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JointVenture

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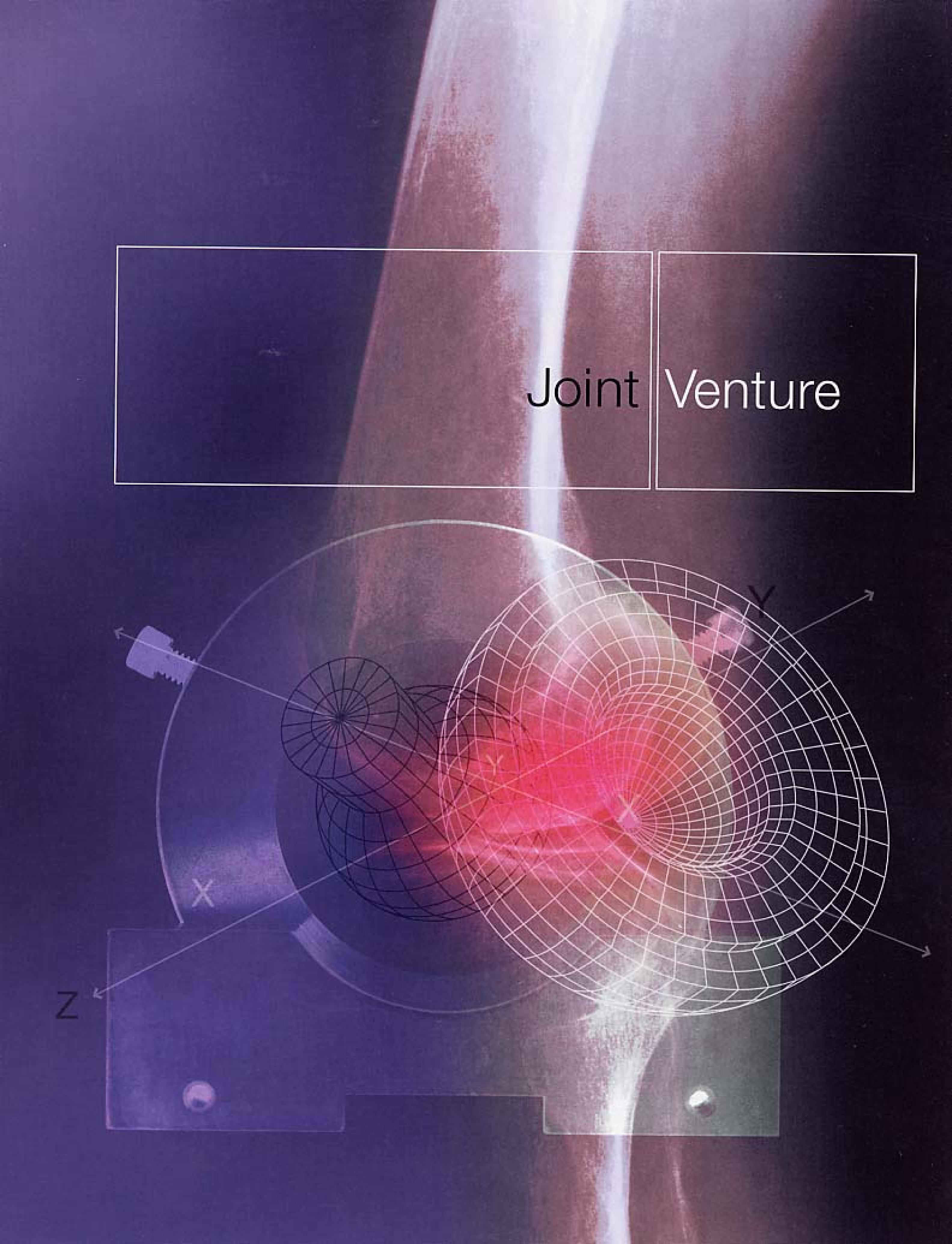
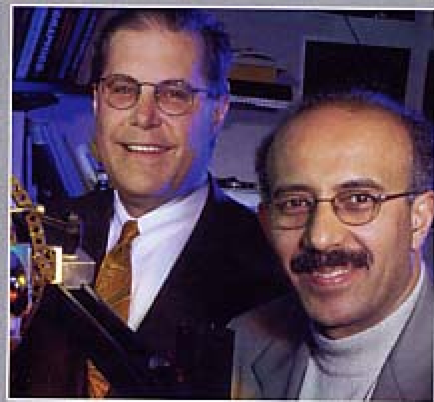


Merging Orthopaedics and Engineering

by Carmen Marti

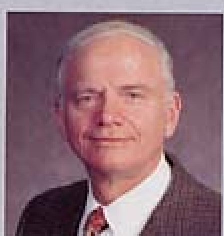


Dale DeBolt Photography

Mark Gonzalez, MD, and Farid Amirouche, PhD

The lab is peopled with graduate students, turned toward computers, concentrating on mathematically modeling various body parts: knees, hands, hips, spines.

One student stands out from the rest. He's a few years older than the others and dressed in a tailored suit. He's halfway to his master's degree in biomechanical engineering, and he's already an orthopaedic surgeon. He's Mark Gonzalez, MD, Res '85, BS '76, professor of orthopaedic surgery in the College of Medicine.



Edward Abraham, MD, head of the department of orthopaedics

As an orthopaedic surgeon, Gonzalez specializes in hand surgery and hip and knee replacements. He performs between 600 and 700 surgeries a year, operating at both UIC and at John Stroger Hospital of Cook County in Chicago, where he is chairman of orthopaedics.

As a graduate student, Gonzalez studies the physics of his work as a surgeon. Frustrated by a lack of understanding of the biomechanics behind hand surgery and hip and knee replacements, he teamed up with Farid Amirouche, PhD, professor in mechanical and industrial engineering in the College of Engineering at UIC and adjunct professor of orthpaedics. The two began to study the science of prostheses, gathering data and quantifying biological forces. In an effort to facilitate the collaboration, Gonzalez went back to school to learn the language and methods of engineers. For his part, Amirouche began attending weekly clinical seminars run in the department of orthopaedics.

Together, over a nearly 10-year partnership, Gonzalez and Amirouche have combined medical and biomechanical expertise in a unique multidisciplinary effort to improve orthopaedic outcomes.

"In our specialty, we treat several parts of the body, including bone, joint surfaces, muscle and peripheral nerve," says Edward Abraham, MD, Res '75, head of the department of orthopaedics. "Understanding the biology and biomechanics are important components of joint function orthopaedics. Our close collaborative work between the colleges of Medicine and Engineering is advancing a better understanding of prosthetic design and function and ultimately will provide better care for our patients."

Toward this end, Gonzalez and Amirouche are poised to release new wireless knee technology that will take the guesswork out of implanting prostheses.

Using tiny sensors and transmitters embedded in key contact points of the prostheses, Gonzalez and Amirouche can measure the fit of a knee replacement as it is being implanted. They have developed a system of reading stress points that will guide surgeons toward optimal balance of the prosthetic knee.

"With this technology," Amirouche says, "we have moved from external information to internal information based on more than mathematical understanding. Before, we had to predict what the knee was doing. We don't have to predict anymore. This will give us the exact information we need. The wireless, in my opinion, is going to solve a lot of problems—surgeons will be able to immediately test how well the new knee fits."

In the past, sensors have been used to answer other questions in orthopaedics, but they never before have been used to aid surgeons in correctly balancing a prosthetic knee. This, according to

Gonzalez, is critical to the success of a knee replacement.

"When knee replacements fail, it is often because they're not balanced properly," Gonzalez says. "In a normal knee replacement, the force of weight bearage should be balanced over the entire knee. If it's somewhat unstable, it will impair the longevity of the prosthesis."

And right now, Gonzalez says, the most pressing issue in prosthetic replacements is longevity. "We're now seeing and treating people who have arthritis in their early to mid-50s, and these people can be expected to live until their late 70s or 80s. We are looking at prostheses that can survive longevity of 25 to 35-plus years."

Graduate student Francisco Romero with the hip prostheses micromotion testing apparatus

As it stands, the typical longevity rate for a prosthesis ranges between 10 and 15 years. But Gonzalez says, "Longevity depends on activity level. Bo Jackson destroyed his total hip after one year. But he was playing baseball ... which is not recommended."

Within the next year, however, Gonzalez and Amirouche, under exclusive agreement with industry giant Johnson & Johnson, whose DePuy Orthopaedics Inc. division funded their research, expect to be recommending their wireless knee technology to surgeons across the country. They hope its widespread use will lead to the establishment of a data bank to house information that could lead to new standards in the field.

Their time is now, Gonzalez says. "With advances in technology," he explains, "there's a real need for people who bridge both medicine and engineering. Without understanding the physics of it, it's really hard to get beyond just doing surgery."

Likewise, Amirouche says his job is much easier with the input of a surgeon on his team. "That really is key," he says. "Their perspective is clinical. Sometimes we engineers are very mechanical and we don't know how people respond to things. We understand it from a mechanical point of view because we deal with mechanical things. But people are so different. The biological part of a person is complicated. And these surgeons have great insight. They tell you what the problems are, what they observe, whether this makes sense or doesn't make sense. They really give us guidance about what direction to go. We need their expertise."

Under the tutelage of Amirouche, Gonzalez has learned to make mathematical models for understanding how joints work. "With these models," he says, "which are very quantitative, we get a better handle on what's happening physically. Once we know our model is a realistic representation of what's going on, then we can use it to achieve a new development."

Ultimately, Amirouche says, the goal is to reproduce a joint exactly. "And I think that time has come," he says. "We are working on ideas of generating tissues artificially that in the presence of bone, become bone; in the presence of ligaments, become a ligament. That's where science is going."

In the meantime, Gonzalez and Amirouche study hip and hand joints in addition to the knee. They hope soon to begin using their wireless technology in total hip replacement surgery. "As of this year," Amirouche says, "the number of total hips is getting to be exactly the same as, if not more than, knees. We have mastered these two joints to the point where people are no longer afraid to have a total knee or a total hip done. It's becoming routine. And because of that, the volume is there and the need is there."

Indeed, the need is increasing, Gonzalez says. "There are thousands upon thousands of people every year getting joint replacements, and this number is going up astronomically with the aging of the American population. We clearly have figured out ways to allow people to live longer, but we've not necessarily kept them arthritis-free.

"So," he continues, "we are looking at different prostheses and at different biomechanical ways to better understand the joint in its native state. In this way we can better comprehend how a prosthesis works and also how to create different paradigms, different models, to find ways to improve longevity of the prosthesis."

It's an exciting time, Amirouche says. "There's always more to do. Every time we solve a problem, we look at it in terms of how it opens new doors for us. Biomechanics is an evolving and dynamic world. It takes two old disciplines—medicine and engineering—and merges them."

Adds Gonzalez, "The potential of this collaboration is tremendous."

[WEB INFO]
For more information, see www.uic.edu/labs/brl/

Renovations Begin

When the College of Medicine Research Building is completed in early 2005, the department of orthopaedics hopes to have completed its own remodeling job that will reflect the efficiency and attractiveness of its new next-door neighbor.

"More than half of the original Medical Sciences South Building was demolished to make way for the new research facility. The two buildings will be joined by corridors," says Robert E. Larson, assistant director of architectural services at UIC. According to Larson, a feasibility study to develop a plan for the complete rehabilitation/remodeling of the building has been completed by Chicago architectural firm Solomon Cordwell Buenz & Assoc. Inc. When finished, orthopaedics will be incorporated into approximately 14,500 square feet of space on the first four floors of the building at 835 S. Wolcott. "The study includes new mechanical, electrical and plumbing systems," adds Larson. UIC's Office for Capital Programs and SCB have developed a project budget of $5.5 million.

This architect's rendering shows the courtyard facade of the 1927 collegiate Gothic structure that houses the department of orthopaedics. While the outside of the building will remain the same, the renovation/remodeling of the first four floors will create a fully modern facility.