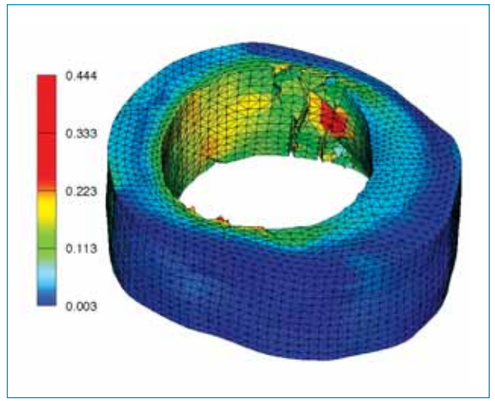
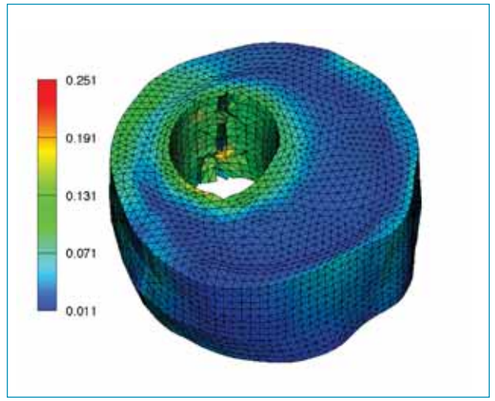
NewsBytes

Modeling Cracks in Clogged Arteries

Every year, doctors in the United States perform more than a million angioplasties: By inflating a tiny balloon inside a clogged artery, cardiologists can compress fatty plaques and restore blood flow. But the balloon also applies high pressure that can crack the wall of hardened, fat-lined arteries—sometimes with disastrous results. Now, structural engineers have created the first fully three-dimensional model to predict how arteries fracture under such stress.





Evolution of cracks in a clogged human artery depends on the geometry of the arterial wall and the pressure inside the artery. In the first simulation (left), a 40-percent-narrowed artery fractures at a blood pressure of 260 mmHg. In the second simulation (right), an 80-percent-narrowed artery fractures at a blood pressure of 380 mmHg. Colors show the distribution of stress on the arterial wall, measured in megapascals. Courtesy of Anna Pandolfi. Reprinted from Pandolfi A and Ferrara A, Numerical modeling of fracture in human arteries, in Computer Methods in Biomechanics and Biomedical Engineering 2008, 11(5):563.

"Once you have the true geometry [of the artery], this model applies pressure to simulate the presence of a balloon and evaluate the possibility of breaking the plaque or rupturing the artery walls," says author **Anna Pandolfi, PhD**, an associate professor of structural mechanics at the Politecnico di Milano in Italy. The research appears in the October 2008 issue of *Computer Methods in Biomechanics and Biomedical Engineering*.

In lab experiments, arteries tend to break when exposed to pressures of 300 kilopascals or more—about 20 times the average human blood pressure. But angioplasty can easily generate such forces, and some areas of diseased arteries are particularly fragile.

To better understand how arteries fracture, Pandolfi and her colleague **Anna Ferrara, PhD**, of the Politecnico di Milano, combined high-resolution magnetic resonance imaging (MRI) of a patient's arteries with a model they previously developed to describe fracture in brittle solids, such as glass. Using a technique called finite element analysis, they divided the artery wall into small volumes and assumed each chunk had a uniform behavior. Then they simulated several high-pressure scenarios and monitored the evolution of arterial cracks.

"What we got was an interesting correspondence with the medical data," Pandolfi says: As others had seen in a clinical setting, cracks usually began at the edge, or "shoulder," of a fatty plaque.

But, Pandolfi says, the model has limitations: An MRI scan can only describe an artery's shape, not its mechanical properties, such as resistance. And these parameters vary from patient to patient, depending on the extent of arterial disease. To get individualized data, Pandolfi says, one must test a piece of artery outside the body or do an *in situ* experiment—dangerous procedures in a patient with unstable arteries.

"The key thing is to get more data and do more tests on human tissue," says **Gerhard Holzapfel, PhD**, professor of biomechanics at Graz University in Austria who published his own model of arterial fracture last year. "When we throw in more data," he says, "I am very certain we can actually define a more optimal stent, on a computer, for a specific lesion."

—By Hadley Leggett, MD

Modeling Muscles From the Inside Out

A new model of skeletal muscle starts from the micro-mechanical properties of the smallest possible unit—the sarcomere—and builds up to the muscle fibers and then to the muscles themselves. In addition, it places the fibers in their natural context—within surrounding soft tissue. The effort brings a new degree of flexibility and realism to muscle simulation.

"The idea behind micromechanical modeling is to imitate the behavior of the material as well as possible," says lead researcher **Markus Böl, PhD**, professor of mechanics of polymers and biomaterials at the Braunschweig University of Technology in Germany.

"You cannot go to the patient and say, 'Okay, give me a part of your body and we'll test it,'" Markus Böl says.