for strategies that augment the repair by mechanically reinforcing it while also promoting the tendon’s natural healing potential.

The search for such strategies centers increasingly on RTC repair augmentation with biological scaffold materials composed of extracellular matrix (ECM), and Cleveland Clinic Florida is playing a lead role. We have developed an all-arthroscopic technique for placement of an ECM dermal allograft and are generating some of the first clinical data on the use of such a technique.

A COMPLETELY ARTHROSCOPIC APPROACH

Shoulder surgeons traditionally perform augmentation through a formal open or arthroscopically assisted mini-open approach. In contrast, our technique is completely arthroscopic, offering the advantages of a minimally invasive approach. We perform the RTC repair in a standard arthroscopic fashion using the double-row technique, but we also arthroscopically incorporate the ECM graft into the repair for reinforcement (Figure 1).

Briefly, the untied limbs of the medial anchor sutures are passed through the medial edge of the graft, and the innermost mattress sutures are tied using a sliding-locking knot. The graft is advanced into the clear cannula, and the knot is advanced onto the cuff and tuberosity. Remaining sutures are tied in a load-sharing fashion, after which a limb of each tied suture is passed through a lateral row anchor. A suture bridge technique secures the graft-incorporated repair through the lateral edge of the graft with adequate tension.

The goal is to strengthen and evenly distribute the biomechanical load across the repair site (Figure 2), ensuring that the native tendon does not carry all the rupture risk during the healing process. Additionally, the graft is believed to enhance healing by addressing many of the challenges of RTC repair, including poor-quality tissue (especially in a revision setting), large defect size and high tension where the tendons join the bone.

SUPPORTIVE BIOMECHANICAL AND CLINICAL DATA

Our technique’s potential is supported by initial biomechanical findings in cadavers as well as results from a retrospective case-control series.

Our biomechanical study involved repair of RTC tears in 11 matched pairs of cadaveric shoulders free of soft tissue. Both shoulders in each matched pair underwent RTC repair with the same technique, either with or without human dermal allograft augmentation. We found that graft-augmented RTC
repair yielded a 29 percent greater mean load to failure and reduced gap formation by 21 percent compared with unaugmented RTC repair (Table 1). Although the repairs were done in an open fashion without overlying soft tissue, the technique used is identical to the arthroscopic technique we use in vivo. Our results, which have been submitted for publication, suggest that human dermal allograft is able to provide load-sharing to protect the repair site during early healing.

These findings prompted in vivo assessment of our technique in a case-control study of 40 patients undergoing arthroscopic repair of large to massive RTC tears by standard methods alone (n = 20) or with ECM graft augmentation (n = 20). The primary outcome measure was the incidence of a re-tear of the RTC as assessed by ultrasound 12 months after repair. Secondary measures were patient satisfaction according to four validated shoulder surveys and ultrasound-defined maximal thickness of the supraspinatus 1 cm proximal to the most distal aspect of its footprint on the greater tuberosity.

As detailed in Table 1, the rate of re-tears at 12 months was two-thirds lower in the augmentation group than in the control group, and satisfaction rates and supraspinatus thickness favored the augmentation group as well. Study results are now being prepared for manuscript submission.

**NEXT: RANDOMIZED TRIAL, FURTHER REFINEMENT**

While these clinical data are encouraging and our biomechanical findings support the theory behind our technique, further substantiation of our arthroscopic approach to RTC repair remains to be done. We are planning a randomized controlled trial that will build on these cadaveric and retrospective in vivo findings with a prospective comparison of augmented and non-augmented arthroscopic repairs in a larger number of patients.

**LESSONS AND ADVICE TO DATE**

Our group has accumulated some observations that may help guide adoption of this innovative approach to RTC repair augmentation if its early promise ultimately pans out:

- **Patient selection is key.** We’ve found so far that patients with a failed prior RTC surgery appear to make the best candidates for our augmentation technique. Others who may stand to particularly benefit include older patients; those with large to massive chronic tears; and younger,

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**Table 1. Studies of Our Technique at a Glance**

<table>
<thead>
<tr>
<th>Study description</th>
<th>Outcomes</th>
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| Biomechanical study in 11 matched pairs of cadaveric shoulders with RTC tears repaired with or without human dermal allograft augmentation | • 29% increase in mean load to failure in augmented vs. nonaugmented repairs  
  • 21% decrease in gap formation in augmented vs. nonaugmented repairs            |
| Case-control study of patients undergoing repair of large to massive RTC tears by standard methods alone (n = 20) or with ECM graft augmentation (n = 20) | At 12 months:  
  • Re-tears: 6 in control group vs. 2 in augmentation group  
  • Supraspinatus maximal thickness of 0.473 cm in control group vs. 0.577 cm in augmentation group  
  • Satisfaction rate of 66.7% in control group vs. 93.3% in augmentation group |
Progress in Rotator Cuff Repair Extends to the Lab as Well

As Dr. Gilot further refines his scaffold-based augmentation technique in Florida, his colleagues at Cleveland Clinic’s main campus have been developing novel fiber-reinforced extracellular matrix (ECM) scaffolds for musculoskeletal soft tissue repair.

A Cleveland Clinic team led by Kathleen Derwin, PhD, saw its patent-pending design for a reinforced allograft fascia lata patch receive 510(k) clearance from the FDA in November 2012. The patch was approved for use in reinforcing soft tissues repaired by sutures or suture anchors during tendon repair surgery, including reinforcement of rotator cuff, patellar, Achilles, biceps and other tendons.

Use of fascia lata gives the patch structural and biochemical properties similar to those of tendons and distinct from other ECM-derived scaffolds, explains Dr. Derwin, of the Departments of Orthopaedic Surgery and Biomedical Engineering. “However, native fascia lata has poor suture-retention properties, which limits its usefulness as a tendon-like scaffold for rotator cuff repair augmentation,” she says. “We reinforced fascia ECM with PLLA polymer braids to engineer the suture-retention properties of fascia to meet the needs of musculoskeletal applications.”

The Derwin lab has published studies showing that:

• The patch maintains its suture-retention properties before and after implantation in a rat subcutaneous model.

• Augmentation with the patch decreased cyclic gap formation compared with nonaugmented repairs in a human cadaver model.

“These studies demonstrate the potential for a reinforced fascia patch to provide mechanical augmentation, minimize tendon retraction and possibly reduce the incidence of rotator cuff repair failure,” notes Dr. Derwin.

Her lab is now seeking funding for a first-in-human study of the patch.

The learning curve is steep. The technique can be technically challenging. A skilled arthroscopist who is facile at standard arthroscopic shoulder surgery is best positioned to navigate the initial steep learning curve. I recommend initial training in the cadaveric setting, as it improves understanding of RTC pathoanatomy and the best indications for surgical augmentation.

Adoption is best in a specialist team setting. The technique is best performed within the setting of a dedicated shoulder surgery team. At Cleveland Clinic Florida, I am fortunate to be able to draw on deep expertise in this area from other orthopaedic surgeons and specially trained support staff.

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Dr. Gilot is Chairman of the Department of Orthopaedic Surgery and Director of the Orthopaedic and Rheumatologic Center at Cleveland Clinic Florida. He specializes in adult reconstructive shoulder surgery and sports medicine. He can be reached at 954.659.5430 or gilotg@ccf.org.
Regenerating the Physis: New Insights and Tissue Engineering Advances Could Transform Repair of Pediatric Growth Plate Injuries

By R. Tracy Ballock, MD

Childhood fractures are practically a rite of passage: Approximately 42 percent of boys and 27 percent of girls suffer at least one broken bone by the time they reach age 16. About 20 to 30 percent of fractures of long bones in children involve the growth plate, the area of growing tissues near the end of the long bones in children and adolescents that determines the future length and shape of the mature bone. The growth plate (epiphyseal plate, or physis) is the weakest area of the growing skeleton and is therefore susceptible to injury.

Successful regeneration of growth plate cartilage architecture would make it possible for the first time to replace irreversibly damaged growth plates.

GROWTH PLATE INJURIES: WHY STAKES CAN BE HIGH

Although most fractures through the cartilage growth plates of the long bones heal uneventfully, specific types of injury may cause growth arrest with subsequent leg length inequality and progressive deformity. This growth arrest is due to formation of a bony bar or bridge across the injured growth plate that acts as an effective tether to resist further longitudinal growth. Once a physeal bar forms, surgical excision is technically difficult and is often unsuccessful in restoring normal growth.

PHYSICAL CARTILAGE REGENERATION WOULD BE TRANSFORMATIVE

Our understanding of factors that regulate the proliferation and differentiation of growth plate chondrocytes, combined with advances in cartilage tissue engineering, now provides a unique opportunity to develop strategies for regenerating physeal cartilage in vivo following serious growth plate injuries. Successful regeneration of growth plate cartilage architecture would have a transformational impact on the practice of pediatric orthopaedic surgery, making it possible for the first time to replace growth plates irreversibly damaged not only by trauma but also by infection or irradiation.

OUR WORK TO REPLICATE COLUMNAR GROWTH IN VITRO

An essential step in achieving the overarching goal of growth plate regeneration is to understand the factors required for recapitulation of the normal columnar architecture of growth plate cartilage. Alignment of growth plate chondrocytes into columns is necessary to impose direction on longitudinal bone growth. Though the precise cellular and molecular mechanisms governing columnar morphogenesis remain unknown, our laboratory has developed a three-dimensional cell culture model (Figure 1) that replicates in vitro the critical features of an integrated systemic and local signaling network that appears to regulate columnar morphogenesis in the growth plate in vivo.

Using this model to investigate the molecular mechanisms governing columnar morphogenesis at the growth plate, we have demonstrated that column formation can occur in vitro under low serum conditions — or under chemically defined, serum-free conditions in the presence of thyroid hormone and growth hormone. Activation of the local Wnt planar cell polarity signaling pathway also induces morphogenesis of columnal cartilage, a process that is significantly enhanced by overexpression of the Wnt receptor Frizzled-7 and receptor-associated proteins (Figure 2).

WHERE WE AIM TO TAKE OUR RESEARCH

These preliminary data are consistent with the existence of an integrated systemic and local signaling network that regulates columnar morphogenesis at the growth plate. The objective of our future work is twofold:
• To determine how these systemic and local signaling pathways interact to achieve the orchestrated control of chondrocyte column formation in the growth plate that produces oriented longitudinal bone growth in children.

• To use this information to eventually optimize column formation of growth plate cells in vitro as a prelude to eventually regenerating growth plate tissue in vivo.

Elucidating how this signaling network functions to regulate columnar morphogenesis will facilitate regeneration of the columnar architecture of the growth plate in vitro, which is a crucial step in achieving the ultimate goal of regenerating damaged growth plates in vivo.

The research described here is supported by grants from the National Institutes of Health and the Musculoskeletal Transplant Foundation.

ABOUT THE AUTHOR

Dr. Ballock is a surgeon in the Center for Pediatric Orthopaedic Surgery, Professor of Surgery at Cleveland Clinic Lerner College of Medicine and a staff member in the Department of Biomedical Engineering. His clinical interests include skeletal development, hip dysplasia, clubfoot, deformity correction, leg lengthening, pediatric foot and ankle problems, and pediatric fractures. He can be reached at 216.444.5775 or ballocr@ccf.org.

Figure 1. Growth plate chondrocytes cultured as a three-dimensional cell pellet.

Figure 2. Column formation in a growth plate chondrocyte pellet culture treated with Wnt5a for 21 days.
A 50-year-old woman presented to an outside institution with bilateral hip pain. An MRI of the pelvis showed multiple marrow-infiltrating lesions in the pelvic bones and spine, and a diagnosis of metastatic disease was made. Staging CT studies did not reveal a primary tumor in the chest, abdomen or pelvis. The bone lesions seen on MRI were not visualized on CT of the abdomen and pelvis. A CT-guided blind biopsy of the pelvic lesions was done. Immediately after receiving a nondiagnostic biopsy result, the patient came to Cleveland Clinic for a second opinion. MRI-guided biopsy of the pelvic lesions was performed (Figure 1), and histology showed extensive granulomatous inflammation consistent with sarcoidosis and no evidence of a neoplasm.

**CT GUIDANCE IS NOT ALWAYS ADEQUATE**

Percutaneous or open surgical biopsy is often required to confirm the diagnosis of an indeterminate or aggressive bone lesion. Percutaneous needle biopsy of bone lesions is a safe and accurate method with a very low (1.1 percent) complication rate (Cancer. 2000;89:2677-2686). Real-time CT fluoroscopic guidance is typically used, often with low-dose techniques to limit radiation exposure. Nearly all primary and metastatic bone lesions are visible on CT, which allows accurate needle localization inside the lesion. In rare cases, however, lesions cannot be visualized on CT despite obvious findings on MRI. In these cases, MRI can be a safe and reliable alternative for guiding the biopsy.

**PROS AND CONS OF MRI GUIDANCE**

Compared with CT, MRI has several advantages for guiding biopsies, including superior soft tissue contrast, unique three-dimensional imaging capabilities and a lack of ionizing radiation. The main disadvantages are the long scanning time and the need for MRI-compatible devices, including biopsy needles. During CT guidance of a bone biopsy, scanning time is often less than a second, whereas MRI guidance requires three to four minutes of scanning at each step, which can add up to 60 to 90 minutes or more in complicated cases.

For the occasional patient who would benefit from image-guided biopsy of a bone lesion visible only on MRI, Cleveland Clinic is one of the few medical centers in the world offering this distinctive service. MRI-guided biopsies are performed under conscious sedation in the MRI suite on our main campus.

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Total Ankle Replacement for End-Stage Ankle Arthritis: One Center’s Take on Sorting Out the Options

By James J. Sferra, MD, and Eva Umoh Asomugha, MD

Ankle fusion or total ankle replacement (TAR)? It’s one of the biggest dilemmas faced by patients with end-stage ankle arthritis and their orthopaedic surgeons. Ankle arthrodesis has been the gold standard, but development of both radiographic and clinically relevant degenerative disease in the adjacent joint at long-term follow-up has made TAR an attractive option in appropriate patients. For patients requiring bilateral ankle fusions or those with end-stage ankle arthritis and previous hindfoot or midfoot fusions, studies demonstrate that ankle fusions have unfavorable effects on gait and functional capability.

CEMENTLESS DESIGNS BRING BETTER OUTCOMES

First-generation ankle replacements, which required cemented fixation and significant bone resection, were hindered by high complication and failure rates. Renewed interest in more anatomically based, cementless designs spurred development of second- and now third-generation implants, which have demonstrated improved results at short- and medium-term follow-up.

The hallmarks of third-generation implants are cementless fixation, with minimal bone resection as a result, and a polyethylene articulation. Outcomes, in terms of pain scores, range of motion and patient-rated functional capacity, have been promising with newer-generation designs.1

COMPLICATIONS REMAIN, SO PATIENT SELECTION IS KEY

Complications with TAR are prevalent and are often related to patient-related risk factors or technical errors. Reported complications include infection, delayed wound healing, stress fractures (of the malleolus or distal tibia), osteolysis, and implant migration or subsidence.

Proper patient selection is critical to increasing the longevity of the prosthesis and minimizing these complications. TAR can be used in patients with idiopathic, post-traumatic or inflammatory arthritides. Ideal candidates are middle-aged or elderly nonlaborers who have adequate bone stock, little to no deformity, and a normal foot and ankle neurovascular exam.

WHAT WE USE AT CLEVELAND CLINIC

Of the several FDA-approved TAR implant systems, Cleveland Clinic currently uses the following three:

- The Scandinavian Total Ankle Replacement System (STAR™ Ankle, Small Bone Innovations) is the only FDA-approved cementless, three-piece, mobile-bearing implant. One of the proposed benefits of this system is the limited bone resection needed for implantation, which should make future conversion or revision more feasible if necessary. Five- and 10-year implant survival rates as high as 90 percent and 80 percent, respectively, have been reported.2 The mobile-bearing system increases the planes of motion, allowing some varus and valgus tilt in the mortise during ambulation.

- The Inbone® Total Ankle System (Wright Medical Technology) is a modular, fixed-bearing, two-component system with intramedullary tibial and talar components. The modularity allows different-sized tibial and talar components to be used to match the patient’s native anatomy. Preoperative CT scans can be used to fabricate preoperative navigation alignment guides to serve as patient-specific instruments to assist in intraoperative positioning of the TAR components. These guides also allow the surgeon to avoid use of the Inbone leg holder intraoperatively, which can be dramatically helpful in the OR. This system works well for primary cases as well as revisions.

- The Salto Talaris™ Total Ankle Prosthesis (Tornier) has a design and instrumentation founded on the Salto mobile-bearing ankle prosthesis, which has been in clinical use in Europe since 1997. Studies demonstrate greater than 90 percent implant survival at midterm follow-up.3 A key principle of this system is that the mobile-bearing concept has been moved from the final implant into the stage of trialing instrumentation. Specifically, the trial tibial base is allowed to rotate into proper position by moving the ankle through an arc of motion, thus allowing the prosthesis to self-align. The tibial keel preparation is then completed, essentially locking the components into their appropriate positions.

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The Trabecular Metal™ Total Ankle (Zimmer) was recently approved in the U.S. but has not yet been implanted at our institution. It is a semiconstrained device with three implant components designed to be implanted via a lateral malleolus osteotomy.

**MAKING THE CHOICE**

At Cleveland Clinic, many factors are considered when choosing whether to perform ankle fusion or TAR — and then, if TAR is pursued, which implant to use. The patient's weight, age, angular deformity, soft tissues and activity level are all considered. The aim is to match these patient characteristics to the implant system in order to minimize soft tissue dissection and bone resection and preserve the ankle's natural anatomy and kinematics.

**REFERENCES**


**ABOUT THE AUTHORS**

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Dr. Asomugha is a PGY-5 resident in the Department of Orthopaedic Surgery. She can be reached at asomuge@ccf.org.

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**Case Study:**

**A 64-Year-Old with Chronic Post-Traumatic Ankle Pain**

A 64-year-old woman presented for evaluation of left ankle pain. She had sustained a left bimalleolar ankle fracture 12 years previously, which was treated with operative reduction and internal fixation at another facility. On presentation, she reported a history of several years of ankle pain with ambulation. Previous treatments included steroid injections, NSAIDs and Arizona-type AFO bracing.

On physical exam, she had a BMI of 29 and a severely antalgic gait. She had very limited motion in her ankle, which was exquisitely tender to palpation at the tibiotalar joint. Subtalar motion and midfoot motion were supple and nontender. Anteroposterior (AP), lateral and oblique weight-bearing X-rays (Figure 1) demonstrated severe left tibiotalar degenerative joint disease. Her subtalar and transverse tarsal joints were well maintained. There was retained hardware in the distal fibula and tibia.

She underwent TAR with the Inbone Total Ankle System and removal of her medial hardware. Intraoperatively, she was found to have a chronically ruptured tibialis anterior tendon. The remnant of this tendon was tenodesed to the extensor hallucis longus tendon.

She remained non-weight-bearing in a cast for three weeks. At three weeks, she was transitioned to a non-weight-bearing pneumatic walking boot during the day to begin gentle range-of-motion exercises three times daily. At postoperative week 8, her weight-bearing was increased by 25 percent every four to five days in the boot.

At her last follow-up, 14 months after surgery, she had no complaints and reported no pain. She did have some active ankle dorsiflexion, which on clinical exam appeared to be through her tibialis anterior. Postoperative X-rays at that time revealed well-fixed components (Figure 2).
Figure 1. Preoperative weight-bearing AP and lateral X-rays demonstrating severe osteoarthritis. No deformity is present, and adjacent joints have been spared. Figure 2. Postoperative weight-bearing AP and lateral oblique X-rays demonstrating the Inbone TAR implant.
Fracture Nonunions:
Inevitable, Challenging, Yet Manageable

By Damien G. Billow, MD

Although most fractures go on to bony union with appropriate treatment, 5 to 10 percent end in nonunion and can be difficult to treat. When treating a variety of fracture nonunions at Cleveland Clinic, we follow the general principles and pearls laid out below to navigate their management challenges.

INITIAL CLINICAL AND RADIOGRAPHIC FINDINGS
Clinically, a nonunion occurs when the normal biologic reparative process stops before solid bony fusion takes place and the bone is unable to withstand normal physiologic stresses. Clinical signs, such as increased pain with weight-bearing, may be present. Radiographically, nonunions will show lack of progression on serial radiographs over a course of months and may demonstrate hardware failure in terms of loose screws or broken plates or nails. CT may be helpful in evaluating for a nonunion, but metal artifact may make scans difficult to interpret.

HYPERTROPHIC OR ATROPHIC?
Nonunions are commonly classified by their radiographic appearance as hypertrophic or atrophic, and there is a spectrum between the two. Hypertrophic nonunions show significant callus formation with incomplete union and usually result from a lack of mechanical stability. Atrophic nonunions have little or no callus formation and often are due to a lack of biology. Infection should always be investigated as the cause of nonunion and is most commonly associated with atrophic nonunions (Figure 1).

FIRST SEEK THE CAUSE
Treatment of nonunions should always start with an investigation into the cause. History-taking and the physical exam and laboratory workup should thoroughly assess for systemic factors such as smoking, use of NSAIDs and other medications (including steroids), malnutrition, vitamin D deficiency, and diabetes and other endocrine disorders. Lab tests should include, at minimum, a comprehensive metabolic panel, CBC, ESR, CRP, and levels of TSH and vitamin D. Smoking cessation counseling, medical management and appropriate referral to specialists should be addressed preoperatively to optimize the patient for future interventions.

CHARACTERIZE FRACTURE, OPTIMIZE FOR HEALING
Fracture characteristics should also be evaluated. High-energy fractures with more soft tissue stripping can compromise the biological environment for healing. Open fractures with segmental bone loss will be obvious. Poor soft tissue or wound healing problems should be noted. Preoperatively, the surgeon may need to plan on soft tissue coverage with a rotational flap or free flap with the help of a plastic surgeon. The initial fixation construct should also be critically evaluated, as it may have been biomechanically insufficient or possibly too stiff to allow for some physiologic stresses to the bone.

ASSESS FOR INFECTION
After the patient is optimized for further surgery, development of a preoperative plan — based on assessment of the patient and the fracture — is paramount. A good first step is to assess the likelihood of an ongoing infection. Wound drainage or erythema, history of an open fracture, and elevated ESR or CRP level are all suggestive of infection.

Infected nonunions are best treated in a staged fashion starting with thorough debridement and irrigation of the nonunion and infection, placement of antibiotic-loaded cement, and some sort of provisional fixation. An antibiotic cement nail...
Figure 2. Radiographs from the patient in Figure 1 after extensive debridement of femoral shaft nonunion with additional areas of bone loss proximally and distally. Antibiotic cement spacers were placed, as was a temporary bridging locking plate covered in antibiotic cement.

Figure 3. Radiographs from the patient in Figures 1 and 2 after reconstruction with locked plating over a retrograde nail. Bone grafting was done with bilateral iliac crest autograft to the nonunion site and allograft with BMP to proximal and distal areas of bone loss.

can be created with the aid of a chest tube and used in cases of infected tibia nonunions. Alternately, antibiotic cement spacers can be inserted into the bone defect after debridement. The spacer induces a membrane that has osteoblastic properties and also aids in containing bone graft at the next stage of treatment. Deep cultures from the nonunion site should always be obtained regardless of the suspicion of infection, as they can rule out an infective cause as well as guide appropriate antibiotic therapy. After a complete course of antibiotics and normalization of CRP lab results, the last stage of treatment is usually performed around six weeks after debridement (Figure 2).

ENSURE SUFFICIENT BIOLOGY AND STABILITY

Definitive treatment of nonunions most commonly consists of adding both biology and stability to the fracture. In a hypertrophic nonunion with evidence of callus formation and a low suspicion of infection, simply improving stability may suffice. If the hardware has catastrophically failed, it must be removed, usually with application of a new fixation construct. Creating compression across the nonunion is important and can be accomplished with lag screws, compression plating or an articulating tensioning device. If the initial fixation remains intact, options for improving stability include placing additional screws or plating over top of an intramedullary nail.

There are various ways to provide biology to the nonunion through bone grafting. Iliac crest autograft remains the gold standard and can be obtained anteriorly or posteriorly. Additional options include Reamer Irrigator Aspirator (RIA)-harvested autograft from the femoral or tibial canals, proximal tibia autograft, allograft with bone morphogenetic protein (BMP) or vascularized bone grafts (Figure 3).

In the most difficult nonunion cases — such as those with infection, segmental bone loss, malalignment and failed prior attempts at nonunion treatment with bone grafting — bone transport through use of an Ilizarov external fixator or Taylor Spatial Frame with delayed bone grafting may be the best treatment strategy.

BOTTOM LINE

Nonunions inevitably are encountered by those who treat fractures and can often pose management challenges. They are best treated with a well-thought-out preoperative plan based on careful assessment of the patient and the fracture. Providing additional stability — and often biology — to the nonunion is usually required.

ABOUT THE AUTHOR

Dr. Billow is a traumatologist in the Department of Orthopaedic Surgery who specializes in fracture care, including nonunions, malunions, and pelvis and acetabulum fractures. He can be reached at 216.445.4570 or billowd@ccf.org.
Anterior Approach to Total Hip Arthroplasty: Mounting Evidence of Its Merits for Appropriate Patients

By Carlos Higuera-Rueda, MD, and Pratik P. Desai, MD, MS

Recent years have seen renewed interest in minimally invasive approaches to total hip arthroplasty (THA). Perhaps the most important implication of “minimally invasive” — looming even larger than the length of the incision — is the reduction in damage to surrounding muscle and tissues within the operative field.

EVIDENCE OF LESS TISSUE DAMAGE, INFLAMMATION
Recent literature chronicles this. In 2011, Bergin et al.1 shared results comparing a minimally invasive direct anterior approach (DAA) with a posterior approach for THA. They particularly evaluated the rise of inflammatory markers and muscle damage markers. Their study demonstrated that the postoperative increase in serum creatine kinase levels (an indicator of muscle damage) was 5.5 times lower in the DAA group than in the posterior approach group, and other markers of inflammation (CRP, IL-6, IL-1, TNF-alpha) also rose to a lesser degree following DAA compared with the posterior approach. In theory, less muscle damage will lead to less pain and quicker recovery. The outcomes data presented below corroborate this theory.

PLEN'TY OF POSITION-RELATED ADVANTAGES
Most traditional approaches to THA employ a lateral decubitus position, which has been widely used with great success. However, this position makes access to the extremities, and therefore venous access, more challenging for anesthesia personnel. Access to the airway is also more difficult, posing challenges for pulmonary hygiene during the procedure and for conversion from spinal to general anesthesia, if needed.

In contrast, the anterior approach is performed in the supine position (Figure 1), allowing for easier patient suctioning/pulmonary hygiene and better venous access. Moreover, accurate assessment of leg lengths is easier in the supine position.

We perform the anterior approach using a regular operative table, which reduces cost and potential complications such as femoral fracture when compared with use of a special table design to facilitate exposure of the proximal femur.

DISADVANTAGES — AND HOW TO ADDRESS THEM
At the same time, the DAA does have some disadvantages:

• It puts the lateral femoral cutaneous nerve at risk for injury. The incidence of meralgia paresthetica has been reported to be 17 percent in some studies.2

• Femoral exposure can prove to be difficult, and several series have demonstrated an iatrogenic femoral fracture risk around 2 percent.2

Patient selection is important in preventing some of these complications. Careful examination of the patient’s body habitus is also key, as a large pannus may predispose to wound breakdown, hematoma or infection. For this reason, the DAA is not appropriate for every patient, especially at the beginning of the surgeon’s learning curve.3 The surgeon must carefully select patients for this procedure and have ample experience with this exposure.
At Cleveland Clinic, we use a modified version of an anterior approach using a more lateral muscle interval between the tensor fascia lata and gluteus medius to avoid compromise of the lateral femoral cutaneous nerve. This interval may improve exposure of the hip joint and can be extensible in case of complications such as femur fracture and in revision cases. Appropriate exposure of both the acetabulum and the proximal femur is achieved with this approach (Figure 2).

**EVIDENCE OF SWIFTER RECOVERY**

Many studies have documented that the DAA offers faster recovery with less pain. In one of the most recent studies, Martin et al. retrospectively compared DAA cases with traditional posterior approach cases, finding that mean hospital stay (2.9 vs. 4 days) and days to patient mobilization (2.4 vs. 3.2) were significantly shorter with the anterior approach.

The surgical literature has repeatedly demonstrated earlier recovery with the DAA in the early weeks after surgery. At six and 12 weeks, the anterior approach allows patients to progress faster through more gait and rehabilitation parameters than do conventional hip approaches. In addition, the use of assistive devices (crutches, cane, walker) is significantly less in the short term with the DAA.5,6

**EXPERIENCE COUNTS**

Despite the above advantages of minimally invasive DAA for many patients undergoing THA, the learning curve for this procedure is steep. Surgeons with experience in a minimum of 40 such procedures or six months or more in a high-volume hip arthroplasty center should be sought for the anterior approach.3 Indeed, when patients and referring physicians are making decisions regarding THA, the most important factor is the surgeon’s experience, regardless of whether an anterior or a posterior approach is used.

**REFERENCES**


**ABOUT THE AUTHORS**

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Dr. Desai is an adult reconstruction fellow in the Department of Orthopaedic Surgery. He can be reached at desaip2@ccf.org.
Giant cell tumor of bone is a nonmalignant but locally aggressive lesion. Vigilant follow-up after tumor removal is a cornerstone of management, as outlined in the below summary of factors guiding our approach to these lesions at Cleveland Clinic.

**WHEN, WHERE AND HOW LESIONS PRESENT**

Giant cell tumor of bone most commonly occurs between ages 20 and 40. The bone lesion is typically located in the epiphysis and metaphysis of the distal femur or proximal tibia. Other common sites are the distal radius, proximal humerus, distal tibia and sacrum. The epicenter of the tumor is in the metaphysis, but the tumor crosses the epiphysis, usually to within 1.5 cm of the joint line unless the joint is apophyseal.

Giant cell tumor of bone can penetrate and erode the subchondral bone and even invade the articular cartilage. It has been described as having sharp margination, generally without sclerosis, and a cookie cutter-type appearance on radiographs (Figure 1). Patients frequently report a deep, persistent, intraosseous pain that mimics an internal derangement of the joint. A pathologic fracture or reactive knee effusion is the initial symptom in about one-third of patients; in a small number (<1 percent), the tumor undergoes pulmonary metastases, which are generally, but not always, benign.

**WHAT TO EXPECT ON IMAGING, GROSS EXAM, HISTOLOGY**

Radiographs reveal a large radiolucent lesion, sometimes surrounded by a distinct margin of bone, that is frequently without a soft tissue mass and usually without a sclerotic margin. Cortical thinning, endosteal erosion and trabecularization, or bony septation, of the cavity are associated findings. CT or MRI can delineate the extent of involvement and bony margination. A chest radiograph or CT should be performed in all patients with giant cell tumor to rule out rare chest metastases.

Gross examination reveals soft, friable, reddish-brown neoplastic tissue with the consistency of a wet sponge. Some areas are gelatinous or fatty, while some are aneurysmal and cavitated. Histologic features include multinucleated giant cells, a proliferative stroma with vesiculated nuclei, areas of aneurysmal tissue, areas of necrosis, reactive peripheral bone and occasional mitotic figures.

**DIFFERENTIAL DIAGNOSIS**

The most concerning lesion to consider in the differential diagnosis is telangiectatic osteosarcoma, although telangiectatic osteosarcomas are usually more destructive and have higher T2-weighted signal on MRI. Chondroblastoma should be considered in younger patients with open physes. Whereas chondroblastomas have their epicenter in the epiphysis and most involve less than 50 percent of the epiphyseal width, giant cell tumors, in contrast, have their epicenter in the metaphysis and more commonly involve more than 50 percent of the epiphysis. Both giant cell tumors of bone and chondroblastomas may have aneurysmal bone cyst-like areas.

**TREATMENT CONSIDERATIONS**

The size of and destruction caused by the tumor determine the type of treatment. Giant cell tumors of bone have a recurrence rate between 5 and 30 percent. Radical curettage with exteriorization of the lesion and adjuvant treatment with phenol or liquid nitrogen and cementation (placement of methyl methacrylate) may reduce the recurrence rate of giant cell tumors.

According to reports by several groups, long-term results after giant cell tumor removal show a worse outcome with cementation when it is placed next to the articular cartilage. For this reason, many centers advocate placing bone graft adjacent to the articular cartilage with or without cement in the rest of the defect. For recurrent lesions or articular destruction, extensive joint reconstruction or joint replacement may be required.
CASE STUDY: THE FOLLOW-UP IMPERATIVE

H.C. is a 35-year-old woman who had a giant cell tumor of bone removed at an outside institution. She came to Cleveland Clinic for follow-up several years after that index surgery. She had noted a subtle increase in pain, and radiographs revealed lytic lesions in the distal tibia (Figure 2), so we obtained MRIs based on concerns about the degree of bone resorption in her distal tibia. The MRIs revealed what appeared to be a recurrence of her giant cell tumor with aneurysmal bone cyst components (Figure 2).

She was taken to the operating room, where a frozen section confirmed the giant cell tumor recurrence. The tumor was curetted, phenol was placed on the edges of the bone in the area of the lesion, and demineralized cortical bone powder was added. She is now back on her feet after the surgery. This case underscores the need for follow-up after giant cell tumor curettage and illustrates some common aspects of the treatment of these aggressive but benign lesions.

ABOUT THE AUTHORS

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Figure 2. Radiographs and MRIs of the case patient H.C. after presentation several years after removal of a giant cell tumor of bone. The radiographs on the top reveal two lytic lesions within the lateral aspect of the distal tibia. The MRIs on the bottom show recurrence of her giant cell tumor with aneurysmal bone cyst components.

Homing in on a Rare Giant Cell Tumor of Bone — Cherubism — in a Novel Clinical Trial

We became interested in a very rare form of giant cell tumor of bone called cherubism when a patient with this entity presented to our clinic. He had a mandibular jaw tumor, and we found that he also had a novel heterozygous mutation in a restricted six-amino acid region (415-420) of the Src homology 3 binding protein 2 gene (SH3BP2), which encodes a widely expressed adapter protein.

The specific timing and localized expression of cherubism indicates that it is a unique and novel model of human osteoclastogenesis, bone resorption and osteopenia, so we have developed a research program aimed at the mechanism involved in the formation and treatment of these specific giant cell tumors.

We have discovered a novel mechanism of bone resorption in these tumors and are interested in recruiting patients for a clinical trial that is registered at clinicaltrials.gov (identifier: NCT01916772). For more information about this trial, contact Dr. Lietman at 216.445.2742.

Figure 2. Radiographs and MRIs of the case patient H.C. after presentation several years after removal of a giant cell tumor of bone. The radiographs on the top reveal two lytic lesions within the lateral aspect of the distal tibia. The MRIs on the bottom show recurrence of her giant cell tumor with aneurysmal bone cyst components.
Care of the Senior Athlete:
Age-Tailored Management to Improve Strength, Endurance, Flexibility, Performance

By Alfred Cianflocco, MD

Older adults tend to be less active as a group, but many remain or choose to become active, as evidenced by the increasing popularity of the National Senior Games. These highly motivated athletes require guidance on training, injury prevention and care, and performance. This article outlines principles that inform the management of older athletes by Cleveland Clinic Sports Health providers.

AGING, PHYSIOLOGIC CHANGE AND EXERCISE

The effects of aging on the musculoskeletal, cardiovascular, pulmonary, hematologic, neurologic and metabolic systems can all impact the ability to exercise. Musculoskeletal changes alone decrease muscle mass, bone mass and tensile strength in ligaments and tendons; stiffen muscles, tendons and ligaments; and weaken articular cartilage.

Aging alone does not account for all these changes; a decline in physical activity is also responsible. Many age-related changes faced by senior athletes can be limited, reversed or prevented, allowing athletes to continue to exercise.

The slow, progressive decline in athletic performance with aging accelerates after age 60. Contributing factors include:

• Increasingly prevalent medical conditions
• Musculoskeletal conditions and injuries
• Longer recovery from training sessions
• Hormonal changes influencing exercise response
• Changes in motivation
• Lack of time for training/suboptimal training

RISKS IN THE OLDER ATHLETE

Musculoskeletal injury. Injury risks increase among senior athletes with previous joint injuries, underlying osteoarthritis, or sensory impairment from altered proprioception, vestibular function, vision or hearing.

When the Senior Athlete Needs Surgery: Challenges Beyond the OR

By Thomas Anderson, MD

An 80-year-old male tennis player presents with a torn rotator cuff in his dominant arm. How do you manage him?

Because many senior athletes are highly goal-driven individuals focused intently on return to competition, managing their expectations is often central to managing their overall care, especially if surgery is required. Many of the issues involved in managing a rotator cuff tear in an elderly tennis player apply to other senior athletes regardless of their sport or particular injury.

EARLY CLINICAL MANAGEMENT MAY BE THE EASY PART

The first step is to assess the tear and look for atrophy of the supraspinatus or infraspinatus muscles, which is best done via MRI. If there is no atrophy, physical therapy can be tried to see if other muscles can substitute for the supraspinatus. This is best accomplished with Blackburn or Hughston exercises, which work the intact portion of the rotator cuff without aggravating any subacromial bursitis. If these techniques do not adequately help, surgery may be necessary.

The surgical procedure may be open or arthroscopic, depending on the surgeon. It may involve single-row or double-row suturing — neither offers a significant advantage over the other. What’s needed is simply to get the tendon to heal down to the bone again. In general, the surgeon should use the technique in which he or she is most proficient.

POSTSURGICAL REHAB IS KEY

The most important part of management is postoperative rehabilitation. Range of motion is the first priority and is strived for during the initial five or six weeks of physical therapist-guided therapy. Resistance exercises are then added to gradually stimulate tendon healing and resume muscle use. This gradual increase is best guided by pain: Lots of reps are recommended to stimulate tendon healing and muscle use, but they should be light enough to not cause any pain. This regimen gradually builds up the shoulder’s strength and endurance.
Overuse injuries are more common due to a longer recovery time and training errors. Aggravation of lumbar disk disease and osteoarthritis are common, as are the following injuries:

- **Muscle strains.** These are the most common injury type seen with aging. They tend to occur acutely, especially in strength and power sports, due to increased muscle stiffness.

- **Tendinopathy.** The patellar tendon, rotator cuff and Achilles tendon are common sites. Age-related decreases in tendon flexibility and tensile strength, degenerative changes with repetitive loading, and decreases in blood supply are predisposing factors.

- **Degenerative meniscal tears with osteoarthritis of the knee.** These are often seen together. Meniscal tears can occur with minimal trauma in arthritic knees, contributing to osteoarthritic progression.

**Temperature-related illness.** Age-related physiologic changes make adaptation to temperature changes harder. During exercise, older athletes are more prone to:

- **Heat illness** — from an increased risk of dehydration, a decrease in sweat gland function, impaired increase in skin blood flow with elevated core temperatures, or the effects of common medications (e.g., beta-blockers, diuretics)

- **Cold injury** — from an impaired perception of ambient temperature and vasoconstrictor response, autonomic dysfunction, and a decreased capacity for thermogenesis through shivering
Studies demonstrate delayed healing of musculoskeletal injuries in older adults, but these patients can respond to active and progressive rehabilitation.

**CARE OF MUSCULOSKELETAL INJURIES**

Initial management of musculoskeletal injuries — protection, rest, ice, compression and elevation — is the same for all ages. For both older and younger athletes, delayed evaluation and treatment can result in injury chronicity, delayed recovery and unnecessary time lost from the sport or activity. Appropriate treatment for musculoskeletal sports-related injuries does not stress an aging body.

Studies demonstrate delayed healing of musculoskeletal injuries in older adults, but older adults can respond to active and progressive rehabilitation. Relative rest and activity modification — avoiding total inactivity, which can lead to cardiac deconditioning and loss of flexibility, strength and bone mass — are key.

Physical therapy (focusing on range of motion, flexibility, strength and proprioception) and alternative training methods are essential to a safe, timely return to activity. Fewer than 5 percent of musculoskeletal injuries require surgery (see sidebar, pages 18-19).

**MEDICAL EVALUATIONS**

Medical evaluations before athletic participation are based on age, underlying health problems and plans for activity. The major objectives are to identify:

- Underlying medical conditions that may limit the ability to exercise or increase the risk of significant medical events with activity
- Musculoskeletal or other medical issues, such as balance or vision problems, that could limit participation or increase injury risks

**A PREMIUM ON PREVENTION**

Injury prevention may be more important for senior than for younger athletes, but prevention guidelines are similar. Strength, flexibility and neurophysiologic capacities should be ensured prior to the activity. Activities that may aggravate an underlying condition, such as high-impact exercise in athletes with osteoarthritis of the spine or lower extremities, should be modified or avoided.

Surface conditions cannot be overlooked; soft surfaces can reduce impact on lower extremities, while uneven surfaces place senior athletes with balance problems at risk.

The basics of injury prevention apply to athletes of all ages and include:

- Proper warm-up with adequate cool-down after activity
- Avoidance of abrupt changes in activity frequency, duration and intensity
- Allowance for adequate recovery by alternating days of intense activity with less strenuous activity
- Adjusting for environmental conditions such as temperature and humidity

Age-related physiologic changes can impact nutritional and fluid requirements as well as the ability to meet these needs. Proper nutrition and hydration are key to optimal performance for all athletes.

By applying many of the same training and injury prevention and management guidelines used for younger athletes, sports medicine providers can, with a few special considerations, help senior athletes continue to compete optimally and safely.

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Spinal Deformity in Adults: More than Managing ‘Big Kids’

By R. Douglas Orr, MD

To many people, spinal deformity is synonymous with adolescent idiopathic scoliosis (AIS). Although this is the case in younger age groups, spinal deformity is much more varied and complex in adulthood. This article reviews the special challenges of managing spinal deformity in adults and some principles and approaches we have found effective in managing these cases at Cleveland Clinic.

REAL DIFFERENCES IN ADULTS

The management of AIS centers around curve measurements and involves predominantly the thoracic spine. Pain, though sometimes present, is not a major feature in management. In contrast, in adult deformity we are concerned mostly with the lumbar spine, and pain is the dominant presenting complaint. Curve magnitude and progression generally do not constitute an independent indication for treatment, and there is no role for bracing in the adult population.

Adult spinal deformity can develop via a number of processes, including:

• De novo deformity due to degenerative change
• Development of symptoms from treated or untreated AIS
• Deformity secondary to trauma
• Iatrogenic deformity resulting from prior surgery

Decision-making in spinal deformity management is often highly complex and involves weighing a host of treatment approaches and options. In some cases the deformity is incidental to the presenting problem, whereas in others the deformity is a major cause of symptoms.

ALL ABOUT BALANCE

There is a wide variation in what is considered “normal” spinal alignment. The human body goes to great lengths to maintain the head’s position directly over the pelvis in both the frontal and sagittal planes. This allows standing and walking to be done with minimal energy expenditure. We call this spinal balance, and in adults with deformity it is the single most important factor in treatment options and patient-perceived outcome. Patients who are balanced have fewer symptoms and a higher level of function before and after treatment. A primary treatment goal is balance maintenance or restoration.

ASSESSMENT AT A GLANCE

The first step in assessing the adult with spinal deformity is to identify the dominant presenting complaint. Many patients are unaware that they have a deformity and usually want information on natural history and activities to be avoided or encouraged. Patients most often present complaining of pain. In these cases it is important to get a clear description of the pain and attempt to determine its cause.

Patients with spinal deformity are subject to the same sorts of aging-related spine problems as the general population. Most acute back pain in these patients is muscular and self-limiting. Likewise, herniated disks and spinal stenosis can occur in the presence of spinal deformities.

In adults with deformity, spinal balance is the single most important factor in treatment options and patient-perceived outcome.

Obtaining a history of the pattern of pain — including onset, location, exacerbating and alleviating factors, and response to treatments to date — often leads to a presumptive diagnosis. The physical examination should include a neurologic exam as well as assessment of spinal alignment, motion and balance. Hip and knee exams are also often important.

In the acute setting, the indication for imaging is the same as in a patient without deformity. In the absence of red flags, imaging is not indicated at first presentation. When indicated, imaging should begin with standing X-rays in both the antero-posterior and lateral planes, ideally including the entire spine from occiput to hip joints. Advanced imaging, such as MRI or CT, is indicated for assessing the neural axis and for surgical planning, and CT may be useful for assessing the status of a previous fusion (see “Case study” sidebar, page 23).
INITIAL THERAPY: NO SPECIAL MEASURES NEEDED
Whereas surgery is often considered prophylactic in AIS, there is little or no role for prophylactic surgery in adult deformity. In asymptomatic cases, education (and sometimes observation) is the mainstay of therapy. Initial treatment of back or leg pain in an adult with a deformity is usually no different than in a person with normal alignment. Acute back pain should be treated with NSAIDs, mobilization and core-strengthening exercise. Acute radicular pain is managed expectantly, as most cases will resolve. Claudicant leg pain is managed with exercise, activity modification and medications, and possibly with interventional therapies such as epidural injections.

Essentially, the spinal deformity becomes a factor in treatment only after the appropriate conservative care has failed and surgery is being considered.

SURGERY IS GUIDED BY THE DEFORMITY’S ROLE IN PAIN
When appropriate nonoperative management has failed and surgery is being considered, the first step is to determine what role, if any, the deformity plays in causing the pain. A patient with a balanced, stable scoliosis with sciatica due to a herniated disk may do very well with just a microdiscectomy. On the other hand, a patient with a fixed deformity who is unable to stand with head balanced over hips will not benefit from an operation that does not restore balance.

If the dominant symptoms result directly from the deformity, surgery must address the deformity. In general, a patient who is no longer in balance will need to have the deformity corrected and stabilized. These are generally very complex major procedures with significant risks and a prolonged recovery. In some medically fragile patients, the risks of surgery to correct deformity are simply too high for it to be a viable option.

LIMITED PROCEDURES: DON’T BELIEVE ALL YOU WERE TAUGHT
Many surgeons were taught that limited surgery has no role in cases of deformity and that an all-or-nothing approach is needed. I no longer believe this, as I see a role for limited surgery in certain appropriate situations. In a patient with a balanced spine in whom the pain generator can be localized, there is a role for focal surgery to address just this problem. For example, in a patient with spinal stenosis, a degenerative spondylolisthesis and a balanced degenerative scoliosis, treatment of just the stenosis and spondylolisthesis may be a very good option.

TAILOR THE MULTIPLE TECHNIQUE OPTIONS
Surgery to correct spinal deformity is a highly complex undertaking that many surgeons opt not to offer as part of their practice. These operations generally involve long incisions and extensive instrumentation to correct and stabilize the spine. Many different techniques can be used, with no single technique appropriate for all situations. Anterior, posterior, combined and minimal-access approaches may be used, and each surgeon should employ the techniques he or she performs best for the given clinical situation. Outcomes studies show that as long as a balanced, stable spine is achieved, outcomes are equivalent regardless of technique.

Less-invasive techniques have attracted much interest in recent years, and some show a lot of promise. In other cases, less-invasive techniques have produced inferior results compared with standard techniques and are no longer used. No studies have directly compared newer approaches to traditional ones. Overall, it appears that minimal-access techniques shorten recovery time but have not shown a benefit over the longer term. These techniques are often a very good option in selected patients, and their role in treating spinal deformity continues to evolve.

THE STAKES OF PROPER MANAGEMENT ARE HIGH
There is a wide range of potential treatment options for spinal deformity in adults, and no single approach works for all problems. Patients with symptomatic spinal deformity should seek a clinician with experience in treating these problems — ideally one who can provide the full range of treatment options. An inappropriate initial surgical choice carries a significant risk of worsening the deformity. It is not uncommon for patients to undergo multiple procedures to treat a deformity even at the most experienced centers. While spinal deformity can lead to debilitating pain, its successful treatment can dramatically change patients’ quality of life.

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Case Study in Adult Deformity

A 75-year-old man presented eight years after an L2-3 posterior fusion with increasing axial back pain, neck pain, L5 radiculopathy and inability to stand upright. Pain had progressed over five years to the point that he was unable to stand for more than a few minutes and was unable to walk more than 50 yards using a walker.

Lumbar X-rays (Figure 1) showed a degenerative scoliosis and a focal kyphosis above the fusion. Sagittal CT imaging (Figure 2) showed solid fusion from L2 through L5 and a vacuum effect change in the disk spaces at L1-2 and L5-S1.

The patient underwent an anterior interbody fusion at L5-S1, a pedicle subtraction osteotomy at L2 (Figure 3), and a T10-ilium posterior instrumentation and fusion. Good balance was achieved, as shown in Figure 4. Six months after surgery he had no pain in his back or neck, and his radiculopathy had resolved.
High Interest in Debut Musculoskeletal Ultrasound Workshop Promises Expanded Offerings Ahead

When Michael P. Schaefer, MD, talks with colleagues about musculoskeletal ultrasound, one aspect that frequently comes up is its ability to perform dynamic assessment.

“Almost all other imaging modalities show only a static picture, but with musculoskeletal ultrasound, we can see the structure of interest in motion,” he says. “And if there’s a catch or a pop or a click, we can often correlate that with whatever structure is abnormal. That’s something that stands out for a lot of practitioners.”

Besides these dynamic capabilities, Dr. Schaefer thinks ultrasound’s affordability and portability are important reasons for the high level of interest in the inaugural offering of Cleveland Clinic’s Musculoskeletal Ultrasound Workshop in May, for which he served as course director.

The half-day CME-certified course — which featured a generous offering of live scanning and hands-on lab sessions — reached maximum registration a couple of months in advance, drawing more than 70 attendees from across Ohio and from states as far away as Georgia. The interest has led to plans to offer the workshop on an annual basis and to expand its length and curriculum.

**A HUNGER FOR TRAINING**

“We were hoping to fill a void in musculoskeletal ultrasound education in the Northeast Ohio region,” explains Dr. Schaefer, who is Director of Musculoskeletal Rehabilitation with a joint appointment in the Department of Orthopaedic Surgery and the Neurological Institute's Department of Physical Medicine and Rehabilitation.

“There’s a well-established need for education in musculoskeletal ultrasound,” he says. “Many people were asking for one-on-one mentoring or other learning opportunities, so we decided to bring together our own top experts in ultrasound as it relates to the musculoskeletal system so we could educate a lot of providers in a single setting.”

**MULTIDISCIPLINARY FACULTY AND ATTENDEES**

Those experts came from a broad range of specialties at Cleveland Clinic — orthopaedics, rheumatology, physiatry, sports health and neurology — and from locations as far afield as Cleveland Clinic Florida. The workshop’s multidisciplinary faculty is one factor that distinguishes it among the handful of musculoskeletal ultrasound courses offered by other institutions, says Dr. Schaefer. “For instance, we had a neurologist, Steven Shook, MD, demonstrating ultrasound of the peripheral nerve, one of the more challenging applications, so that was an important and distinctive contribution.”

Attendees were similarly varied, with significant numbers of orthopaedists, physiatrists and rheumatologists, among others. An informal poll of the audience found that two-thirds were not yet using ultrasound in their practice, and most of the rest had been using it for less than two years. “Probably more than half of practices treating musculoskeletal conditions have an interest in developing ultrasound,” Dr. Schaefer says.

**FROM THE BIG PICTURE TO HANDS-ON LEARNING**

The workshop covered the following applications:

- Using ultrasound to do bedside diagnosis — everything from detecting a rupture in a tendon to measuring the size of a nerve to elucidate possible disease processes
- Longitudinally monitoring structures of interest throughout a course of therapy
- Assessing inflammatory changes using the Doppler feature
- Guiding needles for injections

Instruction was offered in multiple formats. Lectures provided critical reviews of the newest techniques and devices. Demonstration sessions revealed sonographic findings in common pathologies. Sessions at lab stations, offered in intimate groups of four or five attendees, presented hands-on opportunities to do everything from scanning multiple joints on live models to attempting a saline injection within a deep joint capsule to optimizing machine settings for diagnostic and interventional techniques.
Cleveland Clinic Launches Musculoskeletal Medicine Fellowship

The ultrasound workshop isn’t Cleveland Clinic’s only new educational offering in musculoskeletal medicine. A new one-year Musculoskeletal Medicine Fellowship was launched in July 2013 through Cleveland Clinic’s Orthopaedic & Rheumatologic Institute, with physiatry/physical medicine and rehabilitation (PM&R) as the primary specialty in which candidates are recruited.

“There’s been a move within PM&R toward more musculoskeletal care, and this fellowship reflects that,” says Michael P. Schaefer, MD, the fellowship’s director. “I’ve designed this fellowship to be practical for a physiatrist in real-world practice or a primary care specialist who wants to do more musculoskeletal care.”

An important part of that, he adds, is the “regular and systematic exposure” to musculoskeletal ultrasound that the fellowship provides, including dedication of one day a week to bedside ultrasound. “This is more exposure than in any other fellowship I know of,” says Dr. Schaefer.

The program also provides the fellow with much practical interaction with orthopaedic surgeons through rotations in orthopaedic clinics. “Side-by-side training with orthopaedists is necessary to really gain understanding of the surgical options available, the indications for them, and what's needed for postsurgical follow-up and outcome assessment,” says Dr. Schaefer. “We see the growth in musculoskeletal medicine fostering a greater partnership between physiatrists and orthopaedic surgeons, with surgeons relying more on physiatrists for initial evaluation and management of chronic musculoskeletal disease.”

The fellowship accepts one candidate per year. Those interested in applying may contact Dr. Schaefer at schaeferm5@ccf.org.
Orthopaedic Residency Update

By Thomas E. Kuivila, MD

In his magnum opus *The Complete Walker*, Colin Fletcher, personal hero, weaver of ornate prose, purveyor of sage backpacking advice and father of the modern wilderness backpacking tradition, reflects on a moment of inspiration from his prehiking days. He recalls witnessing two hikers emerge “all at once, quite without warning” from impossibly dense and rugged wilderness. They were “weatherbeaten and distilled to bone and muscle. But what I remember best of all is that they were happy and whole. Whole and secure and content.”

What is this if not the perfect allegory of what our residents become in their time at Cleveland Clinic? Transitioning from naïve and oft-cherubic medical students to raw-boned, confident and skilled orthopaedic surgeons. Distilled to the essence of what one needs to practice orthopaedic surgery in an increasingly complex and regulated medical environment. And hopefully, at long last, secure and content in their skills and path.

**SENDING OFF OUR RESIDENCY GRADS**

At our residency graduation dinner in June, we strove to add some weight back to the chiseled cheeks of our graduates as we bade *au revoir* to six outstanding young orthopaedic surgeons:

**David Ebenezer, MD**, a graduate of the six-year orthopaedic residency track, continued to eschew his Southern California roots as he traveled to Vanderbilt University in country music-ville to begin a yearlong fellowship in children’s orthopaedics.

**Nicholas Frisch, MD**, fresh-scrubbed Midwest farm boy, sought a change of venue and is happily ensconced at Sports, Orthopedic and Rehabilitation Medicine Associates in the San Francisco Bay area as a fellow in orthopaedic sports medicine.

**David Joyce, MD**, also a graduate of the six-year residency track, set off, like Ebenezer, to Vanderbilt, where he is a fellow in orthopaedic traumatology. Because of his broad interests, or perhaps because he’s a bit of a masochist, in July he begins another fellowship year in musculoskeletal oncology at the Moffitt Cancer Center at USF before looking for a real job.

**Nathan Mesko, MD**. I am not just cutting and pasting when I relay that Dr. Mesko is also now a fellow at Vanderbilt. Not sure if he and “the Davids” got a buy-two, get-one-free deal. Nate is spending a year as a musculoskeletal oncology fellow there. We’ve successfully recruited him to return to Cleveland Clinic next August to ply his diligently acquired operative skills here.

**David Schub, MD**, former East Coast hipster, has bought into the whole West Coast thing, first with a Prius and then by taking his talents to California. Dave is now a fellow in orthopaedic sports medicine at Santa Monica Orthopaedic and Sports Medicine Group.

**Thomas Wuerz, MD**, formerly the Euro hipster of the class, has packed up his fine loafers and headed to the fashion-friendly streets of Chicago to begin his fellowship in orthopaedic sports medicine at Rush University Medical Center.

**A FRESH STELLAR CLASS ARRIVES**

In the 2012-13 interview cycle, we again topped 700 applicants, of whom we interviewed 72 and ranked 60. We were delighted to then match six outstanding individuals with fantasy-like curricula vitae from our top 11 ranking positions. We are proud to welcome the Orthopaedic Residency Class of 2018:

**Kevin Bigart, MD**, Case Western Reserve University

**Reid Chambers, DO**, Chicago College of Osteopathic Medicine

**Jason Ho, MD**, Cleveland Clinic Lerner College of Medicine

**Jennifer Peterson, MD**, University of Virginia

**Rachel Randall, MD**, Cleveland Clinic Lerner College of Medicine

**Timothy Wagner, MD**, George Washington University

If their accomplishments and academic credentials are any measure of future success, we remain in good shape indeed. This also marks the first time in orthopaedic residency history that we have matched two women into a single class!

We’re also happy to welcome back a Class of 2012 resident as a staff surgeon. After finishing a fellowship in adult reconstructive surgery at Thomas Jefferson University, **Michael Bloomfield, MD**, has joined our busy Center for Adult Reconstruction.

Today’s pace of change in medicine is as swift as at any time in history. As we are called on to do more with less, we all might benefit from distilling our spirit back to that which lured us into orthopaedics in the first place. The Persian proverb that “fortune is infatuated with the efficient” is perhaps more true now than when it was penned more than a thousand years ago.

**ABOUT THE AUTHOR**

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In 2013, Cleveland Clinic was ranked one of America’s top 4 hospitals in U.S. News & World Report’s annual “America’s Best Hospitals” survey. The survey ranks Cleveland Clinic among the nation’s top 10 hospitals in 14 specialty areas, and the top in heart care for the 19th consecutive year.

Orthopaedic Insights is published by Cleveland Clinic’s Department of Orthopaedic Surgery to inform musculoskeletal specialists about advances in diagnosis, medical and surgical management, and research.

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The Orthopaedic & Rheumatologic Institute brings together physicians, researchers and engineers to pursue excellence and innovation in the care of patients with joint, bone, muscle, connective tissue and immune disorders. The Orthopaedic & Rheumatologic Institute is one of 27 institutes at Cleveland Clinic, a nonprofit academic medical center ranked among the nation’s top hospitals (U.S. News & World Report), where more than 3,000 physicians and researchers in 120 specialties collaborate to give every patient the best outcome and experience.

Orthopaedic Insights is written for physicians and should be relied on for medical education purposes only. It does not provide a complete overview of the topics covered and should not replace a physician’s independent judgment about the appropriateness or risks of a procedure for a given patient.

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A profile of active externally funded clinical and basic research in orthopaedics at Cleveland Clinic. Funding totals indicate total dollars of all currently active grants.

- **65** active research projects with external funding
- **23** active extramural NIH research projects
- **$24.12m** in NIH funding
- **$7.7m** in other federal government support (NASA, DOD, VA, etc.)
- **$11.4m** in state government support
- **$1.16m** in foundation support
- **$3.2m** in industry support