A Cleveland Clinic Roundtable:
New Developments in Minimally Invasive Hip and Knee Replacement

Earlier this year, the Cleveland Clinic Department of Orthopaedic Surgery held a roundtable discussion of minimally invasive hip and knee replacement. Participating in the discussion were Wael Barsoum, M.D., resident; Lester Berndt, M.D., Mark Froimson, M.D., Kenneth Marks, M.D., and Robert Zehr, M.D. The highlights are presented here.

Dr. Barsoum: Total hip and total knee surgery are the two most common operations in the history of medicine. We are always thinking of ways to improve these procedures, and therein lies the interest in minimally invasive surgery. It has been applied to the hip for two to three years, and more recently there has been interest in the application of minimally invasive techniques to arthroscopic and total knee replacements.

Dr. Zehr: There is more focus on the hip, and it has been done longer, so we will begin there. How would you define minimally invasive hip replacement surgery?

Dr. Barsoum: The two keys to the definition of minimally invasive surgery are the smaller incision and the muscle and soft tissue-sparing aspect of the operation. I tend to think of minimally invasive surgery and traditional surgery as a continuum.

Dr. Barsoum: Minimally invasive surgery uses a very small incision, with the procedure performed through the use of fluoroscopy, through multiple incisions, usually two. Minimum incision surgery is a standard, conventional incision that is made smaller.

Dr. Froimson: The heart of the issue is the surgeon’s ability to visualize the operative field. Today we have fluoroscopy to assist with this, and perhaps, computer-assisted surgery in the future.

Dr. Zehr: The purpose of this is to promote a faster recovery for the patient. A quicker return to activities and lower recuperation time and morbidity are clearly what are driving this trend.

Dr. Borden: What is your goal for a patient in his or her late 60s to early 70s with limited activity due to an osteoarthritic hip?

Dr. Marks: The primary goal is long-lasting pain relief. Other goals are to improve mobility and function, allowing the patient to be active longer.

Dr. Borden: What is your goal for a patient in his or her late 60s to early 70s with limited activity due to an osteoarthritic hip?

Dr. Marks: The primary goal is long-lasting pain relief. Other goals are to improve mobility and function, allowing the patient to be active longer.

The lure of minimally invasive surgery is that it fits with the patient’s goal of getting back to full activity as quickly as possible, with immediate pain relief, a minimum of risk and a maximum of longevity in the prosthesis.

Dr. Borden: How do you achieve those goals?

Dr. Froimson: What is required is a properly positioned implant with the ability to provide durable function, achieve optimum fixation in the bone and restore the patient’s anatomy. If we can achieve good fixation with good materials and a proper alignment, we have successful long-term results.

Dr. Borden: Is a standard, conventional incision that is made smaller.

Dr. Zehr: For the patient’s benefit, try to combine minimal incision surgery with the least amount of muscle disruption.

Chairman’s Report
By Joseph Iannotti, M.D., Ph.D., Chairman, Department of Orthopaedic Surgery

As I begin my fifth year as Chairman of the Department of Orthopaedic Surgery, the Cleveland Clinic Foundation is marking its 80th anniversary as a hospital. This is a particularly auspicious anniversary, in that this summer the newly formed Cleveland Clinic Lerner College of Medicine of Case Western Reserve University welcomed its first class of medical students. The 32 young pioneers accepted for enrollment are embarking on a unique medical education program designed to train “physician scientists.”

Hopefully some of them will find their way to orthopaedics, which remains full of opportunities and clinical challenges. Indeed, they can join our Department’s mission of becoming the best in the world in patient care, research, and education. Currently we are ranked among the top five orthopaedic departments in the country by U.S. News & World Report’s 2004 listing of “America’s Best Hospitals.”

The department currently has 56 active full-time physician staff members who practice in 13 sites in the Northeastern Ohio region of the Cleveland Clinic Health System. The active staff includes 48 surgeons—45 orthopaedic and five pediatric surgeons. The surgical staff is complemented by five primary care physicians, two orthopaedists and two pediatricians. In 2003, the Department reported 242,667 outpatient clinic visits, 9,754 new patients, and 12,600 surgeries.

In 2003, we trained 20 residents and graduated four and trained 14 clinical fellows in seven subspecialties. We also trained eight research fellows. Two orthopaedic residents entered the six-year residency program completed one year of basic science research and both were successful in securing $125,000 in extramural funding for their research endeavors. Two other residents began their research projects this summer.

Our residents and fellows published 22 peer review articles and 13 book chapters or reviews articles. The residents and fellows are involved in 47 clinical and 20 basic science research projects.
there are approximately 2 million patients diagnosed with advanced fracture nonunion. The bone segment does not heal and fractures occur frequently. The incidence of nonunions is about 5-10% at 6 months post injury. These fractures are often refractory to conventional surgical or pharmacological interventions, and can require a combination of different treatments. Some patients may benefit from the use of growth factors or bone grafts, while others may require more invasive procedures such as open reduction and internal fixation (ORIF) or bone grafting. However, the success rate of these treatments is relatively low, with healing rates ranging from 50% to 70%.

In conclusion, there is a need for more effective treatments for advanced fracture nonunion. New therapeutic strategies, such as the use of growth factors, bone grafts, or other novel interventions, are being explored to improve outcomes and reduce the morbidity and mortality associated with this condition. Further research is needed to identify the most effective methods for treating advanced fracture nonunion, and to develop new treatments that can provide better outcomes for patients.

References:

Pulsed Electromagnetic Fields in Healing Fracture Nonunion Promises, Controversy
By Ronald Midura, Ph.D.

Pulsed electromagnetic fields (PEMFs) have been used for several decades in the treatment of bone fractures. PEMFs are low-frequency, low-intensity electromagnetic fields that are generated by an alternating current passing through a wound site. The fields induce changes in the rate of bone formation and bone resorption, which can accelerate the healing process. PEMFs have been used in clinical settings to treat non-union fractures, delayed healing fractures, and osteoporosis.

However, there is controversy regarding the efficacy of PEMFs in healing fracture nonunion. Some studies have shown promising results, while others have failed to demonstrate significant improvements in healing rates. The mechanisms by which PEMFs affect bone healing are not fully understood, and there is a need for more research to clarify the role of PEMFs in the treatment of fracture nonunion.

Nevertheless, PEMFs continue to be used in clinical practice, and further research is needed to determine their role in the treatment of fracture nonunion.

References:

Above: Cleveland Clinic orthopaedic specialists expressed differences of opinion regarding some of the new minimally invasive techniques for hip surgery. In the literature, the studies using less accurate imaging procedures were relatively small in magnitude and it was concluded that clinical significance. The principal finding in this study was that PEMF’s were able to significantly reduce loss of bone volume at a bone nonunion site in live rats as compared to their paired-matched control. (Figure B) This finding indicates that PEMF treatment might be useful at sites of bone trauma in live rats. Further study to prove that these PEMF’s dependent effects were relatively small in magnitude and would be considered of minimal clinical significance. This can be considered to be one of several factors that is currently continuing the controversy regarding PEMF’s efficacy in hip surgery, particularly nonhuman.

High-Resolution 3-D Bone Imaging Yields Micro Images By Kimberly Powell, Ph.D.

Microcomputed X-ray tomography (micro-CT) is a three-dimensional imaging technology that is similar to clinical x-ray computed tomography. It can be used to interrogate small biological specimens (less than 1 cm in diameter) and internal structures of small animals at high spatial resolution (less than 1 micron). It is used in bone and joints in a variety of applications, primarily to evaluate the trabecular structure of cancellous bone in vivo (of specimens of bone undergoing hip replacement surgery).

In vivo micro-CT is a noninvasive, nondestructive imaging modality suitable for monitoring treatment effects in small animals over time. It is significant in that further analytical results can be obtained in animal studies using significantly fewer animals than are used in traditional methods of analysis.

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Management of Elbow Instability Emphasizes Early Intervention

By Peter J. Evans, M.D., Ph.D.

The elbow is a critical link to upper limb function, and injury to the elbow resulting in instability can impair its role and lead to dysfunction. Injury recognition followed by prompt, appropriate, comprehensive, and effective treatment can avoid chronic, incomplete functional recovery. A number of advances in diagnosis and treatment have been made, with the result that many patients are able to return to a normal lifestyle.

Traumatic Injury

Fractures on the extensor side or extensoraponeurosis force the elbow to the leading causes of acute, traumatic injury. Elbow instability follows two patterns, articular fracture and ligamentous injury, both of which must be addressed.

Typically, a combination of axial loading with the arm in extension, combined with a rotary force through the olecranon, causes the radius and ulna to subluxate posteriorly. Soft tissue or posteroarticular rotational instability (PLRI) and, often, bony injury typically occur.

Successful restoration of elbow stability must be achieved at the time of the first operative procedure.

More recently, varus posterior rotational instability (PMRI) has been recognized as a distinct entity of critical importance as early treatment options are readily available. Failure to perform early corrective surgical procedures can lead to inevitable, degenerative changes.

PMRI is caused by fracture of the anterior medial facet of the coronoid and/or computer tomography by an incongruity of the ulnohumeral cartilage space, or a medial drift of the ulna relative to the humerus. Depression of the medially displaced anterior rims of the coronoid makes it possible to perform an anatomic reconstruction. PMRI probably will lead to progressive cartilage injury, stiffness, osteoarthritis and ulnar nerve compression in the cubital tunnel.

Atrumatic Rupture

Rupture of the anterior medial buckle (AMCL), as seen in baseball pitchers, the tensile force placed on the AMCL during late cocking and moving towards ball release generates more than 100 degrees of flexion moments of force. This is at least twice that of the failure point of the AMCL, indicating load sharing by the dynamic kinetic chain of forearm musculature and statically via the ulnohumeral and radiocapitellar joints.

The AMCL is the primary soft tissue restraint to ulnar stress across the elbow, and progressive failure of this ligament is ominous.

As the technology advances and the biology becomes more understandable, the Minimally Invasive Surgery Center at The Cleveland Clinic will play a valuable role in bringing these and other advances to the treatment of our patients.

MDIC, among the first programs for practicing physicians to gain non-clinical testing site for experimental research and education to benefit patients. The Center’s mission is to advance least-invasive surgical techniques through research and education to benefit patients.

The Cleveland Clinic Minimally Invasive Surgery Center: Convergence of New Ideas to Enhance Patient Outcomes

By Isador Lieberman, M.B.A.

The isometric point on the medial epicondyle is at the midpoint of the humerus in the olecranon fossa. The common hole and secured with a biotenodesis graft through bone holes in the humerus and ulna as needed.

This is accomplished with heavy, nonabsorbable sutures placed from the capitellar to the humerus (replacing the posterior third of the radial head) acting as a sling, wearing the nature stable along the lateral course of the UCL toward the superior part of the ulna. With the elbow at 45° of flexion and full pronation, the nature is driven down, the capsular augmentation of a double-strand mattress is performed and monofilament absorbable suture through bone holes in the humerus and ulna is needed.

Reconstruction of the UCL utilizes a palmaris longus, gracilis, semitendinosus or extensor carpi ulnaris graft placed in a double-strand, sutured fashion. Usually, two bone holes (or a single femoral olecranon) are made at the supinator crest proximally and in the center of the ulna. The cortical bone hole is made, accommodating the two bone holes of the graft. The graft is trimmed and secured through these two bone holes. Pin fixation of the lateral collateral ligament and the UCL graft to the capsule can augment the repair.

Repair of the MCL is effective only in traumatic cases. Traumatic tearing occurs off the proximal distal (PMRI) insertions. Usually, outgrowth of the femoral root or bone holes with a deep locking nonabsorbable suture, in the center of the capsule and UCL through bone holes on the medial epicondyle, confers adequate stability to allow stable healing.

Reconstruction with a tendon graft, preferred for attritional cases, can be achieved via a muscle-splitting incision through the flexors directly over the MCL. The tendon itself is passed through a converging drill hole at the medial tubercle of the coronoid or the olecranon via the common hole and secured with a bone-odonto suture or pull-out sutures laterally. The isometric point on the coronoid is determined, evert slightly anterior and proximal to the center of the radius of the trochlear articular surface and just medial to the junction of the medial epicondyle and the posterior olecranon. The proximal ends of the suture are woven through the coronoid tip.

The UCL is typically avulsed of the lateral epicondyle and must be reattached.

The Center is designed to enhance least-invasive surgical techniques through research and education to benefit patients.

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To challenge the conventional orthopædic training in surgical techniques that promoted to revolutionize the management of these diseases, the Cleveland Clinic Minimally Invasive Surgery Center (MISC) was established in 1998. Less than a decade later, more than 40 surgeons and associated health professionals from nearly every specialty converge here to share and explore new minimally invasive surgical techniques.

The Center’s mission is to advance least-invasive surgical techniques through research and education to benefit patients. The group is collectively responsible for the design of innovative, including many in orthopedics:

• Video-assisted approach to spinal tumor resection and reconstruction
• Endoscopic shoulder surgery, minimal invasive release with posterior correction
• Kyphoplasty
• Partial knee replacements
• Hip arthroscopy.

As the technology advances and the biology becomes more understandable, the Minimally Invasive Surgery Center at The Cleveland Clinic will play a valuable role in bringing these and other advances to the treatment of our patients.

The Cleveland Clinic Minimally Invasive Surgery Center is dedicated to bringing the latest advances in minimally invasive techniques to patients.

The isometric point on the medial epicondyle with a lock to full extension allows the degree of flexion that instability initiated when tested in the operating room. The forearm position restriction is maintained with an outrigger attachment.

Passive range of motion exercises begin with maintenance of forearm position restrictions while the elbow is in less than 90° of flexion. Full supination and pronation is encouraged when the elbow is fixed greater than 90°. Full motion is allowed by six weeks.

Dr. Evans led joint appointments in the Department of Orthopaedic Surgery and the Department of Neuroscience in the Lorain Research Institute. He has specialty interests in surgery of the upper extremity and the peripheral nerves.

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External Fixation

Familiarity with application of a bipodal elbow external fixator is a must for orthopaedics who perform elbow surgery. This external fixator effectively contains the variabilistic gravitational force of the extremity.

The elbow is immobilized in 90° of flexion with the forearm in full pronation in cases of PLRI and in neutral or supination if PMRI exists. At 10 to 14 days, this is connected to a burlap brace with a lock to full extension for the degree of flexion that instability initiated when tested in the operating room. The forearm position restriction is maintained with an outrigger attachment.

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The Problem
Bone loss during space flight has been a concern ever since 1963 when the early Gemini flights sent astronauts into low Earth orbit for periods of between one and two days. It was soon realized that the risk for loss of bone mass based on measurements made before and after Gemini Flights (up to 1.5 percent per day) were based on the result of inadequate measurement techniques. However, scientific studies of human space flight over the last 40 years have shown that there is indeed a serious risk of bone mineral density (BMD) in some parts of the skeleton, so serious that many experts cite bone loss as one of the major “show stoppers” for interplanetary human missions.

The magnitude of the problem can be best appreciated by comparison with bone loss in post-menopausal women—usually estimated at approximately 1.5 percent per year. Astronauts on missions to the Mir Space Station lost approximately 1.5 percent per month to their proximal femurs—so much in one month as a typical post-menopausal woman loses in one year. And there is no indication in the literature that this rate of change doubled during pro-longed space flight. Since the current Design Reference Mission being used by NASA for the Mars mission is a 30 month round trip (including a stay on the Martian surface in Earth Gravity), the arithmetic leads to a staggering estimate of 45 percent regional BMD loss.

The Mechanisms
Many attempts have been made to understand the mechanisms for bone loss in space flight, many and varied. They include such factors as changes in bone blood flow, structural alterations in osteoclasts and osteoblasts, alterations in calcium absorption and Vitamin D pathways, alterations in endocrine pathways that control bone homeostasis, and disease. This last hypothesis is particularly attractive because of an important piece of data from the MIR Flight. Bone mass was lost in the lower extremity and lumbar spine but maintained at pre-flight levels in the upper extremity.

Anecdotal observations (and our own in-flight experimental results—seen below) suggest that the lower and upper extremities follow quite different functional usage patterns on the ground compared to is in space. The lower extremities are primarily used for positioning while the upper extremities are used for locomotion—in addition to their functions of manipulation and tool use.

The Experiments
Since December 2002, Cleveland Clinic researchers have been conducting an experiment on the International Space Station (ISS) to test the validity of the dietary explanation for bone loss in man—the phenomenon sometimes called hypercalciemic osteoporosis. We have built a Lower Extremity Monitoring Sari (LEMS), which contains sensors to measure muscle activity, joint motion and foot reaction forces that can be worn for the entire work day while subjects are being performed. Before launch, astronauts wear this suit for four days during their training at the Center for Human Research on the ISS. We have found dramatic alterations in force input to the feet. Not only is the overall daily input to the feet markedly reduced, but the magnitude of force peaks during exercise intended to provide an osteogenic stimulus are also reduced compared to their 3G values.

The Solutions
A team of researchers allied with the National Space Biomedical Research Institute is exploring various solutions to the problem of flight osteoporosis.

Our work suggests that improved exercise countermeasures could offer a possible solution, and other team members are examining pharmacological interventions (anti-estrogens and anabolics), novel mechanical stimuli such as vibrations, and the potential for time building in reduced gravity. Countermeasures for renal bone formation also are being explored.

The Experiments
Cavanagh is a Chairperson of the Department of Biomedical Engineering and holds a joint appointment at the Department of Orthopaedic Surgery and the Orthopaedic Research Center. His special interest is in orthopaedic research related to space flight. He can be reached at 216-445-8890 or BMJ553-5596, extension 68998.

Conservative Management of Plantar Fasciitis Improves Symptoms and Flexibility
By Brian Donley, M.D., and James Sferra, M.D.

Plantar fasciitis, a disorder of the plantar aponeurosis, is the most common cause of heel pain in adults. In addition to a large body of legitimate scientific literature, however, it also has garnered much speculation and misinformation. Particularly in lay publications, plantar fasciitis is sometimes mistakenly labeled “heel spur.” But the data show no correlation with the existence of these bony deposits in the heel and plantar fasciitis, either as a cause or a result. Indeed, plantar calcified spur, or excrescence, often is present in patients with no heel or foot pain but absent in those diagnosed with plantar fasciitis. Even the etiology of plantar fasciitis is controversial. Although usually described as chronic inflammation of the plantar fascia, some argue that the problem is caused by excessive stretching that results in microfractures in the fascia/tissue. This in turn causes collagen degeneration when the fascia attaches to the medial tubercle of the calcaneus, resulting in inflammation.

Assessment and Diagnosis
The diagnosis of plantar fasciitis is based mainly on the medical history and clinical presentation. The most important finding from the history is the report of foot pain conspicuous upon waking. The most important risk factor is a flat arch (a shoes that do not provide the necessary arch support). Other risk factors are explored below. Although pain may occur along the entire course of the plantar fascia, it usually is limited to the inferior medial aspect of the calcaneus, at the medial point of the calcaneal tubercle. Pain is typically worse in the morning and almost always worsens with the day’s first steps. As the day progresses, however, normal movement helps loosen and stretch the Achilles and plantar fascia, helping to reduce pain levels. The process tends to reverse during sleep. Some patients may report noticing pain after prolonged standing, for instance, after standing a long distance. Individuals who are on their feet all day often report pain becoming conspicuous at end of day. The cause of plantar fasciitis is often unclear, and this is the most important physical finding. Radiography results are used to exclude abnormalities—stress fracture, for instance—that can also cause heel pain. Magnetic resonance imaging is typically used only to confirm the clinical diagnosis.

Possible Risk Factors
Several studies have attempted to identify risk factors for plantar fasciitis. One such study (Dawson PA, Holdsworth JS, Krieger JD, et al. The Causes of Heel Pain. J Clin Rheumatol 2000; 6:140-143) showed that decreased daily activity and cigarette smoking were associated with increased risk of developing plantar fasciitis.

The Experiments
Cavanagh is a Chairperson of the Department of Biomedical Engineering and holds a joint appointment at the Department of Orthopaedic Surgery and the Orthopaedic Research Center. His special interest is in orthopaedic research related to space flight. He can be reached at 216-445-8890 or BMJ553-5596, extension 68998.

Cavanagh to Lead National Research Group Investigating Bone and Muscle Loss During Space Flight
Peter R. Cavanagh, Ph.D., D.S.C., chairman of the Cleveland Clinic Department of Biomedical Engineering, has been named the leader of the Bone Loss Team for the National Space Biomedical Research Institute. With his appointment, Dr. Cavanagh received a $1.5 million grant to study exercise devices for astronauts to use in space to protect themselves against the bone and muscle loss associated with long-duration space flight. The grant will be disbursed over four years to research that will complete in collaboration with Cleveland’s NASA Glenn Research Center.

Established in 1997, the National Space Biomedical Research Institute is a consortium of 12 institutions working to prevent or solve health problems related to long-duration space travel and prolonged microgravity exposure. The group, which receives funding from the National Aeronautics and Space Administration, is dedicated to safe and productive space flight. Dr. Cavanagh leads 15 principal and co-investigators on the Bone Loss Team, which focuses on finding solutions to bone loss in space.

Dr. Cavanagh is the Virginia Leo Kennedy Chairman of Biomedical Engineering at the Cleveland Clinic. He joined the Clinic in 2002 from Pennsylvania State University, where he was Distinguished Professor of Kinesiology, Orthopaedics and Rehabilitation, Medicine and Behavior and Health. Dr. Cavanagh has been involved with space life sciences since 1967 and was named in 2003 to join the NASA Research Institute Committee and the advisory group on long-duration medical care on the International Space Station.
Spinal Navigation Aids MIS Intervention for Spinal Tumors: Two Case Studies

By Robert F. McLain, M.D.

Beginning in 1995, Cleveland Clinic surgeons helped pioneer the use of image-guided spinal navigation, and today they have the world’s most extensive experience using this technology. Spinal navigation extends computer-aided tomography (CT) imaging data to real-time intraoperative positioning and localization, the result being a detailed, three-dimensional anatomical roadmap of the intended operating field. Such anatomical data is not available using traditional, two-dimensional imaging systems. Thus, spinal navigation permits the surgeon to more accurately localize unseen targets—hidden deep within bone and skinlessly flanked by vital structures—using key landmarks on the surface of the spine.

Common components of each image processing system are an image acquisition array capable of capturing the image information; a workstation capable of manipulating this information; and a display device capable of presenting the image information. These components work in concert to present an image that can be manipulated in real time during spinal surgery. The image that is displayed can be generated by using a preoperative computed tomography (CT) scan, magnetic resonance imaging (MRI), or both. The system can be further enhanced by allowing the display of both preoperative and intraoperative images.

Discussion

The second patient, a 22-year-old major league baseball pitcher, had a history of right shoulder impingement and had undergone surgical debridement. He sustained a right shoulder injury at the beginning of the 2003 season. The shoulder pain persisted despite the usual nonoperative care, and a more aggressive work-up was undertaken. A CT scan revealed a C7 osteoid osteoma (Figure 1). A microsurgical approach was undertaken to excise the osteoid osteoma. The patient was discharged from the hospital on the day of surgery and returned to full activity the following week.

The pain began insidiously but was exacerbated by recreational activities. His biggest complaint was the restriction in his arm motion, with limitations in his back and neck surgery and activity. He could not run and was bedridden at times. He could not complete his rehabilitation program without the aid of an epidural steroid injection. Surgery was undertaken. A CT scan revealed a C7 osteoid osteoma. A microsurgical approach was undertaken to excise the osteoid osteoma. The patient was discharged from the hospital on the day of surgery and returned to full activity the following week.

By Anthony Calabro Jr., Ph.D.

Science Imitating Nature: Designing a Gel-Like Artificial Cartilage for Long-Term Use in Reconstructive Surgery

The unique, self-folding cross-linking chemistry allows direct injection of cells within the gel hydrogel at the site of tissue injury. Individual section of denuded cartilage is embedded in a 2:1 mixture of tissue-hydrated, Type I and II collagen. Cells (chondrocytes) are then sterically stabilized with positively charged side chains of the gel hydrogel, allowing the formation of cross-links.

Surgeons faced with repairing cartilage damaged by disease or trauma historically have had few choices. If the damage is serious and extensive, a metal and plastic total joint prosthesis has been the treatment of choice. When cartilage damage is limited to a particular feature, such as an ear, surgeons have relied on cartilage harvested from elsewhere in the body to reconstruct the feature. We are working to develop a third option for orthopaedic and plastic surgeons—cartilage hydrogel—made from the constituents of natural cartilage. One of the advantages of this material is that it can be tailored to fit into any defect. For example, to fill a small defect, cut, correct, a defect, use an implant and replace an anatomical structure.
Cherubism is a rare skeletal disorder that involves overgrowth of both the upper and lower jaws (mandible and maxilla) beginning in the first decade of life. The condition is characterized by cheruboid facial features, keratoconus, and tooth malalignment.

Molecular Basis of Heuter-Volkman Principle of Physiological Growth Yields Insights into Correction of Pediatric Deformities

By R. Tracy Ballock, M.D.

One of the guiding principles of pediatric orthopaedic surgery is that lengthening of a bone will reduce mechanical forces and result in an increase in mechanical forces that stimulate growth. This concept was first postulated by Dipchand in 1929 and subsequently by Heuter and Volkman in 1940, and it has been supported by studies performed over the past decade in our understanding of the growth plate.

Molecular signals in bone are responsible for controlling bone growth, and these signals are modulated by the presence of hormones and cytokines, which in turn are modulated by the presence of messenger proteins that bind to the surface of osteoblasts and osteocytes and their precursors, controlling their development as well as turning them on and off. It is the sequence and ever-changing concentrations of these signaling pathways that tightly regulate the balance between bone formation and resorption. Mutations that lead to changes in these signaling proteins disturb this balance and likely contribute to the bone overgrowth and lesions of cherubism.

Distraction Lengthening Effectively Reconstructs Congenital Hand Differences

By William J. Seitz, M.D.

The Cleveland Clinic Children’s Hospital has a long history of excellence and innovation in medical and surgical care for those with musculoskeletal injuries and diseases. The Cleveland Clinic Children’s Hospital, among the nation’s top five orthopaedic programs, is a university training program with mortality rates and other data. The Cleveland Clinic has been designated as one of the top five hospitals in America since 1990 by U.S. News.
Evaluating Causes of ACL Injury in Women Athletes
By Antonie J. van den Boogert, Ph.D., Scott C. McLean, Ph.D., and John T. Andrish, M.D.

Anterior cruciate ligament (ACL) injuries are one of the most common injuries in female athletes, occurring in some 3 percent of elite-level female basketball players every year. Not only painful, these injuries also are costly to the team in terms of lost performance and, ultimately, to the athlete as she returns to her previous level of play after treatment. Additionally, ACL injury jeopardizes the athlete to the risk of early-onset osteoarthritis in the knee.

Although ACL injuries are common and costly, the exact mechanism by which they occur is still a debate, as is the question of why these injuries are so much more common among female athletes than in male athletes. Several hypotheses have been proposed in the literature, including the manner in which women move compared to men, the strength differences between women’s hamstring and quadriceps, and anatomical differences between women and men. By incorporating all these potential risk factors for ACL injury into a biochemical and understanding the biomechanics of the event, we can define the causative factors and, therefore, appropriate prevention strategies.

Using computational modeling based on movements of elite-level subjects, we are testing the popular hypotheses in our laboratory. We have brought 10 elite-level male basketball players, 10 elite-level female basketball players, and 10 female and 10 male recreational athletes into the lab and had them jump, pivot, and sidestep while recording their movements at 240 frames per second with high-speed motion analysis equipment. After these images are input into the computer, we can see one particular “mistake” in a subject’s movements to simulate injuries and then identify the attributes that contributed to the ACL injury.

Using these techniques, we have demonstrated that neither anatomy, differences in movement nor differences in muscular strength alone causes an ACL injury. Although some of these factors appear to be contributory, we have demonstrated that the previously proposed two-dimensional quadriceps-hamstring mechanism cannot rupture the ACL during any of the movements we have studied. Even when possible neuromuscular perturbations (“mistakes”) are considered.

Our data suggest that the mechanism of knee valgus, which occurs immediately after an ACL injury, is a likely explanation for the increased incidence of ACL injury in women. Increased knee valgus (“knock-kneed” posture) in women compared with men has been well documented during standing and, more recently, during the stance phase of sport movements. Valgus stress on the knee is known to strain the ACL. We recently demonstrated with our computer model that knee valgus stress during sidestepping is influenced more by neuromuscular control than anatomy. This is substantiated by differences in hip and ankle angles in women vs. men in the stance phase of sidestepping. If neuromuscular control is an important contributor to valgus stress on the knee, it may be possible to prevent ACL injuries in women through appropriate training.

In the next phase of our study, funded by the National Institutes of Health, we will incorporate data from detailed MRI scans on each individual into our computer models. We also now have a technique for predicting force in the ACL, under any combination of knee-joint loading conditions that will be incorporated within each model. These additions will allow us to study the effects of combining anatomical and neuromuscular control on ACL injury risk.

Ultimately, identifying the factors that put a woman at risk for ACL injury will lead to recommendations for injury prevention. From an MRI of the knee, joint sport medicine specialists will be able to predict which is susceptible to an ACL injury so that the athlete may undergo training to change her movements in such a way that the forces on the joint are modified to prevent such an event.

Teaching female athletes to move like their male counterparts is probably too simplistic an approach and is not sufficient to prevent ACL injury. The solution appears to be more complex than this unilinear approach, and additional research is necessary, such as that conducted within our laboratory, to fully understand the problem.

Dr. van den Boogert, Department of Biomedical Engineering, has a joint appointment with the Department of Orthopaedic Surgery. His specialty interest is in biomechanics, particularly related to knee injury. He can be reached at 216/444-5556. Dr. McLean, Department of Biomedical Engineering, can be reached at 216/445-8987. Dr. Andrish is head of the Section of Orthopaedic Research, Department of Orthopaedic Surgery, and specializes in pediatric orthopaedic and sports medicine and can be reached at 216/444-2629. Our toll-free physician line is 800/553-5556, extension 5556 for Dr. van den Boogert; 858/327-7763 for Dr. McLean; or 412/268-4232 for Dr. Andrish.

Cleveland Clinic to Host 2nd National Medical Innovation Summit October 18-20

The Cleveland Clinic again is hosting a national medical innovation summit, which is expected to draw more than 800 top-level industry executives, entrepreneurs, investors and clinicians. This year’s summit, scheduled for October 18 through 20 at the InterContinental Hotel & MIRRA Conference Center, will place particular emphasis on challenges in cardiovascular disease -- new therapies and new research combined with rising health care costs.

Several internationally recognized Cleveland Clinic physicians, including Cardiovascular Disease Medicine Chairman Eni J. Topol, M.D., and Cardiovascular Surgery Chairman Delos M. Cosgrove, M.D., will be among the speakers.

Dr. Cosgrove recently was named Cleveland Clinic Chairman and CEO of as of October 2004. Kenneth Duntli, M.D., Chairman of Division of Surgery, will moderate a live surgery during a presentation on minimally invasive techniques.

For more information, including a list of speakers and a registration form, visit www.clevelandclinic.org.innovations.

Dr. Andrish is head of the Section of Orthopaedic Research, Department of Orthopaedic Surgery, and specializes in pediatric orthopaedic and sports medicine and can be reached at 216/444-2629. Our toll-free physician line is 800/553-5556, extension 5556 for Dr. van den Boogert; 858/327-7763 for Dr. McLean; or 412/268-4232 for Dr. Andrish.

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### Staff Directory

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<th>Name</th>
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### Specialty Interests:

- **Sports Medicine**: Focus on joint disorders and replacement, and traumatic injuries related to sports activity.
- **Orthopaedics**: Focus on joint disorders and replacement, and traumatic injuries related to sports activity.
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**Stem Cell Autografts: The Wave of the Future**

By George Muschler, M.D.

Advances in stem cell therapy are opening the opportunity for new strategies in musculoskeletal engineering. Since the 1920s, surgeons have been using stem cells for tissue engineering by removing bone from the pelvis and other sites and transplanting them where new bone is needed. However, new methods, developed at The Cleveland Clinic, now allow those same stem cells to be collected and transplanted with much less effort and risk.

The first application of these new methods was in the treatment of fracture nonunion and in spinal fusion, both sites where the use of periosteal autograft has remained the gold standard for bone grafting. Based on the premise demonstrated in 1923 that mesenchymal stem cells activated by growth factor yield osteoblasts, stem cell therapy yields results comparable to those achieved with iliac crest grafts. At The Cleveland Clinic, we have been using stem cell therapy in selected patients with nonunions or spinal fusion.

Stem cell therapy relies on aspirated bone marrow that is passed through an implantable graft matrix under conditions that create the environment of an affinity column. These methods have been incorporated into a new product (Cellcine, DuPoyspine), a technology developed at The Cleveland Clinic, results in a graft that concentrates and retains 88 percent of osteoprogenitor stem cells, but only 20 to 40 percent of other cells in bone marrow. This allows more marrow-derived stem cells to be implanted in an environment in which they have fewer nonskeletal cells with which to compete. The result is improved graft performance using the patient’s own cells. The matrix embedded with the patient’s own stem cells, thus becomes the graft that is implanted in the wound.

Results with this technique at The Cleveland Clinic over the past three and a half years in the treatment of established fracture nonunion and long bone defects have been excellent, with a 90 percent success rate and far less graft associated morbidity. Conventional iliac crest autograft procedures, 31 percent of patients experience surgical complications, and 27 percent continue to have pain 24 months later. Bone marrow aspiration as a source of stem cells has minimal morbidity. More than 90 percent of patients have no reported pain at the aspiration site.

As our understanding of the interaction of stem cells, biologic stimuli and matrices advances, we will be able to better target stem cell therapy. We have just scratched the surface of the possible applications of stem cell therapy in orthopaedics. The Cleveland Clinic Orthopaedic Research Center and Department of Biomedical Engineering continue to investigate additional indications for this promising treatment, including osteoporosis and acute fracture, as well as its potential application in cartilage repair.

Dr. Muschler holds appointments in the departments of Orthopaedic Surgery and Biomedical Engineering, the Cancer Center and the Transplant Center. His specialty interests include musculoskeletal oncology, adult reconstructive orthopaedic surgery, fracture nonunion and research in bone healing and bone grafting materials. He can be reached at 216/444-5338 or 800/553-5056, extension 45338.