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First mind-controlled bionic leg a 'groundbreaking' advance

Barbara Mantel, NBC News

4 hours ago

Video: Zac Vawter lost his leg in a motorbike accident. He is now part of a ground breaking research study testing a thought controlled bionic leg.

After losing his lower right leg in a motorcycle accident four-and-a-half years ago, 32-year-old Zac Vawter has been fitted with an artificial limb that uses neurosignals from his upper leg muscles to control the prosthetic knee and ankle. The motorized limb is the first thought-controlled bionic leg, scientists at the Rehabilitation Institute of Chicago reported Wednesday in The New England Journal of Medicine.

“This is a groundbreaking development,” says lead author Levi Hargrove, a biomedical engineer and research scientist at RIC. “It allows people to seamlessly transition between walking along level ground and going up and down stairs and slopes.”

Until now, only thought-controlled bionic arms have been available to amputees.

When Vawter thinks he wants to move his leg, the brain signal travels down his spinal chord and through

Brian Kersey / AP

On Oct. 25, 2012 Zac Vawter, fitted with an experimental "bionic" leg, climbed the 103 flights to the top of Willis Tower in Chicago.

peripheral nerves and is picked up by electrodes in the bionic leg. Unlike robotic models currently on the market, the prosthesis allows a normal, smooth gait no matter the incline. Although the cost hasn't been determined, a version could be available to the more than one million Americans with leg amputations within three to five years, the Chicago scientists said.

“It makes a phenomenal difference,” says Vawter, a software engineer from Yelm, Wash., whose right leg was amputated through the knee in 2009 after he crashed his motorcycle. Aware of the institute's work on bionic arms, Vawter and his surgeon contacted Hargrove and the team developing the pioneering prosthesis. For nearly three years ending in October, 2012, Vawter would travel to the institute periodically.

Vawter would remove his mechanical leg, slip into the bionic one, and run through a set of experiments the scientists devised, suggesting improvements and providing feedback on what was working and what was not.

Now, after multiple revisions to the leg’s software and two major revisions to the leg’s mechanics, Vawter says he can walk up and down stairs the way he did before the accident. With his mechanical leg, Vawter says, “My sound leg goes up every step first, and I’m just dragging the prosthetic leg along behind me.” But with the bionic leg, “I go leg over leg,” he says. “The bionic leg listens to the various signals from my nerves and responds in a much more natural way.”

Some current prosthetic legs are purely mechanical, like Vawter’s; others are robotic and have a motor, a computer, and mechanical sensors that detect how much weight is being put on the prosthesis and the position of the knee. These allow people to walk well but don’t allow people to seamlessly ascend or descend stairs with a normal gait or to reposition their leg while sitting without manually moving it. The thought-controlled bionic leg is much more sophisticated. In additional to mechanical sensors, it has two motors, complex software, and a set of electrodes - essentially antennae - in its socket that pick up the tiny electrical signals that muscles in the upper leg generate when they contract.

Two electrodes pick up signals from the hamstring muscle, where the nerves that had run through Vawter’s lower leg were redirected during the amputation. “So when Zac is thinking about moving his ankle, his hamstring contracts,” says Hargrove.

NBC News

With the bionic leg, “I go leg over leg,” says Vawter. “The bionic leg listens to the various signals from my nerves and responds in a much more natural way.”

More electrodes pick up signals from other muscles in the residual limb. The complex pattern recognition software contained in the on-board computer interprets these electrical signals from the upper leg as well as mechanical signals from the bionic leg and “figures out what Zac is trying to do,” says Hargrove.

The U.S. Army’s Telemedicine and Advanced Technology Research Center funded the Chicago study with an $8 million grant to add neural information to the control systems of advanced robotic leg prostheses. Devising a thought-controlled bionic leg has been more challenging than a thought-controlled bionic arm, says Hargrove.

That's because the motors must be powerful enough to provide the energy to allow someone to stand and push along -- and they must be small. Also, the computer control system must be safe.

“If there is a mistake or error that could cause someone to fall, that could be potentially catastrophic, and we want to avoid that at all costs,” says Hargrove.

The leg is a prototype so Vawter cannot take it home. Error rates in the software are small but need to be made smaller, says Hargrove and the leg itself needs to be made quieter and lighter. In addition, prolonged use can produce chafing where the residual limb contacts the electrodes in the bionic leg’s socket.

The ultimate cost of the final product is unknown, says Hargrove, although upper extremity prostheses range from $20,000 to $120,000. "We are leveraging developments in related industries to make sure we use low-cost components whenever possible," Hargrove told NBC News.

Careful engineering will make it affordable. His goal is to restore “full ability” to all patients, especially the elderly. “This could mean the difference between living in their home longer and having to go to a nursing home,” says Hargrove.

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The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Robotic Leg Control with EMG Decoding in an Amputee with Nerve Transfers

Levi J. Hargrove, Ph.D., Ann M. Simon, Ph.D., Aaron J. Young, M.S., Robert D. Lipschutz, C.P., Suzanne B. Finucane, M.S., Douglas G. Smith, M.D., and Todd A. Kuiken, M.D., Ph.D.

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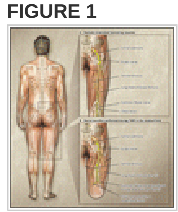
The clinical application of robotic technology to powered prosthetic knees and ankles is limited by the lack of a robust control strategy. We found that the use of electromyographic (EMG) signals from natively innervated and surgically reinnervated residual thigh muscles in a patient who had undergone knee amputation improved control of a robotic leg prosthesis. EMG signals were decoded with a pattern-recognition algorithm and combined with data from sensors on the prosthesis to interpret the patient's intended movements. This provided robust and intuitive control of ambulation — with seamless transitions between walking on level ground, stairs, and ramps — and of the ability to reposition the leg while the patient was seated.

MEDIA IN THIS ARTICLE

Video

Control of Robotic Prosthesis.

FIGURE 1



Natively Innervated and Surgically Reinnervated Residual Thigh Muscles.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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SOURCE INFORMATION

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