

HEALTH & HEALING

NEXT-GEN PROSTHESES

Veterans are on the forefront of testing innovative artificial limbs that could change amputees' lives

By Gina Harkins

WHEN ARMY SGT. JAMES "JP" McGuire Jr. used his own belt as a makeshift tourniquet after his right leg was nearly destroyed by an improvised explosive device blast in Iraq in 2007, he briefly thought he might not make it home.

Now a decade later, the retired McGuire can be found chasing after his two kids, hitting the golf course or sparring with the high school wrestlers he coaches — all using a new prosthetic leg that connects directly to his femur.

"My life has 100 percent turned around," said McGuire, who previously used prostheses that attached to a socket that fit over his remaining limb, but found them so uncomfortable and cumbersome that he often went without using them for most of the day. "It took me about 20 minutes to put my leg on in the morning with the socket and another 10 minutes to take it off. Now it's as quick as five seconds."

McGuire is one of 10 veterans to get a titanium implant surgically inserted into the bottom of the femur as part of a Food and Drug Administration (FDA) trial at a Veterans Affairs center in Salt Lake City. The ground-breaking device is called a percutaneous osseointegrated prosthesis,

or POP, implant and it gives amputees the ability to attach artificial limbs directly into their bodies.

The study is just one way the VA is working to improve the lives of amputees. The VA routinely teams with the Department of Defense, universities and private-sector companies to test and develop new prostheses and orthotics (external braces). Those partners are leveraging 3-D printing, virtual-reality platforms and complex robotics to develop artificial limbs that feel and act more like natural extremities.

Roughly 14,000 patients receive a new prosthesis or have one repaired by the VA each year, according to Dr. Joseph Webster, the national medical director with the Amputation System of Care at the Hunter Holmes McGuire VA Medical Center in Richmond, Va. Amputation is most common among older vets with medical conditions like diabetes or vascular disease, he said. But even if their injuries or illnesses aren't connected to their military service, veterans typically don't face any out-of-pocket costs for the devices, he added.

Artificial limbs have come a long way in the last 10 to 20 years, Webster said. Part of what prompted the innovation was the more than 1,600 troops who lost hands, arms, legs or feet during the wars in Iraq and Afghanistan.

"They want to get back to doing higher-level activities and ... lead a relatively normal and active lifestyle," Webster said. "We have to have artificial limbs that help them to meet those goals."

INNOVATION FOR ALL

Veterans are often the first to test new prostheses, but if the technology is



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approved, any American in need of an artificial limb can benefit.

That has been the case with the DEKA Arm System, a state-of-the-art prosthesis. About three dozen veterans participated in the research for that system, which was developed by the New Hampshire-based DEKA Research & Development Corporation, through funding from the Defense Advanced Research Projects Agency.

Designed by Segway creator and DEKA president Dean Kamen, the arm uses a series of sensors and switches that give patients six different grips. Joints allow for several movements to occur simultaneously, so amputees can do near-natural actions that weren't possible with other prostheses, such as turning a key in a lock, holding a tube of toothpaste or gripping anything from a grape to a glass — all through a wireless control system.

The yearslong study resulted in the bionic Life Under Kinetic Evolution, or LUKE Arm, which is now commercially available through Mobius Bionics. The prosthesis was named, in part, for the bionic limb Luke Skywalker sports after losing his hand in *Star Wars: Episode V – The Empire Strikes Back*. Fred Downs and Artie McAuley, Vietnam War vets who'd each lost all or part of an arm, were the first two veterans fitted with the LUKE arm earlier this year, restoring essential functionality.

"I think that's a good example of how the VA partners not just with the (Defense Department), but also other manufacturers or private industry," Webster said.

Other ongoing VA partnerships include: efforts to restore sensation through prosthetic hands using research from DEKA, Medtronic and numerous universi-

ties; testing new cooling prosthetic sockets that ease discomfort and skin irritation with Vivonics; and developing 3-D printed metal prosthetic fingers with SynTouch, the Alfred Mann Foundation, and others, according to VA officials.

McGuire recently had his ninth checkup as part of the yearlong VA study for the POP implant. His 10th and final one is scheduled for December, and if the FDA approves the device, more veterans and civilians could soon swap their prosthetic sockets for new limbs that attach directly to their bodies. Because the study is ongoing, there's no set time frame for the final FDA approval, but it's likely several years away, Webster said. The next phase of the research is expected to involve 50 to 60 participants, he added.

Webster, who helped get McGuire into the study, said he couldn't comment further on the ongoing research. But added that the other veterans involved have also seen positive results.

HURDLES REMAIN

Prostheses advancements have proved promising, but Webster said amputees still face a lot of challenges.

"JP is a good example of someone who's been able to get back to doing most of the

The DEKA Arm System, an advanced robotic prosthesis, can carry out multiple, simultaneous, powered movements, giving the wearer advanced control.



PHOTO ILLUSTRATION BY MATTHEW BREITBART/NATIONAL MUSEUM OF HEALTH AND MEDICINE

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James “JP” McGuire Jr. is one of 10 veterans testing titanium implants that connect directly to the femur.



PROVIDED BY JAMES MCGUIRE JR.



DEPARTMENT OF VETERANS AFFAIRS

things he'd like to do," Webster said. "But there are still a number of individuals who struggle and aren't able to achieve that."

One reason for that is sockets continue to bother many patients. Before McGuire got his new implant, the former Army combat engineer said he tried about 10 different prosthetic legs with sleeve-type sockets that fit over his thigh.

"There would be times after a few rounds of golf when my whole stump would be just raw and worn out," McGuire said.

Controlling artificial limbs is another challenge, Webster said. Someone wearing an artificial hand, for example, not only has to think about opening or closing it, but also what they need to do to make the prosthesis move. That might mean flexing their wrist to move the hand, so actions typically require multiple steps, Webster said.

"We're looking at how we can connect this person's own nervous

system to ... the artificial limb," he said.

Another issue is that after the surgery, some patients have reported skin irritation, which can be treated with a topical agent.

"There can also be the formation of what is called 'granulation tissue' at the skin-implant interface," Webster said. "This is also usually managed with local treatments, but can require surgery to correct or remove the granulation tissue."

The VA also needs to be able to reach veterans where they live, and that can be difficult — especially for those in rural areas. Webster helps lead a system of care designed specifically for veterans with amputations. The department has designated seven VA medical facilities as regional amputation centers, which allow health care professionals at smaller facilities to consult with experts at their regional amputation center.

The department also uses telehealth technology to connect

with vets in remote areas. Last year, VA officials had 3,000 telehealth encounters with veteran amputees, Webster said. That means veterans don't have to travel as far for care.

"It provides the veterans the ability to receive care from a highly specialized team of amputation care providers (physicians, physical therapists, prosthetists) when that service is not available at the veteran's local VA medical center," said Dr. Joel Scholten, national director of the Veterans Health Administration's physical medicine and rehabilitation office. (To learn more about telehealth initiatives, turn to page 140.)

McGuire urges veterans to talk with their VA doctors about studies or trials that might help improve their lives. He credits his doctors with helping him get back to a "completely normal life."

"They changed in 12 months what I've been trying to change about my life for about 10 years," he said.

STRIVING TO MAKE PROSTHESES MORE NATURAL

Artificial limbs are getting more high-tech, but if they're uncomfortable, heavy or impractical, amputees won't bother using them.

That's prompting researchers like Marco Santello and Bradley Greger to help create prostheses that amputees will use in their daily lives. An artificial hand that can play the piano is useless if it weighs too much, said Santello, director of Arizona State University's school of biological and health systems engineering.

"Nobody wants to wear something that's four times heavier than my regular hand, difficult to control ... or will break as soon as it hits the table," he said.

People also want something that looks and feels like a natural body part, added Greger, an associate professor with Santello's department — not something that's going to draw a lot of attention. "They don't want that cyborg-looking robot arm," he said. "They want normal."

Santello is researching ways to transmit movement, vibration, pressure and temperature from a prosthesis to an amputee's remaining limb. The nerves that run from a stump to the brain are still intact, he said, so his team implants tiny electrodes to stimulate those nerve fibers to mimic sensations.

Greger uses virtual reality to study ways to make prosthetic limbs move. Subjects are given headsets that show virtual limbs where theirs are missing and are asked to complete various movements.

"We're trying to reactivate the part of the brain that controls the limb that's missing, because that's all still there," Greger said.

It's a matter of years — not decades — before people will be able to control artificial limbs through their nervous system channels and receive some sensory feedback, Greger added.

"They'll be able to pick up their child with confidence because they can sense how tightly they're gripping," he said.

Santello, Greger and their partners receive research funding through the Department of Defense, and they said it feels good knowing their work could someday help veterans.

"(Service members) who put themselves at great risk for us and sustain some serious injury, it's almost a social obligation that we try and provide them the best technology we can to get their lives back to what it was," Greger said.

— Gina Harkins