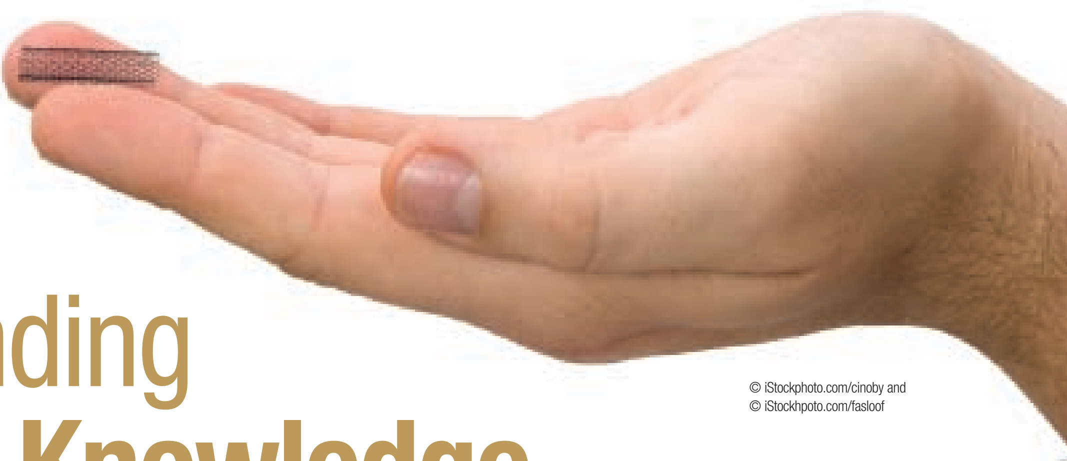


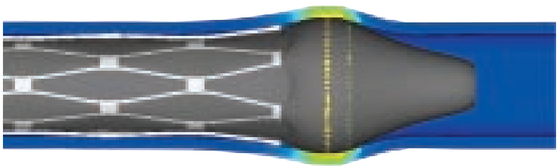
© iStockphoto.com/cinoby and
© iStockhpoto.com/fasloof

Expanding **Stent Knowledge**

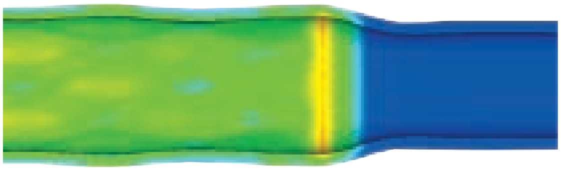
Simulation provides the medical industry with a closer look at stent procedures.

By Matthew R. Hyre, Associate Professor of Mechanical Engineering, James C. Squire, Professor of Electrical Engineering, and Raevon Pulliam, Virginia Military Institute, Virginia, U.S.A.

Heart disease, often caused by partially blocked coronary arteries, is the most common cause of death in the world. Stenting has become one of the most popular forms of treatment to open plaque-encrusted atherosclerotic coronary arteries, with hundreds of thousands of such procedures performed in the United States each year. However, according to the American Heart Association, about one in four stent patients will experience restenosis, a repeated narrowing of the stented artery, less than six months after the procedure. Some patients with restenosis must undergo a second stenting procedure to alleviate the subsequent blockage, while for others a full bypass operation is the only solution. A team from the Virginia Military Institute (VMI) is combining simulation with animation software from Computational Engineering International (CEI) to help identify a possible cause for restenosis and to find solutions that might help reduce the risk of developing it.



The stent expansion process, with the stent shown in light gray, the balloon in dark gray and the artery colored by arterial stress



In this image, the stent and balloon are hidden, and the remaining plot depicts only the artery after stent inflation. The contours represent arterial stress. The red ring, which occurs at the location of highest stress, aligns with the location at which end flare occurs during stent inflation.

The team at VMI hypothesizes that restenosis may be the result of arterial injury incurred during the stenting procedure itself. During this procedure, the medical team inserts a balloon, sheathed by the stent, into the artery and inflates it. Once the stent expands, the balloon is deflated and removed, leaving the stent in place.

The engineering team at VMI identified one possible reason for injury: end flare, which is caused by balloon overhang at the end of the stent. This exerts increased pressure on the arterial wall and may scrape it during inflation, which could stimulate uncontrolled cell growth in that area.

The balloon's mechanical properties vary dramatically during the expansion process. Though it begins as a highly flexible material, the balloon eventually expands in a nonlinear fashion as it nears the stent's final diameter, making the problem numerically unstable. A factor that is critical to accurately simulating the problem is how the structure of the balloon, the stent and the artery are meshed.

The team used Harpoon™, from Sharc, Ltd., to generate a complex mesh designed to follow the balloon, stent and artery through the expansion from a 1 millimeter diameter to a 3 millimeter diameter geometry. Once the mesh was established, the data was exported to ANSYS Mechanical software to provide information about stresses and geometry changes that occur during expansion.

The team used EnSight® to turn the simulation data into animations that depict the inflation process. The resulting images allow the medical research team to visualize the process for the entire assembly or to focus on the individual components — options that are impossible during the stenting procedure itself. By using simulation and visualization tools together, manufacturers may be able to redesign and numerically test stent designs and procedures, arriving at a very clear picture of how each variable affects the overall issue — all without a patient. ■