Engineering solution to orthopedic problem 1999-10-20

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Media contact	Email
Public Affairs	burton@uic.edu

By Leila Belkora

The heroine in the "Princess and the Pea" fairy tale showed her noble lineage by suffering a sleepless night because of one pea under a layer of 20 mattresses.

But you don't have to be exquisitely sensitive to know that physically small imperfections, like a shoe that's just a shade too narrow or a dental filling that barely overflows the cavity, can be a royal pain.

UIC researchers are convinced that small imperfections in the fit of artificial joints -- slight misalignments between the components of a prosthetic knee joint, for example -- are the causes of prosthetic joint failure.

"We've come up with a way for the surgeon to do what we call dynamic fitting," said Farid Amirouche, professor of mechanical engineering.

Amirouche and his student, Luke Aram, worked with Mark Gonzalez, a professor of clinical orthopedics in the College of Medicine, to adapt new engineering technology to a problem in medicine.

They used a new type of pressure sensor to detect problems with the fit of a prosthetic joint while the patient is still in the operating room.

Prosthetic joints, which are made of plastic-like synthetic material, may not work smoothly if the parts are misaligned or if there is an imbalance in the ligaments supporting the joint.

If the fit is not corrected, one moving part grinds against another as the patient moves and flexes the joint. This dramatically shortens the life of the joint, causing pain and infections.

Currently, surgeons test the fit of the joint with their hands or, at best, with a single measurement of the force acting at one point inside the joint.

This may not be enough to detect a slight error that could lead to excessive wear, Amirouche said.

Some surgeons use pressure-sensitive film to measure the pressure distribution across the joint, but the time needed to process the film limits its usefulness in the operating room.

Amirouche's research team placed an array of sensors about 6 square centimeters in area to measure the contact pressure inside the joint while it flexes.

"New pressure-sensing technology recently made it possible to build paper-thin load cells that measure contact pressure instantaneously," he said.

"These sensors enable surgeons to make the necessary adjustments, based on instantaneous contact pressure measurements, right in the operating room."

The surgeon slides the sensor array into the prosthetic joint at the place where one part makes contact with the other.

The sensor continuously records the pressure at more than 80 points across the contact area.

The pressure signals are shown on a computer screen next to the surgeon, who can monitor how the pressure changes as the patient's bone rotates through the normal 90-degree angle of motion.

If the readings are outside normal ranges, the surgeon can modify the fit.

DePuy, a division of Johnson and Johnson Co. that manufactures orthopedic products, is supporting Amirouche's research.

The UIC engineer says the new sensor system could have other benefits.

"Now we can have a better model or representation of the knee," he said.

"We'll be able to understand, for example, the effect of carrying different loads of weight.

"I think this will open up for research the whole issue of joint stability, especially in athletes."