Men have hands amputated and replaced with bionic ones

25/02/2015

The procedure, dubbed "bionic reconstruction", was carried out by Oskar Aszmann at the Medical University of Vienna, Austria.

The men had all suffered accidents which damaged the brachial plexus – the bundle of nerve fibres that runs from the spine to the hand. Despite attempted repairs to those nerves, the arm and hand remained paralysed.

"But still there are some nerve fibres present," says Aszmann. "The injury is so massive that there are only a few. This is just not enough to make the hand alive. They will never drive a hand, but they might drive a prosthetic hand."

This approach works because the prosthetic hands come with their own power source. Aszmann's patients plug their hands in to charge every night. Relying on electricity from the grid to power the hand means all the muscles and nerves need do is send the right signals to a prosthetic.

Preparing the body

Before the operation, Aszmann's patients had to prepare their bodies and brains. First he transplanted leg muscle into their arms to boost the signal from the remaining nerve fibres. Three months later, after the nerves had grown into the new muscle, the men started training their brains.

First they practised activating the muscle using an armband of sensors that picked up on the electrical activity. Then they moved on to controlling a virtual arm. Finally, Aszmann amputated their hands, and replaced them with a standard prosthesis under the control of the muscle and sensors.

"I was impressed and first struck with the surgical innovation," says Dustin Tyler of the Louis Stokes Veterans Affairs Medical Center in Cleveland, Ohio. "There's something very personal about having a hand; most people will go to great lengths to recover one, even if it's not very functional. It's interesting that people are opting for this."

While Aszmann's approach uses a grafted muscle to relay signals from the brain to a prosthesis, others are taking a more direct route, reading brain waves directly and using them to control the hand. A team at the University of Pittsburgh, Pennsylvania, has used a brain implant to allow a paralysed woman to control a robotic arm using her thoughts alone.

Too complex

Tyler says one advantage of an elective amputation is that it allows the surgeons to plan exactly where the cut will be made, and how the prosthesis can graft to the wearer's skeleton for enhanced stability.

Even if nerve and muscle function could be completely restored in the arm, biological hands are too complex for surgeons like Aszmann to rewire. The muscles in our hands have the highest density of nerves in the body, and the interplay of tendons, muscles and ligaments means that even small defects can prevent a hand functioning properly.

A prosthetic hand is simpler, and easier to work with. "I'm not sure we need to replace hands perfectly," says Tyler. "You may not play the piano yet, so rather than replacing the hand, the goal is to make you forget you lost it."

For Aszmann's patients, that simple, functional prosthetic hand works better than their biological one. After the transplant, all three were able to pick up a ball, pour water from a jug and do up buttons.

Function restored

The patients' scores on a range of limb function tests also improved after the surgery. On a test called the Southampton Hand Assessment Procedure they improved their average score from 9 out of 100 to 65, where 100 is a normally functioning hand.

Although Aszmann's procedure gives hand function back to his patients, he can't yet give them back their sense of touch. "There are about 70,000 nerve fibres to a normal hand, and the majority of these are sensory fibres carrying hand-to-brain information," he says. "Only 10 per cent are motor fibres."

"Sensation and touch is what connects us to the world," says Tyler. He's working on a prototype prosthetic arm that provides hand to brain information, not just motor control. The current version uses wires to deliver electronic stimulation to nerves in the arm, but Tyler says his team will have a fully implantable wireless version in three or four years.

Even then, our technological alternatives to the hand will remain crude compared with fully functional human hands. "There's an immense interplay that makes the hand what it is," says Aszmann. "It's a fascinating organ."

"We're rethinking the wiring of the body," says Tyler.