Orthopaedic Research Center Reaps Rewards of Collaboration

The Cleveland Clinic’s Orthopaedic Research Center was established in 2001 to tap into the intellectual synergy that has long existed between the departments of Orthopaedic Surgery and Biomedical Engineering. Developed under the leadership of Joseph P. Iannotti, M.D., Ph.D., chairman of Orthopaedic Surgery, the center melds clinicians’ research interests and strengths with those of tissue engineering, biomechanical and musculoskeletal research scientists.

This rich collaboration was enhanced in September 2002 when Peter Cavanagh, Ph.D., a distinguished researcher of human biomechanics, kinesiology and locomotion from Pennsylvania State University, was named chairman of the Department of Biomedical Engineering. The Orthopaedic Research Center now has more than 30 principal investigators engaged in over 100 peer-reviewed clinical and basic science projects focusing on every aspect of the musculoskeletal system.

They say that the accelerated pace of scientific discovery and innovation is apparent in the development of new techniques such as the Merlot bone anchor for minimally invasive endoscopic sacral fixation. Conceived by Cleveland Clinic orthopaedic surgeon Isador Lieberman, M.D., the Merlot bone anchor’s double-helix design minimizes tissue damage during insertion while increasing the spinal implant’s holding power (pull-out and toggle resistance). This novel design is currently under full-scale development by DePuy-Acromed, a Johnson & Johnson Company, which licensed the technology from The Cleveland Clinic.

The Orthopaedic Research Center is a joint enterprise between the Department of Orthopaedic Surgery, chaired by Joseph Iannotti, M.D., Ph.D. (left), and the Department of Biomedical Engineering, chaired by Peter Cavanagh, Ph.D. (right).

The Cleveland Clinic Department of Orthopaedic Surgery – A Year in Review: 2002 – 2003

From Chairman Joseph P. Iannotti, M.D., Ph.D.

Welcome to this new issue of Orthopaedic Insights. We are pleased to have the opportunity to share the latest developments in the Department of Orthopaedic Surgery at The Cleveland Clinic with you.

Over the past several years, Orthopaedic Surgery has grown at The Cleveland Clinic. We currently have a full-time clinical staff of 57 physicians—including 45 orthopaedic surgeons, seven podiatrists and five nonoperative primary care physicians—offering care at nine different sites in Northeastern Ohio. Last year, we registered 130,000 outpatient visits and completed 11,989 surgical procedures for patients from around the world.

As you may know, U.S. News & World Report has ranked our department fifth in America for five years in a row.

Research is an important part of our mission. In 2001, we created an Orthopaedic Research Center to consolidate all of our investigative efforts. Today, it has grown to include 33 basic science researchers working on a vast range of musculoskeletal problems. Funding for our basic research program totaled $8 million in 2002, with an additional half-million or more in annual extramural funding for clinical research studies.

We support a broad program in continuing medical education. In 2002, we sponsored five CME symposia on sports medicine, upper extremity problems and spine disorders at locations throughout the United States.

In the coming year, our Orthopaedic Research Center will host clinical and basic science conferences in state-of-the-art facilities within the new Cleveland Clinic Intercontinental Hotel and MBNA Conference Center, located right here on our campus. In addition, we will co-sponsor conferences on joint replacement in Las Vegas and Orlando. (Please refer to the Orthopaedic CME calendar on page 13 for details on upcoming events.)

Orthopaedic Surgery is slated to play an important role in the new Cleveland Clinic Lerner College of Medicine at Case Western Reserve University. The first class of 32 students is scheduled for admission in 2004. Our department’s unique six-year curriculum is designed to educate and mentor students for careers in academic medicine and clinical investigation. Research training will be a significant part of the curriculum, and our department will be encouraging and educating students in musculoskeletal care and research.

Finally, in 2002 our department published nearly 100 book chapters, review articles and original peer-reviewed manuscripts. (See back page for highlights of scientific articles and book chapters authored by Cleveland Clinic orthopaedic surgeons and biomedical engineers in the past 12 months.)

We also began producing a consumer newsletter, The Cleveland Clinic Arthritis Advisor, in collaboration with an independent publishing house.

This marks the third year of publication for Orthopaedic Insights. It is our sincere hope that you find the content useful and informative. Should you have suggestions for a future topic, or comments about anything you’ve read, I hope that you’ll call me. I welcome your feedback and look forward to hearing from you.

Dr. Joseph Iannotti, chairman of the Department of Orthopaedic Surgery, is co-chairman of the Orthopaedic Research Center and a member of the Section of Hand and Upper Extremity Surgery. He can be reached at 216/445-5151 or 800/553-5056, ext. 55151.
Limb-Sparing Reconstructions for Childhood Sarcomas Must Now Function Better, Longer

By Kenneth E. Marks, M.D.

The success of adjuvant chemotherapy has helped to change our surgical philosophy toward childhood sarcomas. Replacement therapy, skeletal reconstructions for both osteogenic sarcoma and Ewing’s sarcoma have to last longer and function better.

Forty years ago, through-the-bone amputation or proximal joint disarticulation was the treatment of choice for children and adolescents with sarcomas. Even with radical ablative surgery, results were dismal. Five-year survival was 20 percent for osteogenic sarcoma, and less than 10 percent for Ewing’s sarcoma.

Since that era, adjuvant chemotherapy has made a dramatic difference in prognosis. Today, more than 70 percent of osteogenic sarcoma patients live five years or more free of metastatic disease, with similarly improved survival among Ewing’s sarcoma patients.

Limb-sparing resection and reconstruction have become increasingly important means of achieving local control since the 1960s, when Ewing’s sarcoma was treated with whole-brain radiation therapy.

The past four decades have seen many advances in endoprosthetic design and allograft procurement. In 1977, we established a bone bank at The Cleveland Clinic to facilitate procurement of massive allografts for skeletal reconstruction. A year later, we initiated a program for endoprosthetic skeletal reconstruction for extremity patients.

Since then, hundreds of patients of all ages have undergone skeletal reconstruction with either an endoprosthesis—now the most common approach—or a massive allograft.

Successful limb-sparing surgery depends on the surgeon’s ability to reconstruct the limb, whether it be the femur, tibia or humerus. In selecting a reconstruction technique, function and implant durability, as well as age, tumor location, disease and activity level, are crucial considerations.

In the young sarcoma patient, the limitations and advantages of endoprostheses vs. allografts must be weighed carefully. Limb-sparing surgery is made more difficult by the need to equalize leg lengths in a growing child or adolescent. In the skeletally mature adolescent, leg lengths are equalized at the time of surgery. In patients nearing skeletal maturity, the involved leg is made overly long. Epiphysiodesis is performed on the uninvolved leg when leg lengths equalize with growth.

In children under 10, the anticipated leg-length discrepancy is so great that past surgical options were limited to amputation or a Van Neu rotation plasty. An endoprosthesis now available allows for surgical lengthening of the implant as the child grows. The child undergoes a limited surgery once or twice a year to expand the prosthesis. Once growth is complete, a permanent modular prosthesis is exchanged for the original expanding device.

Customized or modular endoprostheses are used with increasing frequency for skeletal reconstruction after tumor resection. Endoprostheses offer many advantages over allografts, including excellent fit and function, without concerns about disease transmission. Patients recover more quickly, with early restoration of function, and periannular peripheral rates are low. Most importantly for children, relatively low infection and complication rates allow them to return to their adjuvant chemotherapy protocol as early as possible.

Aseptic loosening and late breakage are considered the greatest drawbacks to endoprostheses. However, advances in design and the addition of a porous coating ing at the prosthesis-bone junction have significantly reduced such occurrences. Nonetheless, late failure and revision are to be expected when endoprostheses are implanted in patients younger than 50.

Allografts are more prone to failure when osteochondral joint grafts are used. Causes include fracture, less often, infection; and arthritis. Healing and return to full activity are more gradual with allografts than with endoprostheses. Allografts are incorporated as bone remodeling occurs, usually within two to three years of surgery. Implant longevity is important for the younger, active patient.

However, allografts offer superior long-term function and are preferred over endoprostheses for the following indications:

• Proximal tibia reconstruction, where connecting an allograft with host tissue provides optimal reconstruction of the extensor mechanism;
• Distal radius reconstruction, typically performed using an allograft in combination with wrist fusion;
• Rotor cuff reconstruction at the proximal humerus, where implanting an allograft—prosthetic compos-

Orphaoedic Research Center Reaps Rewards of Collaboration continued from front page

The Center is also dedicated to the training of a new generation of clinician scientists. The Orthopaedic Surgery Department’s six-year orthopaedic residency program—one of few in the nation—has a special concentration in basic research.

The curriculum features a full year devoted to basic science research in the laboratory, learning from such highly skilled investigators as Kathleen Derwin, Ph.D., a specialist in tendon and ligament biology, and Gordon Cavanagh, please call 216/444-2637 or 800/553-5056, ext. 42637.

Two Cleveland Clinic orthopaedic surgery fellows recently participated in a study evaluating SIS as a flexor tendon graft in a canine model. The SIS grafts demonstrated a biologically favorable response in that they were associated with host-cell infiltration, neovascularization and deposition of organized neotissue. However, the grafts were scored significantly reduced such occurrences.

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Pediatric and Adolescent Osteogenic Sarcoma: Improved Outcomes on Clinical Trials

By Joanne Hilden, M.D.

Treatment on clinical trials is the hallmark of pediatric oncology. The National Cancer Institute recently called attention to the problem of poor access for adolescents with cancer to pediatric clinical trials. Teenagers with osteogenic sarcoma represent a group of patients in whom we can begin to reverse this trend.

Cure rates for childhood cancer have increased dramatically, largely through clinical trials designed to identify prognostic factors that can be used to determine high- and low-risk patients, and alter therapy accordingly.

Risk factor analysis, including molecular genetic evidence — largely in leukemias and neuroblastoma, due to diligent tumor banking and scientific investigations in cooperative groups — will be applied to osteogenic sarcoma in the upcoming generation of clinical trials.

At the inception of the Children’s Cancer Group in 1960, the five-year event-free survival for osteogenic sarcoma was 20 percent. The addition of adjuvant chemotherapy — high-dose methotrexate, cisplatin, doxorubicin and ifosfamide — for the primary treatment of osteosarcoma has increased event-free survival in those with clinically nonmetastatic disease to more than 70 percent.

Preoperative chemotherapy has made limb salvage operations possible for more than 80 percent of patients.

Neoadjuvant chemotherapy, followed by surgery, has allowed for an assessment of early response to therapy — the only well-documented predictor of long-term outcome. Children and adolescents with a good response to chemotherapy, defined in various studies as more than 90 to 98 percent of histologically measured necrosis, have a disease-free survival of more than 80 percent.

However, standard responders continue to have disease-free survival of 40 to 60 percent. Clinical trials have proceeded to attempt intensification of therapy for this group. While one study showed a benefit from the addition of ifosfamide and etoposide to standard therapy, current trials are being designed to further optimize outcomes for this group without increasing toxicity.

Up to this point, therapeutic complications have mainly been ototoxicity and cardiotoxicity. The most recently completed clinical trial, still awaiting maturity of data, evaluated the addition of the biologic agent MTP-PE. This agent activates monocytes and macrophages to become cytotoxic, and has shown antitumor activity in spontaneous canine osteosarcoma.

Further studies with other biologic agents, such as IL-2 and interferon gamma, are under discussion, as are clinical trials using the cardioprotectant dexrazoxane.

Approximately 15 to 20 percent of osteosarcoma patients present with metastatic disease, with the majority of metastases found in the lung. Their event-free survival is less than 25 percent. Children with metastatic pediatric osteosarcoma require an innovative approach. Their poor prognosis justifies the exploration of targeted therapy.

Several recently identified potential molecular markers of prognosis are being studied in newly diagnosed osteosarcoma patients.

Among these is the overexpression of the HER2 gene seen in 42 percent of metastatic osteosarcoma patients. This marker was found to correlate with poor outcomes and poor response to standard chemotherapy. An antibody to the HER2 protein, trastuzumab (Herceptin) was developed to capitalize on this target. The currently open Children’s Oncology Group clinical trial for metastatic osteosarcoma employs a strategy that combines this antibody with conventional chemotherapeutic agents.

Cooperative group trials clearly benefit children with cancer. We hope that both children and adolescents with osteosarcoma continue to benefit from this approach.

Dr. Joanne Hilden, chair of the Department of Pediatric Hematology/Oncology at The Children’s Hospital at The Cleveland Clinic, is happy to consult with orthopaedic surgeons about pediatric musculoskeletal cancer patients. To speak with her, physicians may call 216/444-8407, to schedule appointments for patients with Dr. Hilden or her staff, please call 216/444-5517 or 800/553-5056, ext. 45517.

One of America’s Best

The Cleveland Clinic Department of Orthopaedic Surgery has a long history of excellence and innovation in medical and surgical care for those with musculoskeletal injuries and diseases. For the past several years, U.S. News & World Report has consistently ranked the Department of Orthopaedic Surgery among the nation’s top five orthopaedic programs in a survey combining physician polling with mortality rates and other data. The Cleveland Clinic Foundation has been designated as one of the top five hospitals in America since 1998 by U.S. News.
Interbody fusion cages are used widely to promote spine fusion in the treatment of degenerative disease, trauma and deformity. We undertook a study of clinically failed orthopaedic spinal implants in order to expand our understanding of biocompatibility, and mechanisms of implant failure and success.

Many surgeons use iliac crest autograft within these cages, but harvesting autograft is associated with donor site complications in at least 10 to 30 percent of patients. To avoid this morbidity, osteoinductive and osteoconductive materials — including recombinant human osteogenic protein-1, bone morphogenetic protein-2, demineralized bone matrix, and hydroxyapatite — have been tested in preclinical studies and have shown evidence of efficacy in generating intervertebral arthrodesis.

Interbody cages vary in size, shape, composition and flexibility. Most designs are hollow to permit filling with bone graft or bone-graft substitute materials. Lateral holes — of varying size and distribution — allow for potential vascular ingrowth and bone graft remodeling, facilitating fusion between adjacent vertebral bodies.

In spite of widespread use, there has been little histologic documentation of interbody cage contents from the human spine. We analyzed 102 retrieved cages — made of carbon-fiber-reinforced polymer, titanium mesh and other materials — from 66 cases, submitted by 36 surgeons at 33 different centers. The cages, mainly removed due to failed fusion or cage malposition or migration, were in situ for two to 87 months (21 months on average).

We visually estimated the approximate areas occupied by viable bone, necrotic bone, fibrocartilage, hyaline cartilage, fibrous tissue and bone-graft substitute, and expressed this as a percentage of available volume. Particles of debris were estimated by a semiquantitative scoring system.

Most cages showed evidence of vascular ingrowth and histologically viable bone, almost certainly representing incorporating bone graft. Average viable bone area was approximately 44 percent (0–80), a figure that did not correlate on average). We estimated the approximate areas occupied by viable bone, necrotic bone, fibrocartilage, hyaline cartilage, fibrous tissue and bone-graft substitute, and expressed this as a percentage of available volume. Particles of debris were estimated by a semiquantitative scoring system.

Most cages showed evidence of vascular ingrowth and histologically viable bone, almost certainly representing incorporating bone graft. Average viable bone area was approximately 44 percent (0–80), a figure that did not correlate with cage design. In some cages, cortical bone graft fragments were associated with minimal new bone formation, while small pieces of cancellous bone showed greater evidence of bone-graft incorporation. Previous basic science studies have demonstrated greater bone formation with cancellous vs. cortical bone grafts. Our observations suggest that segments of cortical bone graft may be less effective than cancellous bone from the iliac crest.

Several types of bone graft substitutes were present in the cages. We recognized residual demineralized bone matrix in seven cages, but found a small focus of endochondral bone formation in only one cage. Hydroxyapatite granules had been packed without bone graft in one cage. This cage developed about 50 percent bone apposition to the hydroxyapatite and about 20 percent viable bone by volume.

Hydroxyapatite granules had been inserted with bone graft into another cage, but the retrieved device showed no bone apposition and essentially no viable bone.

Particles of debris were present in 66 cages, but there was no histologic evidence of associated bone resorption. The cages contained a relatively high proportion of fibrocartilage (up to 70 percent of available volume). The fibrocartilage was predominantly of intervertebral disc origin. Bands of fibrocartilage connecting bone trabeculae were also present, especially in relatively long titanium mesh cages that had been placed vertically in the cervical spine. The distribution of these bands suggests that the cages may have experienced bending and/or compressive load.

Hyaline cartilage occupied more than 5 percent of the available area in 31 cages and was not associated with bone formation. It had the histologic appearance of articular cartilage, presumably derived from the vertebral end plate or facets, and was probably packed into cages along with local autograft, or entered through lateral holes during cage insertion.

Five cages contained elastic fibers, probably originating from fragments of ligamentum flavum or a similar structure. Another cage had fibers of unknown foreign material.

The results of this human retrieval study emphasize differences in the quality of bone graft preparations from different sites. Careful selection and use of graft substitute materials, and proper implant site preparation, are critical in spine fusion.

To speak with Dr. Isador Lieberman, a spine surgeon in the Department of Orthopaedic Surgery, please call 216/445-2743. To reach Drs. Thomas Bauer or Daisuke Togawa, members of the departments of Orthopaedic Surgery and Anatomic Pathology, please call Dr. Bauer’s office at 216/444-6830. To contact Dr. Edward Benzel, neurosurgeon and director of the Cleveland Clinic Spine Institute, please call 216/445-5514. The Cleveland Clinic’s toll-free number for physicians is 800/353-5056.
Avulsion of the distal biceps from its insertion at the bicipital tuberosity is becoming more frequent, largely as a result of our aging, yet active population. For most patients, anatomic reinsertion provides results superior to nonoperative treatment and brachialis tenodesis.

Repair techniques have evolved over the years in response to complications and technical difficulties attributed to the surgical approach and the means of fixation. At present, the modified two-incision technique is utilized most commonly. Though the safety and efficacy of this procedure have been well-documented, heterotopic ossification with cross-union of the radius and ulna remains a potentially devastating complication of the procedure.

In order to diminish this risk and to allow for earlier functional rehabilitation, we now utilize a single-incision technique that employs a directed surgical approach and suture-anchor fixation. A series of 32 Cleveland Clinic patients treated in this manner achieved full, active elbow motion within six weeks. One year postoperatively, supination strength was 7 percent less and elbow flexion strength 8 percent less than the contralateral arm.

Twenty of these 32 patients were assessed with the Disabilities of the Arm, Shoulder, and Hand outcome questionnaire before surgery and at least one year afterward. The scores improved significantly.

The technique for distal biceps repair favored at The Cleveland Clinic utilizes a 3-cm longitudinal incision along the medial border of the brachialis, beginning 1 cm distal to the elbow flexion crease. The vulnerable lateral antebrachial cutaneous nerve is quickly encountered and protected.

The interval between the brachialis and the pronator teres is developed with the forearm fully supinated to protect the posterior interosseous nerve. Frequently, a leash of vessels is present and must be ligated. To avoid nerve injury, right-angle retractors are utilized rather than self-retaining or Homan retractors.

The radial tuberosity is located by palpation at the distal, ulnar border of the supinator. The bursa and tendon remnants leading to the previous site of tendon insertion are excised. The cortex of the tuberosity is abraded between the locations destined for suture-anchor placement.

The ruptured biceps tendon is retrieved in the distal arm, just superficial to the brachialis fascia. Degenerative tissue is sharply debrided from the tendon stump. Two 3.5-mm Mitek Super anchors, preloaded with #2 Ethibond suture, are each loaded with another #2 Fiberwire suture. One anchor is placed proximally and one distally along the posterior border of the radial tuberosity while the forearm is hypersupinated.

One limb of the Fiberwire from each suture is woven through the biceps tendon using a Krackow stitch and then tied proximally. One limb of the Ethibond from each anchor is sewn through the tendon using a Bunnell stitch and tied proximally. The tendon is guided to the tuberosity as tension is placed on the remaining suture ends in an alternating fashion.

Sequentially tying the remaining sutures from each anchor, tendon remnant and sheath.

Dr. Thomas Hunt, head of the Section of Hand Surgery, can be reached at 216/445-6426 or 800/553-5056, ext. 56426.
Cleveland Clinic’s Center for Research on the Diabetic Foot Established

By Peter R. Cavanagh, Ph.D., and Peter J. Evans, M.D., Ph.D.

Orthopaedic surgery is beginning to merge with biomedical engineering and neuroscience to offer a more complete understanding of the mechanisms underlying injury or disease-related functional deterioration, and functional recovery after treatment.

Orthopaedic surgery related to subcortical neuromuscular and musculoskeletal systems frequently focuses on the spinal cord and peripheral nerve components of the sensorimotor control mechanisms involved in limb movement. Sophisticated electrophysiological, electromyography and functional magnetic resonance imaging (fMRI) of cortically mediated musculoskeletal control mechanisms, in conjunction with peripheral components, may improve our understanding of normal and pathologic anatomy and physiology.

Brain activation of voluntary movement has traditionally been examined via invasive single-cell recordings in trained animals, subdural EEG recordings in patients undergoing neurological surgery, or positron emission tomography, which examines regional blood flow changes in the brain. Although these techniques are still used, their application for clinical evaluation is limited by their invasiveness, limited sampling areas in single-cell and subdural recordings, and poor resolution in PET.

Advances in noninvasive fMRI and multichannel scalp EEG recordings now allow for repeated evaluations with excellent resolution of central nervous system reorganization/ adaptations due to injury or rehabilitation.

Functional MRI signals result from the so-called blood oxygen level-dependent (BOLD) effect. Increased neural activity in a cortical region augments local brain blood flow. On the other hand, oxygen consumption increases only slightly or not at all, reducing the relative content of deoxyhemoglobin in the affected brain region.

Because deoxyhemoglobin is paramagnetic, it produces microscopic magnetic inhomogeneities that increase the dephasing, or desychronization, of spinning hydrogen protons. A decrease in the quantity of deoxyhemoglobin reduces the rate of signal decay, causing a relative fMRI signal increase (compared to the control condition) in the area where uncoupling of changes in blood flow and oxygen consumption occurs.

Besides its noninvasive feature, fMRI offers such advantages as high spatial resolution (1 to 2 mm) and flexibility of signal presentation (two- or three-dimensional, at any plane). Functional MRI can also map activation patterns, recruitment and fatigue in target muscles.

This unique 3-D perspective is not seen with traditional EMG or MRI. For example, selective activation of the flexor digitorum profundus can be observed, and the activated muscle can be traced along the forearm, which is the distal interphalangeal joints of the fingers alone are moved.

Brain function is also increasingly studied via scalp EEG, which records integrated electrical signals of cortical neurons.

There have been two major advances in scalp EEG. One is a dramatic increase in the number of electrodes used for data collection, which improves spatial resolution of the EEG signal. The largest number of channels used has been 512, although 32 to 128 channels are used most often for mapping brain electrical signals.

The other advance is the increasing sophistication of data analysis software. New software packages allow for co-registration of EEG data with MRI or fMRI, data analysis in both time and frequency domains; signal correlation among different cortical regions or between brain and muscle; directional observation of signal flow from one region to another; or estimation of signal sources from scalp EEG on a 3-D brain model.

Compared with fMRI, EEG data provide greater time resolution and probably greater reproducibility of results, largely because they directly measure cortical electrical activity.

In the future, fMRI signals, EEG, EMG and motor performance (such as force or movement) will be investigated simultaneously. This should offer insights into central and peripheral mechanisms of sensorimotor control over joint movement and stability in injury, surgery and recovery. Brain and muscle activation patterns will be studied longitudinally to evaluate the effects of surgical procedures, and the efficacy of rehabilitation.

All of these insights will be important in developing more effective medical interventions.

By Guang H. Yue, Ph.D., and Peter J. Evans, M.D., Ph.D.

Functional MRI, EMG and EEG Shed New Light on Neural Control of Limb Movement

By Peter R. Cavanagh, Ph.D.

Cleveland Clinic’s Center for Research on the Diabetic Foot Established

By Guang H. Yue, Ph.D., and Peter J. Evans, M.D., Ph.D.

Functional MRI study of muscle activation in female who never exercises (upper row) and well-trained male (lower row). Green = low muscle activation; red = high-intensity activation. Functional images in middle result from small number of elbow flexions against a load, and at right from exercising elbow flexors to exhaustion. (Most red pixels in middle result from blood flow artifacts. Panel size = 1 mm.)

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Dr. Guang Yue, who directs the Neural Control of Movement Laboratory in the Department of Biomedical Engineering at the Cleveland Clinic Lerner Research Institute, can be reached at 216/445-9336 or 800/553-5056, ext. 59336. Dr. Peter Evans, of the Section of Hand and Upper Extremity Surgery as well as the Lerner Research Institute, directs the Cleveland Clinic’s Peripheral Nerve Center. He can be reached at 216/444-7973 or 800/553-5056, ext. 47973.

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The Center for Research on the Diabetic Foot, based in the Department of Biomedical Engineering within the Cleveland Clinic’s Lerner Research Institute, was established to study all aspects of diabetic foot disease. The center is part of The Clinic’s new comprehensive Diabetic Foot Care Program.

Our research on new approaches to wound healing, high-technology footwear solutions, alternates methods of drug delivery to patients with foot wounds, and Charcot fractures may be of particular interest to orthopedic surgeons dealing with diabetic foot disease.

To explore new approaches to wound healing, we are pursuing a basic understanding of the molecular biology of the process. A molecular dermatologist associated with our center has developed a model that allows for in vitro study of gene expression in any relevant agent. Clinically, this may lead to a targeted approach to wound healing by enhancing the expression of factors responsible for delayed healing.

In another study, a radiation oncologist is proposing to target growth-factor molecules, tagged with magnetic microspheres, to their delivery site in foot ulcers by means of a magnetic wound dressing.

In hopes of developing new footwear solutions for diabetic patients, we are using finite element models of the foot–shoe interface to predict stresses on plantar tissue. This approach should elucidate the general rules underlying geometry and material properties of footwear intervention.

We also have an interest in “intelligent footwear” that can warn the subject about the etiopathogenesis of Charcot’star disease. This approach should elucidate the general rules underlying geometry and material properties of footwear intervention.

In addition, we hope to learn more about the etiopathogenesis of Charcot’s neuroarthropathy. At the present time, the factors that lead to this devastating complication of diabetes are poorly understood, and treatment consists simply of immobilization. The combined efforts of the many bone biology experts in the Biomedical Engineering Department may finally shed light on this important condition.

Other research under way in the Center for the Diabetic Foot involves:

• MRI imaging of the foot gait and movement problems with those with diabetic neuropathy
• mechanical characteristics of skin and bone in diabetes
• pressure-distribution measurement under the foot
• robotic approaches to the study of foot mechanics, and
• foot complications among African-Americans.

Our new, multidisciplinary Diabetic Foot Care Program integrates a variety of clinical and research activities into one
Using “Old Bones” to Discover New Information About the Anatomy of the First Metatarsal

By Brian Donley, M.D., and James J. Sferra, M.D.

A study we conducted in collaboration with the Cleveland Museum of Natural History may help to predict which patients are at risk for the development of hallux valgus deformity and to direct the course of treatment. Certain anatomical differences in shape, size, and position of the hallux are known to contribute to the development of hallux valgus. Attempts to quantify differences in position through the measurement of a number of angles — including the distal and proximal metatarsal articular angles — have been controversial. The method of measurement, validity and usefulness of these angles have all been called into question.

However, data concerning differences in shape and size, and other anatomical configurations of the hallux metatarsal, are scarce in the literature. Thus, we decided to investigate anatomic variations of the first metatarsal bone, including its dimensions and the angulations of its articular surfaces, in a large diverse sample representative of the general population.

Our Diabetic Foot Clinics, established in April 2003 at our main campus and academic director of the Cleveland Clinic Diabetic Foot Care Program. He has been involved in the study of diabetic foot complications for a number of years, including a term as chair of the American Diabetes Association Council on Foot Care. Dr. Cavanagh works closely with Joseph Iannotti, M.D., Ph.D., chairman of the Department of Orthopaedic Surgery. Dr. Cavanagh specializes in all aspects of foot and ankle reconstruction. He can be reached at 216/445-2570 or 800/553-5056, ext. 52570.

In our study, we used 478 bones from 239 specimens within the Hamman-Todd Osteological Collection to record:

• distal metatarsal articular angle (DMAA)
• surface shape
• proximal metatarsal articular angle (PMAA)
• height
• width at the mid-region of the shaft, and
• existence of a joint between the bases of the first and second metatarsals.

We attempted to correlate these anatomic measurements with the specimens’ weight, height, sex, race and age. Using a specially designed computer program, the DMAA and PMAA were measured in relation to the shaft of the first metatarsal bone, from a digital picture. We found that males and African-Americans had longer and wider metatarsals than females and Caucasians. A joint was present between the first and second bases in 25 percent of the specimens.

The DMAA ranged from 30° of lateral deviation to 14° of medial deviation, with an overall average of 8.2°. It increased 1.2° to 3° with every 10-year increment in age for both the right and left bones (p<0.013 and <0.001, respectively). The average increase from 20 to 60 years of age was 4.45°.

The PMAA (normally medially deviated, as reported in the literature) ranged from 12.7° of medial deviation to 13.8° of lateral deviation, with an overall average of 0°. Medial deviation of this angle was increased among African-Americans and in wider shafts. Lateral deviation of the PMAA was significant when a joint was present between the bases of the first and second metatarsals (p<0.001).

Of clinical importance were the findings that the DMAA had a wider range than reported in the literature and that it increased with age. This might influence the choice of treatment. Although noting an increased DMAA is important in adolescence, it may also be important in the older population when determining surgical treatment for a hallux valgus deformity.

In addition, lateral deviation of the PMAA — which was common when an articulation was present between the first and second metatarsals — could predispose to a varus first metatarsal as well as a hallux valgus deformity. This elevated PMAA may need to be addressed surgically and should be looked for, especially in an individual with a 1-2 metatarsal joint.

Fortunately, we were able to access the Hamman-Todd Osteological Collection at the Museum of Natural History, which contains 3,100 human skeletons collected between 1893 and 1938. This autopsied skeletal collection attracts researchers in the fields of anthropology, forensics and medicine from around the globe. It is especially valuable to forensic and medical researchers because the age, sex, race and cause of death for each specimen are known.

Thus, researchers have been able to investigate such areas as anomalies of the thoracic bodies in individuals with Scheuermann’s kyphosis; sex, race and height from skeletal remains; anatomical differences among sexes and races; and skeletal changes caused by various disease processes.

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Dr. Brian Donley, the Section of Foot and Ankle Surgery, has a strong interest in research and in the treatment of fractures and bunions, reconstruction after foot and ankle trauma, acquired deformities including flat feet, and arthritis and sports injuries in the foot and ankle. He can be reached at 216/445-2570 or 800/553-5056, ext. 52570.

Dr. James Sferra, head of the Section of Foot and Ankle Surgery, specializes in all aspects of foot and ankle reconstruction. He can be reached at 216/445-8507 or 800/553-5056, ext. 58507.
SLAP Lesions of the Shoulder: A Diagnostic Challenge

By James S. Williams, M.D., and Richard D. Parker, M.D.

While progress has been made in detecting "SLAP" lesions by clinical exam and MRI arthrography, diagnosis remains a challenge to treating physicians. Denoting injury to the "Superior glenoid Labrum from Anterior to Posterior," SLAP lesions typically cause patients to develop pain and a popping or clicking of the shoulder with elevation, adduction or internal rotation. However, the physical exam can often be equivocal.

The labrum, a fibrocartilagenous structure, helps to deepen the socket of the glenoid. Loss of superior labral stability reduces the ability to withstand inferior translation of the humeral head on the glenoid. The ability to withstand external rotation forces, thereby placing greater stress on the inferior gleno-humeral ligament and increasing patients' susceptibility to anterior instability, also occurs. The long head of the biceps serves as a humeral-head depressor and in the abducted position helps to limit internal rotation.

The most common injuries are due to compression or traction. Compression, where the superior labrum is driven cephalad by the humeral head, occurs from a fall on an outstretched arm. The typical traction injury mechanism involves a sudden eccentric load to the biceps tendon, such as catching a falling object.

Four types of SLAP lesions can develop: Type I, where the superior labrum is frayted and degenerated, but the biceps anchor is intact; Type II, where the superior labrum and biceps anchor are detached from the insertion on the superior glenoid neck; Type III, where the superior labrum has a bucket handle tear, but the remaining biceps tendon and labral rim attachment are intact; and Type IV, where a bucket-handle tear of superior labrum extends into the biceps anchor, and the torn biceps tendon and labral flap are displaced into the joint.

A careful history — with attention to mechanism of injury—description of pain and popping or grinding, and loss of range of motion and strength — will lead one in the direction of a SLAP injury.
and partial synovectomy to relieve the player’s tendinitis. A foot cast was prescribed for three weeks, and a rocker-bottom boot for three more, to allow for ambulation and ankle mobility.

At that point, proprioceptive, peroneal strengthening and heel-cord stretching exercises were prescribed by Cleveland Clinic Sports Health physical therapists to strengthen (and preserve range of motion) in the ankle. After two more months of physical therapy, the player rejoined his team in time for an exciting playoff run.

Dr. Bergfeld and his team of knee, ankle, shoulder, elbow and hand specialists have been called on for such second opinions by more than 100 professional or semi-professional athletes over the last five years. These include figure skaters, hockey players, football players, golfers, tennis players and soccer players from around the world, as well as elite athletes at the high school and college levels.

Some of the common injuries they see in these athletes besides tendinitis are anterior cruciate ligament tears, torn rotator cuffs, cervical spine fractures, transient paraplegia, ligamentous injuries to the elbow and cardiac problems, especially rhythm disorders. Retired sports figures also seek help at The Clinic for conditions such as post-traumatic arthritis, spinal stenosis, degenerative arthritic problems and cardiovascular disorders, says Dr. Bergfeld.

Richard D. Parker, M.D., head of the Orthopaedic Surgery Department’s Section of Sports Medicine, notes that “90 percent of all team physicians have the athlete’s best interests in mind. However, because of the physician’s relationship with management, players are often gratified to get a neutral opinion from a party with no financial interest.”

Dr. Bergfeld adds, “Evaluation by a third party away from their intense professional environment can help to alleviate an athlete’s concerns. But that goes both ways. An objective evaluation also helps team management understand what is at stake for the athlete.”

Bob Kain, president and co-chief executive officer of IMG, a Cleveland-based sports management company representing hundreds of professional athletes, agrees. “Part of our job is protecting our athletes,” he says. “When they get hurt, it’s understandable that they want a second opinion from someone not connected to the team or to any sponsorship deals they may have lined up.”

Mr. Kain likes the continuum of care provided at The Cleveland Clinic, where the same team of health care professionals handles the athlete’s diagnosis, surgery and rehabilitation. “That helps prevent athletes from coming back too fast and possibly re-injuring themselves,” he notes. “A multispecialty hospital is a great resource.”

Cleveland Clinic sports medicine specialists work closely with orthopaedic surgery colleagues also experienced in dealing with elite athletes. For non-sports-related problems, they consult with other specialists among the 120 disciplines represented at The Cleveland Clinic. For consultations or second opinions on the full range of sports injuries, please call 877/440-TEAM (8326).

### Consider Age and Other Factors in Treating First-Time Shoulder Dislocation

By Richard D. Parker, M.D., and James S. Williams, M.D.

Treatment for first-time shoulder dislocation varies, depending on chronicity, age, traumatic vs. atraumatic injury, degree of joint laxity and severity of injury.

For young patients with first-time dislocations of the glenohumeral joint, acute operative treatment provides a more predictable outcome, with higher success and patient satisfaction rates than nonoperative treatment. In contrast, older first-time dislocators without rotator cuff injury often do well with rehabilitation.

The shoulder is the most mobile joint in the body, relying on a complex interplay between dynamic stabilizers (muscles) and static stabilizers (bone, ligaments, capsule and labrum). There is tremendous individual variation in shoulder laxity.

Subluxation and dislocation are two pathologic processes responsible for shoulder instability, or symptomatic excessive translation of the humeral head on the glenoid. In subluxation, the humeral head slides partially out of the glenoid; in dislocation, the humeral head comes completely out of the glenoid.

Anterior instability accounts for 95 percent of all shoulder instability. Traumatic anterior instability is seen more often in young athletes playing contact sports. Multidirectional instability — inferior plus anterior being the most common — is more common among athletes using repetitive overhead movements, such as swimmers.

Subtle forms of instability (repetitive subluxation) produce pain, weakness, occasional numbness and a sense of the shoulder shifting in the socket. The physical exam typically demonstrates weakness, scapular winging and greater translation of the humeral head on the glenoid in the injured shoulder.

Dislocations can be transient and reduce on their own, but often require reduction in an emergency room. The mechanism of injury is typically excessive force to an abducted externally rotated arm, such as an arm tackle in football. After reduction, patients demonstrate persistent apprehension to motions that simulate the position of their arm at the time of injury.

Those with less severe forms of subluxation will often respond to a good physical therapy program, emphasizing rotator cuff and scapular-stabilizer strengthening exercises. Athletes have to be consistent with these exercises year-round or risk symptom recurrence. Should they fail conservative measures, arthroscopic or open repair of the injured capsule, ligaments, and/or labrum will be necessary.

The treatment of traumatic dislocations often varies by age. The younger the patient, the greater the chance of redislocation. The redislocation rate for teenagers is over 90 percent. For those aged 40 and older, the redislocation rate is much lower, but the chance of associated rotator cuff tear is very high.

MRI arthrography is most helpful in the traumatic dislocator group, providing information not only about the anterior labral injury (Bankart lesion), but also about the rotator cuff in older patients. Older patients without rotator cuff injuries do well with rehabilitation, although younger first-time dislocators do not.

Because of their high recurrence rate, arthroscopic or open fixation of the anterior labrum back to the glenoid using suture anchors or bioabsorbable tacks has gained popularity for young athletes playing contact sports. Success rates for preventing redislocation are in the 90 percent range with surgery, compared to 10 percent without surgery.

Dr. Richard Parker, head of the Section of Sports Medicine, specializes in arthroscopy, and knee and shoulder surgery. He can be reached at 216/444-2992 or 800/553-5056, ext. 42992.

Dr. James Williams, medical director of Cleveland Clinic Orthopaedics at Euclid Hospital, specializes in sports medicine, knee and shoulder surgery and arthroscopy, as well as cartilage repair/ transplantation. He can be reached at 216/892-7770.
Painless Total Knee Arthroplasty Employs Indwelling Epidural Catheter for Pre-Emptive Analgesia

By Peter J. Brooks, M.D.

One of the challenges facing orthopaedic surgeons is control of pain following surgical procedures. Pre-emptive analgesia using an indwelling epidural catheter can achieve “painless total knee replacement.”

Total knee arthroplasty has become increasingly common. More than 300,000 total knee arthroplasties are now performed annually in the United States. Pain is one of the major concerns for these patients and their health care providers. Severe pain, reported by 60 percent of patients following total knee arthroplasty, interferes with rehabilitation, and leads to stiffness and dissatisfaction with outcome. This can create apprehension about surgery in patients, as well as the community at large.

Postoperative pain relief can be achieved after total knee arthroplasty by a variety of techniques, including intravenous patient-controlled analgesia (IVPCA), oral pain medication, femoral nerve blocks and epidural analgesia. Conventional IVPCA accomplishes the goal of postoperative pain control. However, by affecting the brain — distant from the source of the pain — systemic effects include sedation, GI disturbances and respiratory depression. Patients self-administer narcotics in response to pain perception, so pain is not prevented. Severe pain is often experienced in the early postoperative period as the spinal wears off.

There is increasing interest in alternative techniques, such as indwelling epidural catheters, to provide steadier, more effective analgesia and avoid the episodic, excruciating pain that requires aggressive treatment. This analgesic effect can be considered pre-emptive, preventing pain before it even occurs.

Analgesia using an indwelling epidural catheter offers several advantages. It can be the sole method of providing anesthesia as well as postoperative pain management, or it can be used in conjunction with a spinal anesthetic or general anesthesia.

A functioning epidural catheter prevents the “wind-up” phenomenon of severe pain in the recovery room, which recruits additional pain pathways and causes hyperpolarization of the dorsal column, making subsequent pain control more difficult to achieve.

In patients with severe pain, nerve fibers are dorsal before they enter the epidural space, allowing the patient to move the knee during physical therapy without associated pain. This can speed rehabilitation and lead to shorter hospital stays.

A randomized study of patients undergoing total knee arthroplasty at The Cleveland Clinic, 381 individuals were assigned to either spinal or epidural anesthesia. Pain scores were obtained at rest and during physical therapy. There was a significant decrease in pain reported by those patients with an epidural catheter compared to those who had IVPCA followed by oral pain medicine.

No complications occurred that could be attributed to the epidural catheter, which was left in place for up to seven days. Epidural analgesia also had a beneficial effect with regard to thrombophlebitis. This is important, because patients with indwelling epidural catheters are not given low-molecular-weight heparin for thromboprophylaxis, due to the rare but calamitous occurrence of an expanding epidural hematoma.

It has been well-established that regional anesthesia is superior to general anesthesia in rates of deep vein thrombosis. This is due to increased peripheral blood flow, an effect that is prolonged with indwelling epidural catheters. In addition, platelet aggregation is directly inhibited by local anesthetics, which are absorbed into the circulation from the epidural infusion.

The patient comfort produced by an epidural catheter also results in decreased sympathetic tone, associated with a lower tendency toward DVT formation. In our study, there was no difference in the DVT rate between the two groups as assessed by duplex ultrasound, even though patients who received spinal anesthetics were treated prophylactically with enoxaparin, while those with an epidural were not.

Advances in the understanding of gene expression have revealed the existence of a family of nuclear hormone receptors that regulate gene transcription. These receptors are co-expressed.

Given that peroxisomal function is required for normal endochondral ossification and that thyroid hormone plays a central role in regulating skeletal maturation at the growth plate, it is reasonable to ask whether cross-talk exists between TR- and PPAR-mediated gene transcription in growth plate chondrocytes. This is an active area of research.

Epidemiological studies of SCFE demonstrate that more than half the children with this disorder are over the 95th percentile in weight and the 97th percentile in height for their age. SCFE is also more common among African-American children and lower socioeconomic groups, observations which may simply reflect the increased risk of obesity in these subpopulations.

In addition to increased body mass, delayed skeletal maturation has also been found in children with SCFE. Although the etiology of SCFE is unknown, the combination of increased mechanical stress resulting from obesity, along with the relative weakness in the growth plate associated with delayed skeletal maturation, have been suggested as ultimate causes.

In light of the central role played by thyroid hormone in regulating skeletal maturation at the growth plate, it is not surprising that even normal-weight children with hypothyroidism are known to be at increased risk of SCFE.

Advances in the understanding of adipogenesis and lipid metabolism at the molecular level reveal the existence of a family of nuclear hormone receptors that link nutritional signals to the control of gene expression. These receptors are induced or activated in response to a high-fat diet.

These molecules, termed peroxisome proliferator-activated receptors (PPARs), are also expressed in bone and cartilage, and may interfere with thyroid hormone receptor (TR)-mediated gene transcription in cells in which the receptors are co-expressed.

Research Points to “Functional Hypothyroidism” as Link Between Obesity and SCFE

By R. Tracy Ballock, M.D.

The long-term health consequences of obesity in childhood include diabetes, hypertension, gall bladder disease and sleep apnea. Slipped capital femoral epiphysis (SCFE) — in which dysfunction of the proximal femoral growth plate allows the proximal femoral epiphysis to slide off the underlying metaphysis — is a common orthopaedic consequence of obesity in children.

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Given that peroxisomal function is required for normal endochondral ossification, and that thyroid hormone plays a central role in regulating skeletal maturation at the growth plate, it is reasonable to ask whether cross-talk exists between TR- and PPAR-mediated gene transcription in growth plate chondrocytes. Precoding observations of the convergence of signaling pathways for the receptors suggest that obesity may induce the expression of PPAR isoforms in growth plate chondrocytes. These isoforms may then interfere with normal thyroid hormone-mediated regulation of skeletal maturation.

The delay in maturation at the growth plate, combined with mechanical stress from the increased body weight, may combine to cause the failure of normal growth plate function that allows the proximal femoral epiphysis to slip.

SCFE in obese euthyroid children, who represent the most common subset of patients with this disorder, may therefore be caused in part by a “functional hypothyroidism.” This would result from inhibition of TR-mediated gene transcription by PPARs, despite normal circulating levels of thyroid hormone.

Our laboratory is testing the hypothesis that PPARs are inducible repressors of TR-mediated gene transcription in growth plate chondrocytes. If our hypothesis is confirmed, these data will provide a firm biological foundation for returning to the bedside for clinical studies of potential PPAR activation in obese euthyroid children with slipped capital femoral epiphyses.

Frog lateral radiograph of child’s hip demonstrates a slipped capital femoral epiphysis. The epiphysis of the femoral head is slipping posteriorly on the femoral neck, through the growth plate.

Dr. Tracy Ballock, head of the Section of Pediatric Orthopaedic Surgery, directs a laboratory supported by a $1.2 million, four-year NIH grant. In his clinical practice, Dr. Ballock focuses on hip dysplasia, clubfoot deformity, leg-length discrepancy and other pediatric orthopaedic disorders. To reach Dr. Ballock, please call 216/444-5775 or 800/553-5056, ext. 44284.
Anterior Spinal Fusion for Pediatric and Adolescent Spinal Deformity: Shorter Fusions, Greater Corrections

By Thomas E. Kuivila, M.D.

It has become a cliché to state that the advent of new technology has “dramatically changed” an orthopaedic procedure and its results. Clearly, total hip implants have changed significantly in the past 25 years, yet we continue to compare the results of total hip arthroplasty with the Charnley prosthesis. Therefore, when we look at spinal surgery in adolescents, we have to look not only at length of stay, and whether or not the rods are titanium. We need to be sure that we are using the best approach, not just the newest.

Having said that, adolescent idiopathic scoliosis surgery really has gone through a revolution in the past 10 years; we appear to be doing a better job on all fronts because of changes in instrumentation and philosophy. The resurgence of interest in the anterior approach to curve correction is largely due to advances in implant design and technology.

The chief goals of scoliosis surgery — to halt curve progression and fuse the affected segment of the spine — remain the same. Segmental fixation has essentially eliminated postoperative casting and bracing in the large majority of cases.

The main advantage of the anterior approach to curve correction is that it allows us, in most cases, to fuse a shorter segment of the spine while achieving an equal, if not greater, correction than the posterior approach. Fusion of vertebral bodies is typically rapid and reliable, and future procedures to the posterior lumbar spine (especially lumbar puncture and epidural anesthesia) are not affected.

Although anterior spinal instrumentation has been available for more than 30 years, the unreliability of some implants, and the need for postoperative immobilization, limited both applicability and enthusiasm for their use. Today’s implant systems are exceptionally stable and strong, allowing powerful corrective forces to be applied to the curve. Their stability allows for a brace-free postoperative course and independent ambulation, usually by the third postoperative day.

The anterior approach is indicated for treatment of curves both of the lumbar and thoracic spine, as well as thoracolumbar curves. The King II and III curve, previously in the pure domain of the posterior approach, can now be managed through an anterior approach via thoracotomy, or in some cases, thoracoscopy. Thoracolumbar curves are approached through a thoracoabdominal approach, facilitating exposure above and below the diaphragm.

Fixation in the anterior portion of the spine is achieved through screws placed transversely through the vertebral body at each level. The screw, in turn, is affixed to a rod that varies in diameter from 4.5 mm to 6.5 mm. Many spinal surgeons prefer to use titanium implants anteriorly so as not to affect future MRI compatibility.

Two screws per vertebral body and a dual rod construct are frequently used for thoracolumbar curves, while a single rod construct is more typical for pure thoracic applications.

Hospital stay following instrumented anterior fusion is essentially the same as for posterior fusion. Return to school is typically at the three- to four-week mark, and athletic activities are restricted until the vertebral bodies demonstrate good radiographic consolidation — usually at six to eight months.

While much remains to be studied when comparing anterior to posterior fusion using current technology, early data certainly indicate that correction of the curvature is comparable, if not superior, to traditional posterior instrumentation. Clearly, the number of levels requiring fusion is less with the anterior approach.

Internal thoracoplasty, resulting in markedly improved cosmetic appearance, is easily performed during the procedure. This provides an abundant supply of autogenous grafting material, sparing the expense of allograft bone and the morbidity of obtaining bone from the iliac crest.

While not all curves are currently appropriate for a pure anterior approach, it is an excellent tool in our expanding surgical armamentarium for the treatment of spinal deformities.

Dr. Thomas Kuivila, of the Section of Pediatric Orthopaedics, specializes in scoliosis surgery, and pediatric and adolescent trauma surgery. He can be reached at 216/444-2741 or 800/553-5056, ext. 42741.
Cervical Laminaplasty: Fewer Risks for Selected Patients with Cervical Myelopathy

By Gordon R. Bell, M.D.

Cervical laminoplasty, or posterior decompression of the spinal cord without removal of the lamina, avoids some of the risks and complications associated with laminectomy for many patients with cervical myelopathy.

Cervical myelopathy — in which cervical spinal cord compression produces a syndrome characterized by progressive neurological dysfunction — may be of full-blown form cause gait disturbance, extremity weakness, and bladder and bowel dysfunction. Objective neurological findings include long-tract signs such as spasticity, hyperreflexia and clonus. Abnormal neurological signs, such as a Babinski response and Hoffman sign, may also be present.

The etiology of cervical myelopathy is diverse, but common causes include spinal cord compression due to disc herniation or age-related degenerative changes (cervical spondylopathy or CSM).

When cervical myelopathy has a compressive cause, surgical decompression is the treatment. Its goals are to reduce the potential for progression and further clinical deterioration, and to allow for some improvement in function. However, decompression — whether performed posteriorly or anteriorly — has its risks.

Anterior decompression involves either anterior cervical discectomy and fusion for myelopathy from disc herniation, or multilevel corpectomy and fusion for more diffuse disease. Potential risks associated with multilevel anterior corpectomy include:

- neural injury from insertion of a Kerrison rongeur into a severely compressed spinal canal
- esophageal injury
- dysphagia from injury to the recurrent laryngeal nerve and vertebral artery injury from extreme lateral decompression.

Dysphagia following lengthy anterior decompression is more common than previously believed, and may be particularly problematic in elderly patients by interfering with nutrition.

Posterior decompression — traditionally involving cervical laminectomy, or removal of one or more lamina to decompress the central and foraminal canal — avoids many of the risks associated with anterior surgery. However, laminectomy has several drawbacks, including potential neurological deterioration from insertion of surgical instruments into a severely stenotic spinal canal, and risks of kyphotic deformity, particularly in young patients, unless laminectomy is accompanied by posterior instrumented fusion. This is due to loss of the protective and stabilizing functions of the posterior bony and ligamentous structures.

In 1938, Japanese surgeons introduced cervical laminaplasty as an alternative to laminectomy for posterior cervical decompression for CSM due to ossification of the posterior longitudinal ligament (OPLL).

Cervical laminaplasty has since been advocated for cervical spondylopathy due to other etiologies. Laminaplasty, involving posterior decompression without removal of the lamina, expands the spinal canal by “hinging” the lamina open (see illustrations). Because it permits the spinal cord to gently displace posteriorly, it depends upon having a lordotic posture; cervical kyphosis is a contraindication to laminaplasty.

The advantages of laminaplasty for spinal canal decompression include:

- avoiding risks associated with anterior surgery
- preserving the protective and stabilizing function of the lamina
- eliminating the need for fusion because spinal stability is not compromised and the ability to decompress cervical nerve roots on the open side by facetectomy.

Disadvantages include reduced range-of-motion and increased risk of neck pain, and potential injury to the C5 nerve root. This is thought to be a traction injury due to the increased posterior excursion of the C5 root as the spinal cord displaces posteriorly following laminaplasty.

The primary technical problem associated with laminaplasty is inadvertent closure of the hinged lamina. Various techniques have been reported for keeping the hinged “door” of the lamina open. The most widely used is Hiraibayashi’s method, in which a suture placed around the facet capsule at each level on the hinged side of the laminaplasty is passed through the supraspinous and inframescal ligaments, and then around the spinous process.

Other techniques and modifications devised to keep the hinge door open and expand the spinal canal all share the same characteristic: preservation of the lamina and posterior ligamentous structures.

In cases of CSM in which cervical lordosis is present, decompression may be safely accomplished by either anterior corpectomy and fusion, or by posterior cervical laminaplasty. If cervical lordosis is not present, however, laminaplasty is contraindicated, and decompression must be accomplished anteriorly.

Dr. Gordon Bell, head of the Section of Spine Surgery within the Department of Orthopaedic Surgery, is also vice chairman of the department, and a member of the Cleveland Clinic Spine Institute. He may be reached at 216/444-8126 or 800/553-5056, ext. 48126.

Posterior view of cervical spine shows intended site of full-thickness osteotomy (solid red line) and intended site of partial (greenstick) osteotomy (dotted red line). Laminaplasty typically extends from C3 through C7.

Axial view post-laminaplasty shows lamina opened on left side and hinging of laminaplasty “door” through partial-thickness cut.

Axial view post-laminaplasty shows intended site of full-thickness osteotomy on left side through full-thickness osteotomy, and hinging of laminaplasty on right through partial-thickness cut.

Axial view post-laminaplasty shows intended site of full-thickness osteotomy on left side through full-thickness osteotomy and intended site of partial thickness cut on right side. Suture placed through right facet joint capsule and tie around spinous process keep “door” open; such sutures are placed at each level included in laminaplasty.
State-of-the-Art Conference Facilities

The new 35,000-square-foot MBNA Conference Center, in the InterContinental Hotel on the Cleveland Clinic campus, will be home to many upcoming CME symposia. Its 500-seat amphitheater, interconnected to eight breakout rooms, is furnished with state-of-the-art audiovisual and sound systems. Each amphitheater seat is equipped with high-speed Internet access and an audience response system for instantaneous polling. A link to Cleveland Clinic operating theaters allows participants to view procedures and question surgeons in real time.

Cleveland Clinic Bone Summit 2004

The first Cleveland Clinic Bone Summit, “The Clinical Science of Skeletal Repair, Maintenance and Regeneration,” slated for May 13 to 15, 2004, will explore innovative yet practical means of local and systemic repair, augmentation and regeneration of bone tissue. Cell-based therapeutic strategies — including methods of targeting specific cell populations and cellular processes using customized implant materials, bone morphogenic proteins (BMPs), PTH, bisphosphonates and statins — will be addressed.

An internationally renowned faculty will lead participants in an exploration of contemporary biological concepts and technologies essential to the design and assessment of rational, efficient clinical strategies for bone tissue-engineering and maintenance of skeletal health. These include: stem cell biology, stem cell kinetics, growth factor and cytokine action and delivery, implant and biomatrix design, cell-matrix interaction, strategies for intraoperative stem cell isolation, manipulation and transplantation, the role of in vivo mass transport and mechanobiology in tissue-engineered grafts, and skeletal health.

Quantitative assessment of stem cell kinetics, bone mass and structural organization will be defined and applied in the context of contemporary clinical and research settings. Clinically oriented sessions will focus on fractures and fracture non-union, bone-grafting for spinal fusion, skeletal reconstruction, surgical treatment of bone deficiency, and systemic prevention and treatment of osteoporosis.

Speaking at the landmark summit will be innovators and intellectual leaders in the fields of orthopaedics, neurosurgery, ENT, oral surgery, rheumatology, endocrinology, radiology, pathology, bone-tissue engineering and bone biology. Experts in the fields of bone biology and skeletal therapeutics will provide plenary overviews and lead discussions on basic research and clinical paper presentations.

The summit is sponsored by the Cleveland Clinic’s Department of Orthopaedic Surgery, Department of Biomedical Engineering, Orthopaedic Research Center, Center for Osteoporosis and Metabolic Bone Disease, and Center for Women’s Health. The venue is the state-of-the-art InterContinental Hotel and MBNA Conference Center at the Cleveland Clinic main campus. A banquet and guest lecture by curator and anthropologist Bruce Latimer, Ph.D., will be held in the “Dinosaur Hall” of the Cleveland Museum of Natural History in nearby University Circle, the cultural center of Cleveland.

Clinical and basic science abstracts may be submitted for oral or poster presentation by Feb. 25, 2004.

For more information, visit the Bone Summit Web Site at clevelandclinicmeded.com/summit/bone/index.htm, or e-mail or call Eleanora Voelkel at voelkee@ccf.org or 800/553-5056, ext. 52028.

Cleveland Clinic Orthopaedic CME Calendar

Physicians are welcome to attend the following upcoming clinical and basic science symposia:

Sept. 17-18, 2003
The Fifth International Bone Fluid Flow Workshop
W.O. Walker Rehabilitation Center

Oct. 11-14, 2003
Hyaluronan 2003: The International Conference
Cleveland Clinic InterContinental Hotel and MBNA Conference Center

Nov. 15, 2003
Optimizing Diabetic Foot Care:
A Workshop in Collaboration with Penn State University
Cleveland Clinic InterContinental Hotel and MBNA Conference Center

May 23-26, 2004
Current Concepts in Joint Replacement
Rio Suites Hotel & Casino, Las Vegas
(Co-sponsored by The Cleveland Clinic and by Current Concepts Institute)

May 13-15, 2004
Cleveland Clinic Bone Summit 2004:
The Clinical Science of Skeletal Repair, Maintenance and Regeneration
Cleveland Clinic InterContinental Hotel and MBNA Conference Center

Oct. 7-9, 2003
2003 Cleveland Clinic Medical Innovation Summit:
From Boardroom to Patient Bedside – The Need for Speed
Cleveland Clinic InterContinental Hotel and MBNA Conference Center

Oct. 14-16, 2004
Lower-Extremity Complications of Diabetes:
An International Research Summit
Cleveland Clinic InterContinental Hotel and MBNA Conference Center

Dec. 15-18, 2004
Current Concepts in Joint Replacement
Hyatt Regency Grand Cypress, Orlando, Florida
(Co-sponsored by The Cleveland Clinic and by Current Concepts Institute)

For more information, call the Department of Continuing Education at 216/444-5096 or 800/762-8173, or visit www.clevelandclinicmeded.com. For details on The Fifth International Bone Fluid Flow Workshop, contact Eleanora Voelkel at voelkee@ccf.org or 800/553-5056, ext. 52028.
For details on the Current Concepts in Joint Replacement events, visit www.ccjr.com/intro.
Surgery and fractures

Specialty Interests: Spinal surgery, adult reconstructive surgery and fractures

Thomas E. Anderson, M.D.
Office: 216/444-2581
Specialty Interests: Sports medicine and upper extremity surgery, including the hand

Jack T. Andrich, M.D.
Office: 216/444-4269
Specialty Interests: Pediatric orthopaedics, scoliosis and sports medicine

Sunel Apte, M.B.B.S., D.P.Hil.
Office: 216/445-3278
Specialty Interests: Connective tissue biology and orthopaedic research

R. Tracy Balloch, M.D.
Head, Section of Pediatric Orthopaedic Surgery
Office: 216/444-3375
Specialty Interests: Pediatric orthopaedics, orthopaedic research and skeletal development

Wael K. Barsoum, M.D.
Office: 440/899-5600
Specialty Interests: Hip, knee, elbow and shoulder reconstruction and replacement; hip, knee and shoulder arthroscopy

Thomas W. Bauer, M.D., Ph.D.
Office: 216/444-4830
Specialty Interests: Orthopaedic pathology, metabolic bone disease, surgical pathology and biomaterials

George H. Belhadeb, M.D.
Office: 216/445-5394
Specialty Interests: Sports medicine radiology, arthrography, orthopaedic oncology, musculoskeletal MRI and radiology of joint replacements

Gordon R. Bell, M.D.
Head, Section of Spine Surgery; vice chairman, Department of Orthopaedic Surgery
Office: 216/444-4126
Specialty Interests: Spinal surgery, adult reconstructive surgery and fractures

John A. Bergfield, M.D.
Director, Medical Affairs, Cleveland Clinic Sports Health Office: 216/444-2618
Specialty Interests: Sports medicine, knee joint disorders and replacement, and traumatic injuries related to sports activity

Allan M. Bole, D.P.M.
Office: 216/444-8144
Specialty Interests: Intraosseous surgery, footrest surgery and general pediatric conditions

Lester S. Borden, M.D.
Head, Section of Adult Reconstruction
Office: 216/444-3277
Specialty Interests: Primary and revision total joint replacement of the hip and knee

Georgianne Bratik, D.P.M.
Office: 216/444-8132
Specialty Interests: Diabetic foot care, foot surgery (operative, reconstructive and trauma), rheumatoid foot, geriatric foot, and musculoskeletal foot and ankle pathology

John J. Brems, M.D.
Head, Section of Shoulder and Elbow Surgery
Office: 216/444-3866
Specialty Interests: Surgery of the shoulder and elbow, joint replacement and arthritis surgery

Peter I. Brooks, M.D.
Office: 216/444-4284
Specialty Interests: Total joint replacement and revision surgery

Anthony Calabro Jr., Ph.D.
Office: 216/445-3273
Specialty Interests: Carbohydrate chemistry, especially glycoseimminoglycan and cartilage biology and tissue-engineering studies of environmental factors affecting cartilage metabolism and differentiation

John E. Carr, D.P.M.
Office: 440/985-3113
Specialty Interest: Podiatry

John A. Cianfrocco, M.D.
Office: 216/992-7771
Specialty Interests: Neck and back problems, sports medicine and general medical orthopaedics

Wayne Daum, M.D.
Office: 216/449-5600
Specialty Interests: Nonoperative adult orthopaedics, hip disease, low back pain, sacroiliac pain, and evidence-based medicine

Alan W. Davis, M.D.
Office: 440/999-3940
Specialty Interest: Foot and ankle surgery

Brian Davis, Ph.D.
Office: 216/444-4169
Specialty Interests: Gait analysis, orthopaedic biomechanics, biotermal instrumentation and diabetic foot ulceration

Kathleen Derron, Ph.D.
Office: 216/445-5603
Specialty Interests: Tendon and ligament biomechanics, and biology/tissue engineering

Robert J. Dineeff, M.D.
Office: 216/444-2385
Specialty Interests: Anabolic steroid and nutritional supplement use among athletes, and exercise-induced medical disorders

Brian G. Donley, M.D.
Office: 216/444-2370
Specialty Interest: Foot and ankle surgery

Anthony Calabro Jr., Ph.D.
Office: 216/445-3273
Specialty Interests: Carbohydrate chemistry, especially glycoseimminoglycan and cartilage biology and tissue-engineering studies of environmental factors affecting cartilage metabolism and differentiation

John E. Carr, D.P.M.
Office: 440/985-3113
Specialty Interest: Podiatry

Peter Evans, M.D., Ph.D.
Office: 216/444-4973
Specialty Interests: Elbow, hand and shoulder surgery, arthroscopic hand and upper extremity surgery, and peripheral nerve regeneration and transplantation

Aurum J. Freimann, M.D.
Office: 440/800-8333
Specialty Interests: Surgery of the hand, wrist and elbow

Mark L. Freimann, M.D.
Office: 440/800-8333
Specialty Interests: Hip and knee replacement and arthroscopy

A. Seth Greenwald, D.Phil.
Office: 216/432-7904
Specialty Interests: Biomechanics and biomaterials of artificial implants

Alan R. Gurd, M.D.
Office: 216/444-2416
Specialty Interests: Pediatric orthopaedics, scoliosis, cerebral palsy and spinal bifida

James O. Hall, D.P.M.
Office: 216/444-9230
Specialty Interests: General pediatric conditions, diabetic foot care, infections of the foot, and foot and orthopaedic surgery

Vincent Hascall, Ph.D.
Orthopaedic Research Center Office: 216/445-5976
Specialty Interests: Connective tissue biology and role of hyaluronan in inflammation

Christopher Herbert, D.P.M.
Office: 440/895-3113
Specialty Interest: Podiatry

Thomas R. Hunt III, M.D.
Head, Section of Hand Surgery
Office: 216/445-9246
Specialty Interests: Adult and pediatric hand, wrist, forearm and elbow surgery; complex reconstruction and arthroscopy of the wrist; reconstruction of arthritic and congenital deformities, fractures and fracture malunions

Susan joy, M.D.
Office: 216/996-4000
Specialty Interest: Sports medicine

Michael J. Joyce, M.D.
Office: 216/444-4382
Specialty Interests: Trauma, orthopedics, total joint replacement and microvascular tissue banking

UF Knetsch, M.D., Dr. med.
Office: 216/445-4113
Specialty Interests: Adult reconstruction, hip and knee replacement, and orthopaedic research

A. Seth Greenwald, D.Phil.
Office: 216/232-7904
Specialty Interests: Biomechanics and biomaterials of artificial implants

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Publication Highlights:
A Sampling of Publications From Cleveland Clinic Orthopaedic Surgeons and Biomedical Engineering Specialists

Following is a sampling of the nearly 70 scientific journal articles and textbook chapters published during the past 12 months by members of the Cleveland Clinic’s departments of Orthopaedic Surgery and Biomedical Engineering.


Buchler P, Ramazaniya RA, Rakotomaranja LK. Replacement in Total Knee for the Elite Athlete. 8

Functionalsyphiotroism: Cause of SCFE in Obese Children? 10

Pre-emptive Analgesia in Total Knee Replacement. 10

Orthopaedic Insights is a publication of the Cleveland Clinic Department of Orthopaedic Surgery. 10

Joseph P Iannotti, MD, PhD
Chairman, Department of Orthopaedic Surgery
Kenneth Marks, MD, Editor-in-Chief

The Cleveland Clinic Foundation is an independent not-for-profit multispecialty academic medical center, recognized as a National Referral Center and an international health resource. It is dedicated to providing quality specialized care and includes an outpatient Clinic, a Hospital with 956 staff beds, an Education Division and a Research Institute.

www.clevelandclinic.org/ortho

To refer a patient, call 216/444-BONE or 800/553-5056 ext. 42663.

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Histologic Study of Failed Interbody Fusion Cages. 4

“Old Bones” Reveal New Information. 7

An Objective Resource for the Elite Athlete. 8


