Joseph Rosen, M.D.: Facing the future

By Nancy Marie Brown

What does it mean to have a face? To be able to smile, to wink, to sneer? Questions like these haunt Dr. Joseph Rosen, a plastic surgeon at Dartmouth Medical School.

Rosen has seen lots of patients who have lost their faces: a soldier struck by a homemade bomb in Iraq; a hunter in the path of a friend's shotgun blast; a patient with sinus cancer; a 12-year-old African boy infected by a flesh-eating form of gangrene that begins as a simple ulcer in the mouth. Not only has Rosen met these faceless people, but he has done his best to repair the damage that disease or injury inflicted on them.

Fashioning an entire nose and lips and cheeks—from belly fat, a bit of bone from an arm or a rib, a flap of skin from the forehead—is a far cry from doing nose jobs for socialites. But Rosen does tummy tucks and facelifts , too. They're good practice for his other work, repairing multiple, devastating injuries. Not only do Rosen's 500 plastic surgery patients a year help him hone his surgical skills, they get him thinking about the relationship between soul and skin.

"My original major in college was philosophy," says Rosen, who came to Dartmouth in 1991 from Stanford and is now a professor of surgery and an adjunct associate professor of engineering. "Whenever I look at a problem, I look at it through the lens of philosophy. Plastic surgery is about applying philosophical principles to the body."

For instance, what does it mean to be human? Can a body without eyes, nose, or mouth still relate to other people? What about a body without arms or legs? "After the Civil War this was a huge problem," says Rosen, who uses history to introduce students at Dartmouth's Thayer School of Engineering to problems in medicine. There were 80,000 amputees after the War Between the States ended. "When a soldier came home from the war without an arm, he didn't know if the woman he loved would still marry him," Rosen says.

He is fond of a short story written a few decades after the Civil War; the protagonist is a doctor who has lost both arms and both legs and thus his independence as well as his profession. To Rosen, the story is eerily prescient: soldiers today are coming home from Iraq with catastrophic injuries just like that. "Predicting the future is basically understanding the past," he says.

In the 16th century, Dr. Ambroise Paré, a French surgeon, wrote a book called *On Monsters and Marvels*. It was about people maimed in war or born with congenital defects—people who seemed almost inhuman, like a Cyclops. This was just as Europeans saw their first rhinoceroses and giraffes and as doctors began to study the tails of fetuses.

"They had no concept of embryology," Rosen says. "It was a huge challenge to make sense of it all and to balance these monsters and marvels with their ideas of God." The fact that a normal human fetus grows and then loses a tail would have been an immense surprise to Paré, as would the idea that a soldier with no limbs could live an independent life.

Today, Rosen tries to put himself in Paré's shoes and wonders what modern scientists are overlooking. "There's a space out there where surprise comes from," he explains. "I want to discover what we're not seeing that is going to surprise us. I want to ask the pesky questions. The key is to ask the questions, not to know the answers."

Rosen considers himself a futurist. He thinks in terms of "engineering medicine," not medical engineering. In the 1980s, he tried to coax nerve fibers to grow through a computer chip. "A nerve is a cable with thousands and thousands of wires," he explains. A surgeon can stitch the cable together, but the individual wires are too small to sew—and, left on their own, they usually hook up wrong. "We wanted to create a micro-switchboard to help them reconnect," Rosen says. He didn't succeed in teaching nerves to talk to hardware, but his basic idea was sound. Recently, a company called Cyberkinetics (with which Rosen has no connection) developed a robotic arm that patients with spinal-cord injuries can move just by thinking about it.

Rosen's early experiments with "wetware"—an interface between software and living tissue—led him into virtual reality. He has helped develop simulators (based on real patients' CAT scans) that allow a surgeon to practice difficult techniques, such as fixing an abdominal aortic aneurysm through a catheter. He is also collaborating on a robot to be used to defuse bombs and clean up hazardous waste. What's the connection between a "hazbot" and virtual surgery? The software for the hand controls: the hazbot will need to have very

Grew up: Deer Park, Long Island, N.Y.

Education: Cornell University '74 (B.A. in biology); Stanford Medical School '78 (M.D.)

Training: Stanford Medical Center; Ralph K. Davies Medical Center, San Francisco, Calif.; San Francisco Hand Surgery Fellowship

Courses he teaches at Dartmouth's Thayer School of Engineering: Artificial People—From Clay to Computers; Virtual Medicine and Cybercare; Defining Human Performance, Augmenting Human Function

Latest project: Helping to revamp the national healthcare system in Vietnam, using cell phones and laptops to link clinics, hospitals, and rural physicians

Hobbies: Sculpture, drawing, model trains

Rosen's plastic surgery practice gets him thinking about the relationship between soul and skin.

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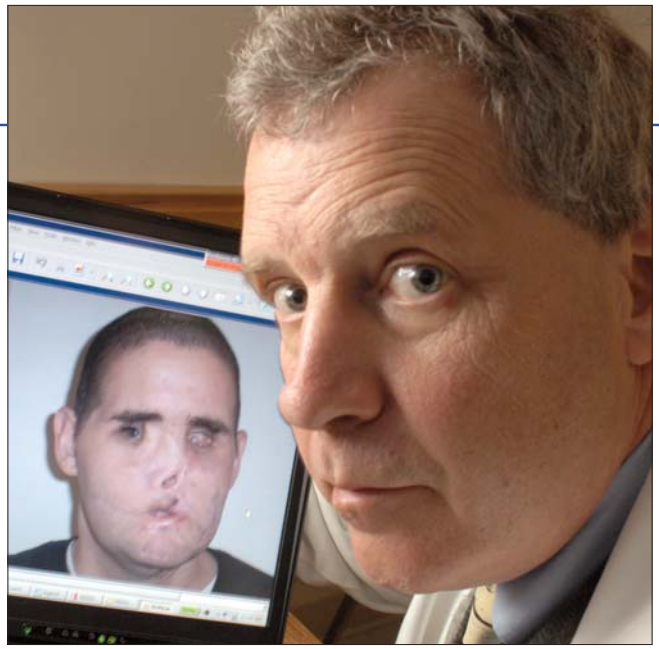

JON GILBERT FOX

Rosen's expertise treating polytrauma—multiple devastating injuries—has been widely covered by the media, including PBS's *NewsHour* and *Smithsonian* magazine.

delicate hands to be able to pick up a bomb without detonating it. Likewise, says Rosen, "when I'm operating on a virtual head, I need a really good haptic device, a simulation with really good feedback, so that I can tell how much force I'm applying. No surgical simulation has that yet."

In 1993, Rosen served on a National Academy of Sciences committee that forecast virtual reality's effects on health care. His insights on human-machine interfaces brought him to the attention of the Department of Defense (DoD), which has since sought his views on virtual reality, future warfare, bioterrorism, and polytrauma. "As a plastic surgeon," says Rosen, "you're often presented with problems that have no solution, with people . . . who have so many damaged parts that there's little or no way to solve their problems. That's what we mean by catastrophic polytrauma." For example, he can fashion a new nose but can't restore a soldier's sense of smell. He can reconstruct an eye socket but can't restore sight. Nor can surgery alone bring hope to a soldier missing a face, arms, and legs.

In 2004, Rosen was asked to give a grand rounds on polytrauma at Walter Reed Army Medical Center in Washington, D.C. Could he, as a futurist, envision a system that would allow such patients to live independent lives? And not in 10 or 20 years, but tomorrow?

Two years later, in December 2006, 100 experts in medicine, engineering, and robotics met at a polytrauma conference that Rosen organized at Dartmouth. "They certainly sacrificed for the country, for freedom, for all the things we believe in," Rosen says of the soldiers whose plight prompted the gathering. "Why shouldn't we do as much as possible?" At least 300 soldiers suffering from massive multiple injuries, most of them wounded in Iraq, remain hospitalized today.

Thinking futuristically, Rosen believes the answer to polytrauma is regeneration. "A salamander can regenerate an arm in 42 days. So somewhere in your genome that ability still exists, to regenerate a whole limb. We just have to find it and turn it on," he says. "We'll be doing that in 20 to 50 years—or sooner."

Actually, he'd prefer to prevent polytrauma. He can envision a virtual reality simulator of a soldier's entire career—training, battle, injury, treatment. "You'd decide all along the line how to maximize performance and inhibit injury," he explains. For instance, the simulator could lead to innovations in armor. "The better you know the weapons," Rosen says, "the better you understand the whole relationship between medicine and war."

The short-term solution, he believes, is to replace the missing parts with machines. "Ambroise Paré did that already in the 16th century," Rosen says. "He made a prosthetic arm out of armor—shining armor—with springs in it, and attached it with leather straps. But what do you do if you're a soldier who's missing one arm and two legs? You get an exoskeleton. It provides a frame you can be in."

Engineers in Utah, with DoD funding, have in fact created a wearable exoskeleton that senses and enhances the wearer's movements. The wearer simply runs or jumps or picks up a wounded comrade, and the robotic exoskeleton increases the person's speed and strength to superhuman levels. Rosen, who wasn't involved in the device's initial design, wants to push the concept further. As a member of the Defense Science Board, he is now lobbying for the DoD to adapt this prototype "bodybot," originally meant for battlefield situations, so that it can also help the limbless walk and the blind see.

But will people accept someone encased in an exoskeleton as human? "First people have to believe that the solution works," says Rosen. "Then the users have to believe it's a positive thing, not a negative thing"—the same problem faced by Civil War amputees. "You also have to consider economics. It can cost $75,000 for one robotic arm. Can you imagine the cost of the whole suit? So we can't, economically, apply this technology just to soldiers," Rosen says. "But we could adapt it for children with cerebral palsy. We could also adapt it for fragile elderly people so that they can continue to be independent. It would be cost-effective if we had a connected health-care system that considered the whole issue of independence for an older person and the expense of long-term care." (Rosen discusses more of his ideas in a multimedia WEB EXTRA Q&A at **dartmed.dartmouth.edu/spring2007/html/faculty_focus_we.php.**)

The idea of restructuring the U.S. health-care system, while making a whole-body prosthesis practical and socially acceptable, might seem more like science fiction than medicine. But Rosen approaches the task with the same tenacious optimism as when he travels to an African village to operate on a child without a face.

"It's just an attitude," he explains. "Someone says to me, 'You can't get there.' I say, 'Well, maybe *you* can't, but *I* can.'" ■