Prosthetics

High-Tech Support for Wounded Warriors

By Dwight Jon Zimmerman

Photo by Fred W. Baker III, American Forces Press Service

Prosthetic technology and rehabilitation have made remarkable advances in recent years with even more on the horizon. The first below-the-knee prosthesis dates back to the Roman Empire, but it was the "Six Million Dollar Man" on TV and Darth Vader and Luke Skywalker in the movies that raised the public consciousness about what technology might be able to do – and greatly exceeded reality.

Real progress has been made since the Vietnam War, mostly for lower limb prosthetics, where both military and civilian demand had been greatest. But it has been the remarkable speed with which computer chips and bioelectric research have advanced that has made the 21st century the true dawn of what might be called a bionic age. Nonetheless, the capabilities displayed by Hollywood's heroes and villains remain science fiction. At least for now.

"The human body is incredibly complex and shows like 'The Bionic Woman' have people thinking the prosthetics we are developing work just like what they see on the screen. But the kind of interfaces they allegedly have just aren't there," says the VA's chief for Prosthetics and Clinical Logistics, Frederick Downs Jr.

The greatest surge in funding, research and development, and actual end-user capability has grown out of the military's success in saving the lives of warfighters in Iraq and Afghanistan through improved body and vehicle armor and battlefield medical care. Many who would have died from head or torso wounds or bled out from the loss of a limb in combat were protected from the former and survived the latter in far greater numbers than any previous human conflict. As a result, there also has been a larger percentage of those wounded in action in Southwest Asia returning as amputees.

The nature of those wounds also has changed. Downs says about 24 percent of combat amputations involve the upper extremities today, compared to about 4 percent from Vietnam. With prior military and most civilian amputations – from accidents or medical problems such as diabetes – involving the lower extremities, which is where most research and development traditionally has gone. The dexterity and fine movements of the human hand and wrist and range of movement of the entire arm also make functional replication more difficult. But the changing metrics of this war are now seeing a new focus on the upper limbs.

The advances made to date have come from lighter, stronger, more durable composite materials enabling the fabrication of limbs in different shapes for different purposes, from walking to running; advanced plastics for lightweight attachments to prosthetic arms and legs; better socket design, which is considered key to the success of any prosthetic; and the increasing use of microelectronics. Those have combined to create energy-storing feet that can spring up, just as do the muscles and tendons of a live foot; computerized ankles that sense how a person is striding and adjust accordingly for a more natural gait; and knees with computer-controlled servomechanisms that help return normal function and agility.

The success of the prosthetic devices now available to warfighters also has led to another new development: Amputees returning to the same battlefield on which they were wounded. The first to do so since

Ross Colquhoun, a firearms instructor, helps Army Staff Sgt. Ramon Padilla learn to fire using his prosthesis in the Fire Arms Training System at the new Military Advanced Training Center at Walter Reed Army Medical Center. Soldiers can relearn to fire a 9 mm pistol and M-16 and M-4 rifles. Also among the multiple treatment rooms at the center is a vehicle simulator to help them relearn to drive using prostheses, and areas that offer practice walking on uneven terrain features, such as sand, gravel, and cobblestone.

Photo by Fred W. Baker III, American Forces Press Service

Army National Guard Spc. Marco Robledo is hooked into the harness of the Solo-Step system, which allows him to practice walking independently without danger of falling. The track is a one-of-a-kind system only at the new Military Advanced Training Center at Walter Reed Army Medical Center. The $10 million, 31,000-square-foot facility opened Sept. 13, 2007.

the Civil War was Army Maj. David Rozelle, who lost a leg below the knee in Iraq in June 2003 and returned in March 2005, commanding a cavalry troop on both deployments. He is now deputy project manager at Walter Reed Army Medical Center's newly opened Military Advanced Training Center (MATC), where severely wounded warfighters from all services are given the help they need to return to duty or become fully functional in civilian life.

"I was injured early in the war and we didn't have a program in place like this. Since I became one of the first to throw my VA paperwork in the trash and say I wanted to continue to serve, we have had 10 percent of the amputee population return to duty," he says. "Some say that is due to advancements in technology, but I probably would have gone back on a peg leg, if need be – what the individual wants to accomplish supersedes technology.

"The Army leadership, under the president's guidance, was pretty clear that if I was physically able and wanted to do it, they would support it. So I didn't have to fight the leadership to stay on – the only tough people to convince were my family and my soldiers."

Only eight Army amputees from Vietnam returned to duty – none to that war and none before a lengthy period of recuperation and desk duty. Of those eight, however, four went on to achieve the rank of general, including Gen. Fred Franks, who commanded 7th Corps in the first Gulf War, and Gen. Eric Shinseki, who became Chairman of the Joint Chiefs of Staff.

"Considering, we wondered why more did not return to duty," Rozelle says. "Today we have 65 returnees [DoD-wide] and we hope they have the same future."

During his 18-month recovery at Fort Carson, Colo., Rozelle was called upon for his input into the development of the MATC, at that time referred to as the Amputee Center, which doctors and clinicians at Walter Reed were working to create.

"Historically, Walter Reed has been a place for tertiary care, where people came to get fixed, but not for long-term care, going from there to the VA. In August 2003, we decided that was not always the best thing because some amputees wanted to return to active duty," he says. "So initially, it was to meet that desire because that population couldn't go to the VA while on active duty. Now we do advanced training – beyond what might be called 'rehab' – working with all severely injured, in addition to amputees."

Grand opening of the $10 million MATC was held on Sept. 13, 2007 – two months ahead of schedule – with clinical care involving more than 15 specialties officially beginning Oct. 1. The new 31,000-square-foot facility is breaking ground as a one-stop shop for virtually anything related to amputee care and recovery. Eventually, the entire facility will be moved to Bethesda, Md., as Walter Reed and the National Naval Medical Center are merged into a single tri-service Walter Reed National Military Medical Center in 2011.

MATC's Center for Performance and Clinical Research – more commonly known as the Gait Lab – employs advanced systems to measure patient strides while walking or running, and research protocols for prolonged activity, all vital to selecting, fitting, and aligning the proper foot or knee for each patient. The Computer Assisted Rehab Environment, meanwhile, provides a virtual environment

Photo by U.S. Army Sgt. Sara Wood

Brian Frasure, left, a clinical prosthetist and world-class athlete, speaks to the audience on the last day of the Military Amputees Advanced Skills Training workshop June 1, 2007, at Walter Reed Army Medical Center.

around a treadmill bolted to a helicopter simulator, allowing patients to perform a variety of tasks on an interactive platform that responds to their every move, while multiple infrared cameras gather data.

Another MATC first is the Telemedicine Conference Room, which patients can use to communicate with their families or even their units anywhere in the world. But its primary purpose is to allow medical personnel in the combat theater or at Landstuhl Regional Medical Center in Germany – first stop for many returning wounded – who treated a warfighter at every moment from the time of injury to follow his or her progress in a way never before possible.

MATC also boasts the word's first oval support harness patients can use to walk or run around a 225-foot indoor track without needing a therapist tethered to them, enabling faster recovery as the therapist is then free to observe and provide immediate feedback. Other physical therapy areas include rope climbing, a two-story rock wall, incline parallel bars, vehicle simulators, a firearms simulator, and uneven terrain walking areas, along with an occupational therapy clinic.

"It initially was funded in consideration of those wanting to return to duty, but we take care of anyone who has a limb loss, whether duty or off-duty, combat zone or not. And not just the 10 percent who want to remain in service; we're not going to turn the other 90 percent away from world-class care," Rozelle explains. "We take the patient from being stabilized out of ICU, fit them for a prosthesis and take them all the way through training with an integrated team – dieticians, physical therapy, etc. – all working at one facility, whether they are here for four months or three years.

"This is an outpatient care facility, including those in the VA system. Like any Army medical center, however, priority is to the active duty population. We take care, on average, of about 100 amputees a day and another 50 to 100 severely injured non-amputees. Each patient is seen every day – it is their place of duty. They are still getting a military paycheck because they are getting paid to heal."

All returns to duty by severely wounded warfighters are considered exceptions to policy, but Rozelle says no one from this conflict who has wanted to return has been turned down, not only amputees, but paraplegics, quadriplegics, and even some blind in both eyes.

"We are not a charity – we don't keep people on unless they can perform a job; if they can prove that, we make the exception," he adds. "One thing I'm working on is future policy, how to take these exceptions and make them policy. A severed spinal cord means you can't pass an Army physical, but we've had people in wheelchairs on active duty for years. It depends on their occupational skills – and in war, we make exceptions."

While the Army and other services have opened the way for amputees to return to duty, Rozelle says it is still an individual decision, one that differs by personality, the nature and extent of the injury and how well he or she adapts to the new reality of a body now relying on mechanical or electronic parts to perform what had always been simple, ordinary tasks.

"Everybody is different; somebody missing a foot is different from someone missing both hands or arms. Some people want to get the surgery over, get their prosthetic, and get on their way. But there is no single approach," he says. "I'm always upbeat in talking to them, talking

Army Spc. Charles Parker looks on as Sven Zarling, from Otto Bock International, demonstrates the capabilities of a prototype of a prosthesis designed to give above-the-knee amputee service members mobility they need to remain on active duty if they choose. The prosthesis uses a microprocessor to control the knee's hydraulic functions and can anticipate the wearer's actions and make changes in real time.

Photo by Fred W. Baker III, American Forces Press Service

about what they used to do and enjoy off-duty, so I can help them set goals. But to be a good peer visitor is to be a good listener, to let them tell me what they want to tell me."

Technology has made amazing advances, but Downs, who lost his left arm above the elbow in Vietnam, agrees the biggest challenges remain – and probably always will be – with the physical and psychological responses of individual human beings.

"Making the adjustment, the acceptance of the loss is first. A lot of people just don't want to believe it happened; there is a lot of rejection. So you have to get comfortable with the fact of having lost a limb," he says. "Then you have to adjust to using the prosthetic. And learn to live with the limitations. I can't clap my hands, I had to learn a new way to hold my babies when they were born – and to dress myself every day.

"The two questions I deal with are 'what kind of person am I going to be' and 'how will people see me.' I tell them they will be the same person as before, but they will have to adjust to the new reality and a new body image without worrying about what other people think. Today's new amputees are going through the same psychological process as all who went before them, but the devices available to them, while still alien, improve their chance of living and quality of life."

Since new military amputees began returning from the battlefields of the second Gulf War – about 670 by October 2007, joining a VA population of some 10,000 amputees from all wars, as well as accidents and disease – a great deal of attention has been given to the successes of new prosthetic feet and lower legs. Video of amputees playing basketball, running in marathons, climbing mountains, and other activities that would have been impossible without 21st century technology have led many to believe amputation is now little more than an inconvenience, that every wounded warrior – including those who lost limbs decades ago – will now be fitted with functionally enhanced, cosmetically indistinguishable bionic replacements.

Reality, however, is a far different story, as Downs knows all too well. Despite his current position in charge of cutting-edge prosthetics available free – along with accompanying rehabilitation and physical therapy – to all veterans, Downs continues to use a hook little different from the one the Army fitted him with nearly 40 years ago.

"I'm used to it, I'm good with it, and I really don't have the time to learn how to use the new one – but it's there if I want to do it," he says, adding the new technology, which requires linkage to and control by remaining muscles – and, in those now in development, nerves – in the limb stump, can be far more difficult, painful, and time-consuming for those whose wounds have long-healed and built up scar tissue. But it is far from a simple transition for new amputees, either.

"The first time you stand up on a prosthetic device, no matter how good it is, it will hurt like hell. And that is a shock. And walking is even more painful. That's why they have to go through rehab. Your body eventually toughens up," he explains. "In my case, I have a lot of scar tissue and any pressure causes me a lot of misery – and the new myoelectric arms [which use electric signals the body sends to muscles to activate micromotors in the prosthesis] weigh a lot more than mine. So these young men and women have to adjust to the reality of the prosthetic device because it does not work as well as a real arm or leg."

Whether it will ever be possible to match the Hollywood image remains an open question, but DoD and the VA are committed to pushing technology as far as possible, as quickly as possible, using every tool available, including those coming from far different disciplines. Downs, for example, keeps a close eye on what is happening in academia, industry and elsewhere in government – especially NASA, DARPA, and other agencies and labs – extending the limits of new developments in satellites, robotics, wireless communications, cell phones, etc.

"The obstacle is to utilize these technologies and effectively interface them with humans. If I could move my artificial arm without thinking about it, that would be a tremendous advance. Northwestern University [NWU] is implanting electrodes into muscles, so the mind runs them automatically, just like the brain does with live nerves and muscles. That's a tremendous advance. Another project is implanting electrodes in the brain, enabling the test subjects to move a pointer on a computer screen, so they can write and send e-mail, for example, without needing to touch a keyboard or mouse," he says.

"Another obstacle is replicating strength, durability, and reliability of the human body part being replaced. When you look at your hand and see all those joints, which have to be replaced by servomechanisms,