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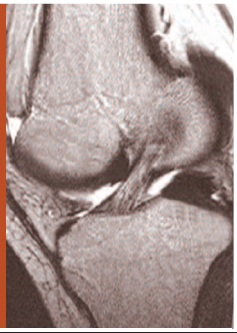

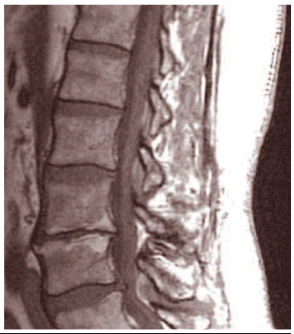

News from the University of Pittsburgh Department of Orthopaedic Surgery FALL 2007

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Chairman

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From Lucy to a Mandrill:

Can We Learn More About the ACL?

Dr. Freddie H. Fu, together with Dr. Sheila Ingham, a research fellow from Brazil, and Dr. Fu's orthopaedic research team, have begun an innovative study of the anatomy of the anterior cruciate ligament (ACL) and its related osseous landmarks in different animal species, both extinct and extant. The study is based on the premise that ACL anatomy can be better understood through knowledge of the evolution of the knee and its kinematics. The team is reaching back to the dinosaurs, stepping forward to "Lucy," and embracing primates.

Pittsburgh is the ideal location for this project because of its considerable human and institutional resources. Collaborating with Dr. Fu are Dr. Christopher Beard, curator of vertebrate paleontology for the Carnegie Museum of Natural History, and Dr. Cindy Stadler, chief veterinarian for Pittsburgh Zoo and PPG Aquarium. Also participating in the research is Dr. Owen Lovejoy, a renowned anthropology professor from Kent State University, who will analyze ACL-related anatomy in early human fossils.

ACL injuries result in more than 175,000 reconstructive procedures each year in the United States alone. A recent level I meta-analysis study has shown that more than 40 percent of patients with a traditional single-bundle ACL reconstruction are dissatisfied with their surgical outcome due to limited function or a repeat tear.

The UPMC Department of Orthopaedic Surgery has attempted to improve surgical outcomes in ACL reconstruction by investigating the structure of the ACL and its contribution to function. Anatomic and biomechanical studies have shown that the ACL has two functionally distinct ligament bundles, named the anteromedial (AM) and the posterolateral (PL) after their tibial insertion sites. The AM bundle principally stabilizes anterior-posterior motion, whereas the PL bundle primarily stabilizes knee rotation.

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Figure 1. Dr. Fu's arthroscopy on Johnny the mandrill.

From Lucy to a Mandrill: Can We Learn More About the ACL? *(Continued from Page 1)*

Functional and anatomical knowledge of the ACL is essential for successful ACL reconstruction and optimal surgical outcome. The Department's research to date has shown that goats and rhesus monkeys (*Macaca mulatta)* have three ACL bundles (AM, PL, and intermediate bundles). The different sizes, weights, and activity requirements of different species create unique biomechanical stresses on the ACL. The study of these variables helps illuminate the relationship between form and function.

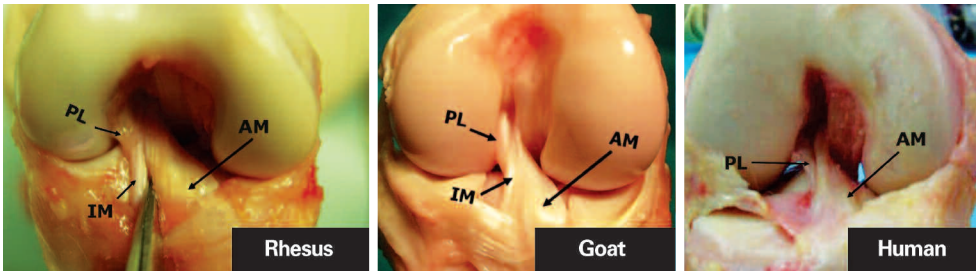

Figure 2. ACLs of rhesus monkey knee, goat knee, and human knee.

The research group obtained new insight into the anatomy and function of the ACL after Dr. Stadler noticed that the Zoo's mandrill, Johnny, was showing signs of knee dysfunction. She invited Dr. Fu to perform an arthroscopy to diagnose and treat the animal. The surgical team established that a mandrill also has three ACL bundles, one of which was torn (the PL) in Johnny's case. After a good recovery from knee debridement, Johnny has no visible knee dysfunction.

Dr. Fu and his orthopaedic research team, including Dr. Scott Tashman, also met with Dr. Lovejoy and Dr. Bruce Latimer at the Cleveland Museum of Natural History to examine the museum's extensive collection of primate bones. Dr. Lovejoy investigates the origins of bipedalism in primates and is celebrated for assembling "Lucy," a 3.2 million-year-old hominid fossil *(Australopithecus afarensis)* discovered in the Afar Triangle of Ethiopia in 1974. Dr. Fu and Dr. Lovejoy are collaborating to investigate the developmental aspects of the bipedal knee.

Dr. Fu's collaborative evolutionary research project seeks links among diverse species that will help clarify the relationship between human ACL form and function. The goal is to enable orthopaedic surgeons to better understand our own anatomy and ultimately provide better care to our patients. ■

The Orthopaedic Biodynamics Laboratory:

Revealing Joint Function via Dynamic Radiographic Imaging

Our joints enable an incredible diversity of movements, with performance and durability that have yet to be matched by any man-made materials. Each joint is exquisitely adapted for its expected loads and range of motion, and can typically withstand a lifetime of normal use. However, if a joint is stressed beyond its physiological capabilities, the resulting damage to joint structures (ligaments, tendons, cartilage, bone) can lead to pain, loss of function, and reduced quality of life. Such damage can occur suddenly, as from a sports injury or accident. It also can occur gradually, caused by improper joint mechanics, habitual overloading, and/or biological factors leading to degraded tissue quality. Restoration of function and joint health requires a thorough understanding not only of the anatomy and biology of joint tissues and structures, but also of their functional behavior during the variety of movements encountered in daily life.

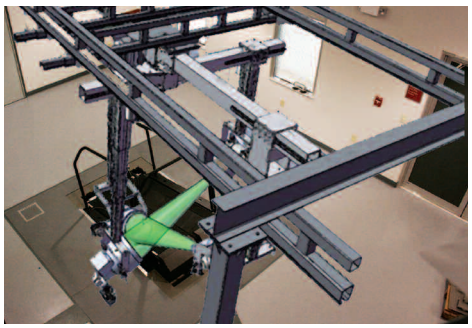

Figure 1. Photograph of the Biodynamics Laboratory with a scaled engineering drawing of the new high-speed biplane radiography system superimposed.

While the anatomy and fundamental mechanical properties of joint structures can be studied using cadavers, the complex response of joints to their loading environment can only be studied in living creatures. Most orthopaedic research laboratories incorporate video-based systems that track markers placed on the skin to study dynamic joint function, but the behavior of specific structures within the joint is obscured by movement of the skin relative to the underlying bone. Thus, fundamental questions about the function of musculoskeletal tissues, such as the amount of stretch in a knee ligament during walking, running, or jumping, remain unanswered.

The new Biodynamics Laboratory under development in the Department of Orthopaedic Surgery at the University of Pittsburgh will incorporate innovative imaging methods to enable accurate measurement of dynamic musculoskeletal function. This technology, called Dynamic Radio-Stereo-photogrammetric Analysis (D-RSA), consists of two high-speed x-ray imaging systems configured to acquire stereo pairs of radiographic images at high frame rates. Custom-written software identifies and tracks bones from the image pairs, using 3D bone models derived from computed tomography (CT) scans. This technology was originally developed at Henry Ford Hospital in Detroit by the laboratory's director (Scott Tashman, PhD) and research scientist/engineer (William Anderst, MS).

Dr. Tashman and Mr. Anderst joined the Department last year to develop the new laboratory, which will incorporate a number of

The 2007 American, British, Canadian (ABC) Traveling Fellowship:

Building International Orthopaedic Bridges

Dr. Constance R. Chu recently became the second American woman to complete the prestigious American, British, Canadian (ABC) traveling orthopaedic fellowship. She also follows former University of Pittsburgh Department of Orthopaedic Surgery chairman Albert B. Ferguson Jr. (ABC 1955), and Harvard Massachusetts General Hospital Orthopaedic Department chairman Harry E. Rubash (ABC 1993) as the third Pitt faculty member to become a member of the ABC club. Other University of Pittsburgh alumni who have been ABC fellows include the distinguished British orthopaedic surgeon George Bentley (ABC 1972), and Robert D'Ambrosia (ABC 1979), past president of the American Academy of Orthopaedic Surgeons (AAOS). Since the inception of the ABC fellowship in 1948, nearly a quarter of AAOS presidents and one-third of AOA presidents have been ABC fellows.

The ABC traveling fellowship, the oldest of the traveling orthopaedic fellowships, was founded by then AOA President R.H. Harris to help expose British orthopaedic surgeons to North American centers during the difficult post-World War II years. Sir John Charnley, inventor of the total hip replacement, visited the United States as a member of the inaugural tour in 1948. The following year, an American group traveled to Great Britain, and the tradition of ABC fellows from Great Britain and America traveling across the Atlantic on alternate years was born. The fellowship grew to include South Africa in 1983, and Australia and New Zealand in 1985.

Dr. Chu traveled with Drs. John Antoniou of McGill University, Brian Donley of the Cleveland Clinic, Steven Frick of the University of North Carolina, Alan Hilibrand of Jefferson University and the Rothman Institute, William Ricci of Washington University, and Alastair Younger of the University of Vancouver. As described in a closing speech by Dr. Frick, the experience assisted in building bridges between institutions and with orthopaedic programs around the world.

The fellows visited ten orthopaedic programs in Great Britain, and also enjoyed special gatherings such as a sumptuous banquet in a medieval castle, behind-the-scenes tours of Parliament and Westminster Abbey, golf at St. Andrews in Scotland, and dinner in an ancient club where the Magna Carta was signed. In the south Pacific, the group visited the Sydney Harbor Yacht Club and Opera House, encountered Australian wildlife, and engaged in a full slate of outdoor activities in New Zealand. As the fellows proceeded around the world in 35 days, engaged by the generosity and the hospitality of their hosts from the British Orthopaedic Association, the Australian Orthopaedic Association, and the New Zealand Orthopaedic Association, they found themselves forming a lifelong commitment to the international exchange of orthopaedic ideas, techniques, and perspectives. ■

significant technological advancements over the Detroit system. The redesigned x-ray system will be capable of acquiring pairs of four-mega-pixel images at rates of up to 500 frames per second, along with greater positioning flexibility to enable studies of nearly any joint in the body during a much wider range of activities. Construction of the laboratory facility was completed earlier this year, and the laboratory is expected to be fully functional in late 2007. Other laboratory equipment includes an instrumented dual-belt treadmill (for measuring foot-ground forces), video-motion measurement (for determining whole-body motion), and dynamic electromyography (for assessing neuromuscular control).

Initially, the Biodynamics Laboratory will focus on knee injury and repair. A primary goal of this research is the prevention of knee osteoarthritis, especially after injury. Dr. Tashman's NIH-funded research project, now in its eighth year, aims to determine why anterior cruciate ligament (ACL) reconstruction surgery may restore clinical function, but fails to reduce the risk of knee osteoarthritis (OA) after ACL injury. This project has identified specific abnormalities in the dynamic function of the ACL-reconstructed knee that alter the biomechanical environment of the cartilage and menisci. The current project period will relate specific kinematic abnormalities to long-term joint degeneration, and investigate surgical techniques that might alter this process. A recent area of focus is anatomic double-bundle ACL reconstruction, which has been championed by Dr. Freddie Fu as a means of better restoring the anatomy of the original ligament. Preliminary high-speed x-ray data suggests that anatomic reconstruction may lead to improved dynamic knee function compared to conventional procedures, but more subjects and longer follow-up are required to define the benefits of this innovative procedure.

New directions in research for the Biodynamics Laboratory will take advantage of the strong existing programs within the Department. The Knee Biomechanics Laboratory, under the direction of Christopher Harner, MD, has recently presented research that quantifies the effects of different types of meniscal injuries on contact areas and pressures in the knee. The directors of the two labs (which share the same facility), along with James Irrgang, PhD, director of Clinical Outcomes Research, are planning collaborative studies to understand the effects of meniscal injury on joint function and the effectiveness of different surgical procedures for restoring and maintaining joint health. Studies of non-surgical treatment for knee disorders are being developed in collaboration with Kelley Fitzgerald, PhD, of the Department of Physical Therapy. The Biodynamics Laboratory also hopes to work with the Sports Performance Laboratory (Scott Lephart, PhD, and Tim Sell, PhD) on a long-running program for knee injury prevention. Finally, several spinal kinematics projects are being planned in collaboration with the Division of Spinal Surgery. ■