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Orthopedic Update

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The Role of Device Development in the Mayo Clinic Approach to Improving Elbow Surgery

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INSIDE THIS ISSUE

As one of the recognized leaders in elbow surgery, Mayo Clinic Department of Orthopedic Surgery strives in multiple ways to continually improve the field. It offers advanced, hands-on training fellowships, conducts rigorous research that is quickly translated into patient care, and develops patented new surgical devices and techniques.

A key strategy behind Mayo Clinic device design is to offer practical, user-friendly solutions to persistent problems. This approach was inspired, in part, by the experience that orthopedic surgeon and elbow specialist Shawn W. O'Driscoll, MD, PhD, had with photography during the point-and-shoot revolution in cameras. Point-and-shoot technology has greatly simplified the process of picture taking—yet still produces high-quality results.

"The point-and-shoot approach has taught us that highly sophisticated technology can be used well by the general population when it is coupled with a simplified method," Dr O'Driscoll explains. "Some of that same philosophy is now applied to making elbow arthroscopy more user-friendly and safe for more surgeons."

Notes Bernard F. Morrey, MD, a Mayo Clinic orthopedic surgeon who specializes in biomechanics and motion analysis: "Reconstruction and complicated elbow arthroscopy are generally performed at tertiary referral centers—but there are a limited number of those. If patients can't reach these centers, they are at risk of not receiving the best or most timely care."

Three examples of novel Mayo Clinic–designed elbow surgery devices demonstrate the role of invention in improving elbow surgery.

Elbow Arthroscopy: Adapting Familiar Instruments

Arthroscopy is especially challenging in the elbow because of the risk of cutting nerves while maneuvering in a small, tightly constrained space. To simplify elbow arthroscopy, Dr O'Driscoll developed an approach using retractors to facilitate visualization and create a space in which to work inside the elbow. This new elbow arthroscopy tool is versatile and can be used in multiple ways, depending on the disorder (Figure 1).

Figure 1. *Arthroscopic retractors permit new complex surgical procedures to be performed safely inside the elbow.*

Shawn W. O'Driscoll, MD, PhD

Bernard F. Morrey, MD

Radial Head Replacement: Overcoming Guesstimates

Radial head replacement surgery is another challenging elbow surgery procedure. "Before the introduction of our devices, we used to guesstimate how high or long the radial head replacement should be. The challenge was how to decide the right height—a great uncertainty for many surgeons," Dr O'Driscoll explains. The prosthetic replacement head and special instruments (Figure 2) for determining the optimal position of the replacement head were both developed by Dr O'Driscoll.

As with the point-and-shoot influence on elbow arthroscopy, a familiar experience guided improvements in radial head replacement: "It's basically the same method that an automechanic uses, a feeler gauge, to set the gap on a car's spark plug," Dr O'Driscoll says.

Fracture Fixation: Plates Guide Orientation

Achieving better fixation and rehabilitation of fractures to the distal humerus, olecranon, and coronoid process through the correct orientation and stability of fragments is another problem that patented Mayo devices have helped overcome. Mayo Clinic Congruent Elbow Plates optimize positioning and stabilize fracture repair. Stability is enhanced by applying the structural principles used in building an arch (Figure 3).

As a result of these and other devices, select elbow repairs have been improved and more widely adopted. Says Dr Morrey: "Developing new devices and disseminating best-practices techniques is just one more way we at Mayo Clinic put the needs of the patients first."

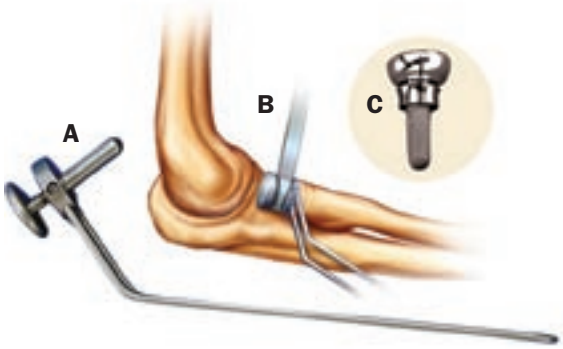


Figure 2. *Prosthetic replacement head and special instruments developed by Dr O'Driscoll for determining the optimal position of the replacement head. A, Neck length gauge. B, Feeler gauge. C, Point-and-shoot anatomic radial head.*

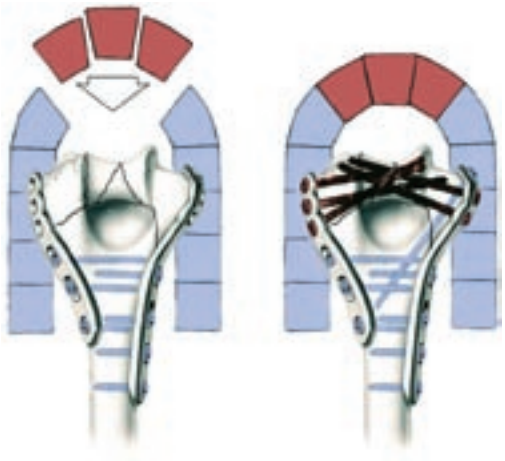


Figure 3. *The stability provided by Mayo Clinic Congruent Elbow Plates is enhanced by applying the structural principles used in building an arch.*

Endocrine Evaluations Integrated Into Consults at Mayo Clinic Musculoskeletal Center

As baby boomers enter the ranks of the elderly, fall-related fragility fractures will become more prevalent, such as those to the distal aspect of the radius or proximal hip. In addition to being a common presentation, fragility fractures may also have predictive value in postmenopausal women at risk for sustaining future fractures.

Despite this well-documented demographic trend and women's increased risk of fractures, most women as they age do not take bone health into consideration when establishing wellness regimens and seeking routine care. Indeed, in a study of 1,162 postmenopausal women, only 24% of women aged 55 years or

Richard A. Berger, MD, PhD

Bart L. Clarke, MD

older who sustained a distal radial fracture over a 3-year period had been evaluated or treated for osteoporosis. Although less well studied, aging men are at risk of fragility fractures, too. These data suggest a tremendous opportunity exists for improving patient service through multidisciplinary collaboration of orthopedic and hand surgery teams with endocrinologists to assure postfracture assessment for osteoporosis or other metabolic bone disease (Figure).

Opportunity for Excellence

Integrated multidisciplinary care is routine at Mayo Clinic's W. Hall Wendel, Jr Musculoskeletal Center. Together, collaborators can identify this "silent" disease of osteoporosis before bone loss is disabling and the fractures become progressively more serious, such as those of the hip, or chronically recurring events.

"By screening fracture patients for osteoporosis and other metabolic bone diseases to identify those at risk and provide early treatment, musculoskeletal teams can play a pivotal role in keeping people healthy and active longer," explains Mayo Clinic hand surgeon Richard A. Berger, MD, PhD. Adds his colleague, Mayo Clinic endocrinologist Bart L. Clarke, MD: "Every patient who has a fracture treated at Mayo Clinic should be seen by an endocrinologist for postfracture assessment for osteoporosis or other metabolic bone disease. Our hope is to identify these cases early, address the disease, and prevent future fractures." Dr Clarke notes that referrals have increased steadily over the past decade as awareness of osteoporosis has heightened, and medications for bone loss have become available. The center is organized to accommodate this increase.

The Collaborative Advantage

Mayo Clinic's W. Hall Wendel, Jr Musculoskeletal Center provides seamless collaboration between the 12 specialists of the Hand Clinic, orthopedic surgeons, the 9 metabolic bone disease specialists in the Division of Endocrinology, Diabetes, Metabolism, and Nutrition, and many other specialists, including those involved in rehabilitation and aftercare. The physical design and layout of the center eliminates the need to travel long distances between offices, laboratories, and imaging and surgery suites. Inpatient and outpatient surgical procedures are offered.

A postfracture work-up typically involves a comprehensive consult that includes taking a general medical history; documenting a history of fractures or osteoporosis in the family; a bone mineral density evaluation; and a review of medications that might affect bone strength and put the patient at risk for osteoporosis. Laboratory analysis of blood and urine may be performed to further evaluate bone physiology. In addition to osteoporosis, the orthopedics-endocrinology teams look for Paget disease, osteomalacia, primary hyperparathyroidism, and rare conditions such as osteogenesis imperfecta.

Figure. *This significantly displaced and comminuted distal radius fracture occurred in a patient with osteoporosis who simply tripped and fell from a standing height. In a nonosteoporotic patient, this type of fracture would most likely occur in a higher energy situation like a motor vehicle accident or a fall from a rooftop.*

Mayo Clinic Orthopedics Scholarship

A Review of Some Influential Articles of 2008

Shoulder

Results of two-stage re-implantation for infected shoulder replacement. *Journal of Bone & Joint Surgery* British Volume 2008;90(4):460-5. JP Strickland, JW Sperling, RH Cofield.

Shoulder hemiarthroplasty for acute fractures of the proximal humerus: a minimum five-year follow-up. *Journal of Shoulder & Elbow Surgery* 2008;17(1):126-31. JE Adams, LH Wolff 3rd, SM Merten, SP Steinmann.

Elbow

Primary osteoarthritis of the elbow: current treatment options. *Journal of the American Academy of Orthopaedic Surgeons* 2008;16(2):77-87. EV Cheung, R Adams, BF Morrey.

Complications of hinged external fixators of the elbow. *Journal of Shoulder & Elbow Surgery* 2008;17(3):447-53. EV Cheung, SW O'Driscoll, BF Morrey.

Hand and Wrist

What's new in hand surgery. *Journal of Bone & Joint Surgery* American Volume 2008;90A(2):453-7. PC Amadio.

Diagnostic comparison of 1.5 Tesla and 3.0 Tesla preoperative MRI of the wrist in patients with ulnar-sided wrist pain. *Journal of Hand Surgery* 2008;33(7):1153-9. ML Anderson, JA Sinner, JP Felmlee, RA Berger, KK Amrami.

Spine

Relationship of the internal carotid artery to the anterior aspect of the C1 vertebra: implications for C1-C2 transarticular and C1 lateral mass fixation. *Spine* 2008;33(6):635-9. BL Currier, TP Maus, JC Eck, DR Larson, MJ Yaszemski.

Ischial spine projection into the pelvis. *Clinical Orthopaedics & Related Research* 2008;466(3):677-83. F Kalberer, RJ Sierra, SS Madan, R Ganz, M Leunig.

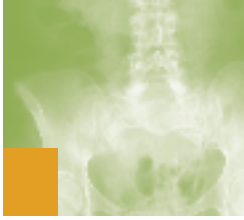
Hip

Modes of failure of Osteonics constrained tripolar implants: a retrospective analysis of forty-three failed implants. *Journal of Bone & Joint Surgery* Series A 2008;90(7):1553-60. O Guyen, D Lewallen, ME Cabanela.

Slower recovery after two-incision than mini-posterior-incision total hip arthroplasty: a randomized clinical trial. *Journal of Bone & Joint Surgery* American Volume 2008;90(5):1000-6. MW Pagnano, RT Trousdale, RM Meneghini, AD Hanssen.

Knee

Patient-reported activity level after total knee arthroplasty. *Journal of Arthroplasty* 2008;23(3):401-7. DL Dahm, SA Barnes, JR Harrington, SA Sayeed, DJ Berry.



Use of porous tantalum metaphyseal cones for severe tibial bone loss during revision total knee replacement. *Journal of Bone & Joint Surgery* American Volume 2008;90A(1):78-84. RM Meneghini, DG Lewallen, AD Hanssen.

Foot and Ankle

Management of distal tibial medial malleolus type-6 physeal fractures. *Journal of Children's Orthopaedics* 2008;2(2):151-4. S Parratte, MW Pagnano.

Synovial chondromatosis of the foot and ankle. *Foot & Ankle International* 2008;29(3):312-7. DD Galat, DB Ackerman, D Spoon, NS Turner, TC Shives.

Infection Control

Midterm to long-term followup of staged reimplantation for infected hip arthroplasty. *Clinical Orthopaedics & Related Research* Epub ahead of print: http://www.springerlink.com/content/j587h23406w20j15/ J Sanchez-Sotelo, DJ Berry, AD Hanssen, ME Cabanela.

Microbiology and risk of infection following open, agricultural upper extremity injuries. *Journal of Hand Surgery* 2008;33(1):87-93. MH Ali, NA Hoekzema, M Bakleh, AY Shin, DR Osmon.

Sports and Trauma

Arthroscopic repair of isolated meniscal tears in patients 18 years and younger. *American Journal of Sports Medicine* 2008;36(7):1283-9. AJ Krych, AL McIntosh, AE Voll, MJ Stuart, DL Dahm.

Medial approach for arthroscopic-assisted fixation of lateral tibial plateau fractures: patient selection and mid- to long-term results. *Journal of Orthopaedic Trauma* 2008;22(3):201-5. BA Levy, DA Herrera, P Macdonald, PA Cole.

Biomechanics and Imaging Research

3D reconstruction of the ribs from lateral and frontal X-rays in comparison to 3D CT-scan reconstruction. *Journal of Biomechanics* 2008;41(3):706-10. D Mitton, K Zhao, S Bertrand, CF Zhao, S Laporte, C Yang, KN An, W Skalli.

Ability of magnetic resonance elastography to assess taut bands. *Clinical Biomechanics* 2008;23(5):623-9. Q Chen, J Basford, KN An.

Biomaterials and Bioengineering

Characterization of porous injectable poly-(propylene fumarate)-based bone graft substitute. *Journal of Biomedical Materials Research* Part A 2008;85(4):1114-9. CW Kim, R Talac, L Lu, MJ Moore, BL Currier, MJ Yaszemski.

Methods for in vitro characterization of multichannel nerve tubes. *Journal of Biomedical Materials Research* Part A 2008;84(3):643-51. GC deRuiter, IA Onyeneho, ET Liang, MJ Moore, AM Knight, MJ Malessy, RJ Spinner, L Lu, BL Currier, MJ Yaszemski, AJ Windebank.

To learn more about Mayo Clinic's ongoing orthopedic research, visit mayoresearch.mayo.edu/mayo/research/ortho/index.cfm

Articular Cartilage Laboratory Focuses on Novel Regenerative Repair Techniques

Regenerative repair of articular joint cartilage is a long-sought goal of orthopedic researchers. Regenerative cartilage repair has enormous potential to improve the quality of life for people in pain and living with limited movement.

The Need for Alternatives

The limitations of current nonregenerative cartilage repair methods and the fact that replacing an injured joint is appropriate primarily for adults in their 60s and beyond are among the reasons research into tissue engineering–based repair strategies is a high priority at advanced orthopedic research centers such as Mayo Clinic.

"Cartilage repairs that blend a number of technologies hold great potential for improving the quality of life for many people. They can also decrease the long-term costs of health care related to joint replacement and the multiple revisions those replacements often entail," explains cartilage researcher and orthopedic surgeon Shawn W. O'Driscoll, MD, PhD.

Dr O'Driscoll leads the Cartilage and Connective Tissue Research Laboratory, which he established at Mayo Clinic in 1992 (see sidebar)."In the history of orthopedics, we are now in the era of biotechnology and tissue engineering, which includes cartilage repair. It's a timely development because when cartilage is damaged or diseased, it has a disabling effect and a huge public and private cost. We badly need new solutions."

Michael J. Stuart, MD, orthopedic surgeon and sports medicine specialist at Mayo Clinic, commonly sees cartilage injuries in the clinic, particularly in adolescents—a group for whom joint replacement is not an option. Subchondral bone microfracture, osteochondral autograft, and allograft transplantation are effective nonregenerative therapies, but durability of results, safety, and donor cartilage availability are important issues."We need better methods to restore hyaline articular cartilage that will provide long-term solutions for young patients," Dr Stuart says.

Research Highlights

Several promising cartilage repair projects are under way in the Cartilage and Connective Tissue Research Laboratory:

- **Tissue Engineering of Cartilage Using Periosteum** Periosteal grafts have been used successfully in biological resurfacing for the repair of damaged joint cartilage, but broader application is limited because cartilage growth potential of periosteum declines with patient age. Dr O'Driscoll and colleagues have successfully used tissue-engineering methods to boost cartilage growth in vitro and repair in vivo in rabbit models through pretreatment/rejuvenation of periosteum with known cartilage-inducing growth factors.
- **Mechanical Factors in Cartilage Repair**

Cartilage Repair

Shawn W. O'Driscoll, MD, PhD

A former president of the International Cartilage Repair Society (2002, 2003), Dr O'Driscoll has pursued cartilage research for more than 20 years. He is one of its most experienced investigators and a pioneer in the field of biological repair of cartilage. Dr O'Driscoll was the first in North America to develop the techniques for biological regeneration of articular cartilage in large defects and to grow cartilage from postnatal periosteal explants in vitro. In 1990, Dr O'Driscoll founded the Cartilage and Connective Tissue Research Laboratory at the University of Toronto. In 1992, he moved his laboratory to its current location at Mayo Clinic in Rochester, Minnesota.

Michael J. Stuart, MD

Mechanical factors are important in chondrogenesis required for fracture healing or cartilage repair. This project focuses on clarifying the relationship between mechanical factors and the stimulation of cartilage growth. It is based on the finding that continuous passive motion creates a sinusoidal oscillation in the intra-articular pressure and greatly enhances the quality of cartilage regeneration after periosteal transplantation.

- **Development of Biosynthetic Composites for Cartilage Repair** This project focuses on developing biosynthetic composites using periosteum and various porous scaffolds. When cultured under chondrogenic conditions or implanted in vivo, the composites form a robust hyaline-like cartilage outgrowth that is attached to the porous scaffold by fibrous tissue ingrowth. The mechanical properties of these composites are similar to normal osteochondral plugs after only 6 weeks in culture. These findings open the possibility of using rejuvenated periosteum combined with porous scaffolds for scaffold-based periosteal arthroplasty (Figure).

Other research projects are under way as well. Notes Dr O'Driscoll: "Our success will rely on a blending of technologies and advances in research that include molecular biology, tissue engineering, and understanding the control mechanisms of cellular processes. At the same time, we need to further develop scaffolding for the implants and the surgical approaches to implanting it in patients. To blend all this is very demanding—but possible."

For more information on other Mayo Clinic cartilage research, visit http://mayoresearch.mayo.edu/mayo/research/cctrl/projects.cfm.

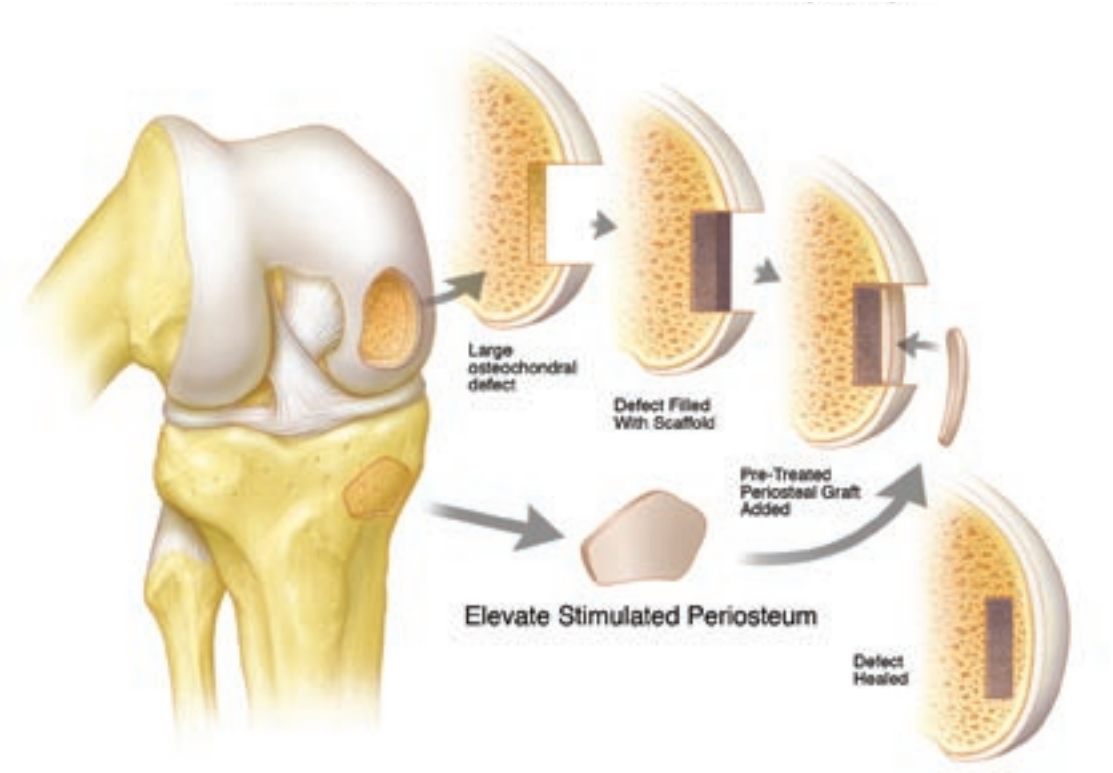


Figure. *The proposed technique of scaffold-based periosteal arthroplasty for the repair of major osteochondral defects. Periosteum that has been stimulated/rejuvenated to enhance its chondrogenic potential is harvested from the medial proximal tibia. The defect is then removed and filled with a porous scaffold so the top of the scaffold is below the level of the surrounding subchondral bone. The periosteal explant is then sutured to the scaffold with the cambium layer facing into the joint. The scaffold will integrate with the surrounding bone, and the periosteal graft will integrate with the scaffold via tissue ingrowth. The remaining defect will then be filled by periosteal-derived subchondral bone and neocartilage formation.*

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CME Opportunities

4th Mayo Clinic International Spine Symposium

The 4th Mayo Clinic International Spine Symposium is scheduled for February 1-5, 2009, at the Ritz-Carlton Kapalua Resort on the island of Maui. This annual 5-day CME event features the latest in new treatment strategies and techniques for orthopedists, neurosurgeons, and neuroscientists involved in treating patients with spinal disorders. The 2009 program will focus on trauma, minimally invasive spine surgery, and nonoperative spine care. During the 5 half-day sessions, attendees and faculty interact in a casual, yet dynamic forum that features debates, panel discussions, case presentations, and evidence-based reviews.

Advanced Shoulder Treatments

An intensive, hands-on skills course, Advanced Techniques in Shoulder Arthroscopy, Arthroplasty, and Fractures, will be offered by Mayo School of Continuing Medical Education (CME) on May 1-2, 2009, in the Mayo Clinic Surgical Skills Laboratory, Rochester, Minnesota. Faculty from Mayo Clinic and orthopedic centers in the United States and Europe will use cadaver specimens, didactic lectures, video demonstrations, and panel discussions to fully explore important shoulder topics. Highlights include arthroscopic shoulder instability techniques, minimally invasive rotator cuff repair, new approaches for fracture reduction and fixation, and arthritis treatment options.

Information and Registration

For more information or to register, call 800-323-2688 or 507-284-2509; e-mail CME@mayo.edu; or visit www.mayo.edu/cme/orthopedic-surgery.html.

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Continuous video-EEG monitoring (inpatient) helps localize seizure focus, determine seizure type, and quantify the number of seizures in patients with intractable recurrent seizures and those with an unconfirmed seizure diagnosis.
Optimizing the Functional Performance of Cancer Survivors
There is a growing understanding of the importance of exercise and rehabilitation for cancer survivors. Physical Medicine specialists can help patients manage the negative long-term sequelae of cancer and its treatments and obtain a more satisfying, high-quality recovery.
New Endoscopic Treatment for Severe Gastrointestinal Bleeding
Endoscopic ultrasound-guided therapy appears to be a safe and effective treatment for patients with severe gastrointestinal bleeding for whom conventional therapies have failed. The therapy involves injecting various agents directly into the source to stop the bleeding.
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A Mayo Clinic study suggests that removing the entire kidney from younger patients

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