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École de technologie supérieure, Montreal, Quebec, Canada

Device Helps Knee-Pain Sufferers Get Back on Their Feet

A technician affixes the exoskeleton of the KneeKG to a patient's leg.

Most drivers hate red lights. But motorists with knee pain might want to reconsider. Thanks to a chance meeting at a stoplight, patients can now get more accurate diagnosis and treatment for their conditions.

The key is a motion-capture-and-analysis device called Knee Kinematics Graphs, or KneeKG. KneeKG allows health care professionals to test a patient's knee function while the patient walks on a treadmill. X-rays and MRIs can only take images of the knee while it is still.

What's more, KneeKG costs less than X-ray or MRI machines. And, with the help of two Canadian technology transfer organizations, the device is on the market in Canada and approved for use in the United States.

The technology benefits anyone with knee pain — both professional athletes and the general population. That includes workers whose jobs are hard on their knees, such as mail carriers and rug installers. In countries with aging populations, osteoarthritis is the most common cause of knee pain in people who reach middle age, no matter what a patient's profession.

In fact, American patients visit their doctors about 19 million times a year for knee problems, according to the American Academy of Orthopaedic Surgeons. Knee pain and other bone and joint problems represent the most disabling and costly medical issues in countries such as the United States.

The Questions That Led to a 20-Year Project

The story of how the device came to market is almost as complex as the knee it was designed to analyze. It offers a clear picture of how technology can help those who need it, thanks to more than 20 researchers, three universities and multiple funding agencies.

Back in 1990, an orthopedic surgeon came to Jacques de Guise, Ph.D., with two questions: How could he limit harmful stresses on a patient's knee ligaments? And was there an optimum position in which the stresses were minimal for the ligament in the knee?

The orthopedist was performing knee surgery on patients with injuries to ligaments such as the anterior cruciate ligament, or ACL. An ACL tear, an injury familiar to many athletes, can be debilitating. Surgery does not always restore a patient's knee to its pre-injury function.

De Guise quickly realized that, to get answers to his questions, the doctor would need to be able to provide a 3-D image of the knee in motion. Unlike an X-ray or MRI, which provides a two-dimensional picture of the knee, the device de Guise envisioned would capture the knee's motion and present it as a 3-D image. However, no existing device could provide such information.

Besides that, getting a portrait of the joint would not be easy because the knee's movement is quite complex. The only way to capture such data was to surgically implant pins into the knee, with wiring leading to a motion-capture device that would compute the data.

Why Did the Professor Cross the Road?

At the time, de Guise was a professor of biomedical engineering at the École de technologie supérieure (ETS) in Montreal. But, the engineering school did not have any medical faculty, something de Guise needed in order to work with a physician.

So de Guise went across the road to the University of Montreal and took a position as an adjunct professor at the faculty of medicine and as a researcher at the University of Montreal Hospital Centre, or CHUM. He continues his work at both institutions today, with multiple roles at each organization.

"My left arm is at the ETS, and the right arm is at the University of Montreal," de Guise jokes. "My head is in between."

With his appointment at the University of Montreal, de Guise was able to install an ETS lab at the CHUM Research Center, the Imaging and Orthopedics Research Laboratory (LIO). At the LIO, he and his students began investigating different options for obtaining data about the knee.

First they reviewed medical literature to see if other researchers had already found a technique for capturing movement with motion sensors. The group did not find anything, so they brainstormed solutions and did an anatomical study of the knee's structure.

De Guise was riding his bicycle one day in 2000 when a former engineering classmate, Francois Bastien, pulled up next to him in a car at a red light. When Bastien asked what he was up to, de Guise told his former classmate about his research. Bastien asked de Guise why he hadn't commercialized the invention.

The idea that emerged from those efforts involved a special motion-sensor attachment system — a knee brace that allowed the quasi-rigid fixation of movement sensors to the knee. In 1994 they came up with the prototype of a fixation system in which a motion detector could be firmly attached to a patient's lower limb.

Their next task involved describing the knee's motion so they could design software that would compute the mechanical stresses to the ACL. That allowed de Guise to show the surgeon the best way to perform orthopedic surgery.

Once they had the hardware and software to record the kinematics — the movement of the knee — de Guise and his students undertook the next phase of research: looking at normal kinematics versus abnormal kinematics.

The funding for the initial research came from several sources. They included NSERC (the National Sciences and Engineering Research Council of Canada) and FQRNT (The Quebec Fund for Research on Nature and Technology). De Guise also secured a grant from the Canadian Institutes of Health Research to study patients with osteoarthritis of the knee.

Red Light Leads to Green-Lighting of Project

What happened next put the project on a different footing.

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The two quickly became business partners and created a new company called Solution YD3. On top of the grants de Guise had received, Solution YD3 obtained funding from INNOV, a special innovation-funding program from NSERC.

"A researcher is always seeking more money," de Guise says.

For a time, the project received adequate funding. And over the course of its development, more than 20 graduate students worked on the KneeKG.

L'Hocine Yahia, a professor at ETS, and Nicolas Duval, a surgeon, worked with several students to help de Guise get the device into clinics and show how it could work in a clinical setting.

However, economics eventually threatened to sideline the project.

Although some Solution YD3 employees were working on the KneeKG project full time, they were not drawing a salary. And, without enough people to continue development, progress would grind to a halt.

So de Guise approached the two universities where he worked. Each had a technology transfer office.

Together, Valeo — the technology transfer agency for ETS — and Univalor — the University of Montreal's technology transfer organization — retired the original KneeKG license and found a new licensee, Emovi Inc.

Valeo and Univalor had asked Quebec-based Emovi to identify any barriers to commercialization for the device. When Solution YD3 gave up its rights to the license, Emovi president and CEO Michelle Laflamme expressed interest in acquiring the license. Emovi, which provides medical products to health care providers, obtained the license for KneeKG in 2007.

Jean Bélanger, director of the Centre for experimentation and technology transfer at the ETS, explains why the university was interested in licensing the technology.

"KneeKG offers a quick way to diagnose the mechanical causess of the knee problems," Bélanger says. "There are not too many techniques that assess the knee in dynamic and weight-bearing conditions, in fact, this is the sole product available for clinical settings. And, it's noninvasive."

Health care providers can use the KneeKG in settings such as doctors' offices, hospitals, clinics and rehab facilities. It helps health care professionals in several ways:

- Looking at whether the knee is functioning normally
- Diagnosing the cause of knee pain
- Allowing comparison of knee function before and after treatment
- Getting a baseline of the patient's knee function for comparison in case of future injury, damage or disease

The device is also much more user-friendly than other systems that analyze the knee while in motion, in a weight-bearing position. Although some laboratories in universities and hospitals can perform similar analyses, those systems are not available in a clinical setting.

What makes KneeKG different from other systems is that it accurately analyzes the function of the knee joint in a clinical setting. A technician performs the 15-minute test. Afterward the device generates an easy-to-read report about the findings.

Licensee Offers a Leg Up

Emovi has been integrating the device into its care protocol at its Emovi Knee Clinic since 2008. According to Laflamme, Emovi invested in the project with two objectives: First, to develop software applications to make the results easily understandable. This technology then demonstrates its added value to the patient, the physician and the health care system.

Second, to develop a database of different knee conditions, diseases and abnormalities. This not only adds to the value of the technology, it also advances the science as it relates to the knee.

The software applications that have been developed cover different angles:

- Highlighting knee-function problems that are linked to known diseases or conditions, to help the investigation of symptoms
- Clinical scores enabling easy post-treatment followup
- Pre- and postsurgery information for total-knee and ACL surgeries
- Diagnostic applications for general practitioners

"Emovi aims to help physicians revolutionize the way they evaluate knee problems," Laflamme explains. "This empowers doctors to provide top-notch knee care."

Working with Universities Allows Licensees to Put Their Best Foot Forward

Laflamme says her company first became involved with the two universities because Emovi wanted to license the technology. Now the company has developed a solid relationship with the universities.

"It's something other companies should look at, when they want to innovate," Laflamme says. "More companies should work with universities. They have terrific knowledge and are also aware of development around the world. Plus, they are the best spokespeople for the innovation because they know it by heart."

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Emovi now focuses on two activities: developing and selling the KneeKG, and operating its knee clinics.

As of early 2011, health care professionals are using the KneeKG in two Emovi clinics in Canada. Emovi has also sold its first units for use in a hospital in Lyon, France.

In addition, Emovi has gotten approval from the Food and Drug Administration to sell the device in the United States. Laflamme says the company is targeting about 10,000 orthopaedic surgeons in the United States, specifically those at the country's 2,000 or so orthopedic and sports-medicine clinics.

As for de Guise, he is continuing his work at both the ETS and the University of Montreal, thanks to grants from the FQRNT and the Fonds de Recherches en Santé du Québec. Due to his efforts to help patients with knee pain, people can get back to work, play with their grandchildren and even ride their bikes — perhaps providing someone else with a chance for a life-changing encounter at a stoplight, too.

— Kirsten Lambert