Technology

Joint motion by number

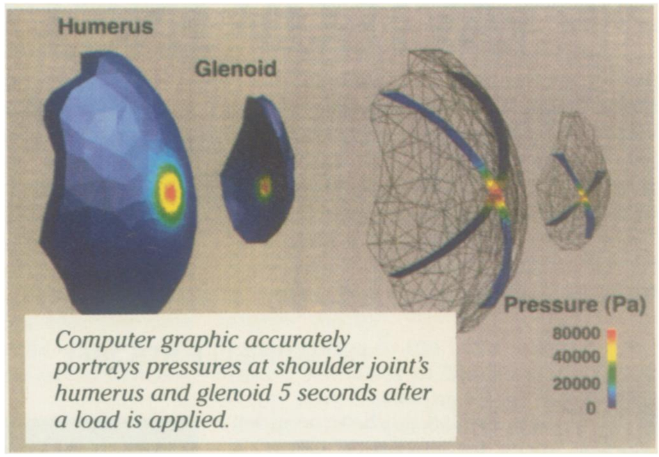
Imagine a famous baseball pitcher plagued with shoulder pain being able to consult a computer that helps diagnose his problem and suggests how he might modify his fastball to keep from straining his joints. Or designers of artificial joints being able to customize their wares according to the activities and body types of those in need of new knees, hips, or shoulders.

Now, by tackling the difficult task of developing the sophisticated computational techniques for solving very complex problems, researchers hope to make such musings possible.

For several years, Van C. Mow and his colleagues at Columbia University in New York City have been devising mathematical models of soft tissues such as cartilage and actually measuring the dimensions and properties of these tissues to develop the data needed to use the models.

However, because joints are irregular, three-dimensional shapes, describing what happens when bone rubs against cartilage or how loads affect joints requires the solving of thousands, even millions, of partial differential equations — simultaneously. "That's where [massively parallel] computers come in," says Robert L. Spilker, a mechanical engineer at Rensselaer Polytechnic Institute in Troy, N.Y. He, Mark S. Shephard, and their colleagues there are working out ways to do these simultaneous calculations.

They have started with the shoulder joint, where the knobbed end of the upper arm bone — the humerus — fits into the concave glenoid cavity, a shallow "socket" along the upper, outer edge of the shoulder blade. First the computer divides the two irregular surfaces into a series of more regular geometric blocks, or "elements," Spilker reported in late November at an American Society of Mechanical Engineers meeting held in New Orleans. These elements, taken together, approximate the true shape but are easier to work with mathematically than actual bone or cartilage shapes, he says.



Computer graphic accurately portrays pressures at shoulder joint's humerus and glenoid 5 seconds after a load is applied.

Spilker

Thus far, the researchers have calculated what happens when they compress the shoulder. The computer applies a specific load on both the bone and its socket and determines how that load spreads across these surfaces over time. A graphics program presents the pressures in different colors at each point in time. "This is our first attempt at understanding how a soft tissue responds to an applied load using real tissue geometry and real tissue load," Spilker says. He expects that within a few years, their techniques will enable them to describe clinically relevant movements.