We have the technology to make bionic hands

Anyone who watches the PBS News Hour regularly knows that aerospace and science reporter, Miles O'Brien could eventually become one of humanity's first recipients of a true bionic arm and hand. It was just announced that he will be returning to flying planes.

O'Brien is a general aviation pilot, but a year ago he lost his left arm. While in the Philippines to report a story in February 2014, O'Brien suffered what initially seemed to be a minor injury when a heavy case landed on his arm, but he developed a complication known as compartment syndrome, a surgical emergency that threatened his life, and the arm had to be amputated just above the elbow.

Earlier this year, he reported a multi-part story on current progress toward the goal providing upper extremity amputees with robotic hands and arms – not merely prosthetics with some rudimentary function, but a true bionic part, one that is integrated into the limb stump and controlled from the person's brain with as much ease as the natural part that was lost.

We have the technology

In my GLP article on human enhancement, I introduced bionic parts using the example of the old 1970s sci-fi series The *Six-Million Dollar Man* (starring Lee Majors), its spinoff The Bionic Woman (starring Lindsay Wagner), and the upcoming remake, -updated, of course, to The Six BILLION Dollar Man for a little more cost realism. But, in addition to the price tag for a hypothetical spy enhanced with mechanical parts that work better than what they replaced, the main premise is actually much more realistic today than it was in the 70s. Unlike 40 years ago, today, the line from the *Six Million Dollar Man* opening -"We have the technology"- would not be crazy, although, to be perfectly accurate it would be that we're getting close to the technology.

Mind control: The biggest challenge

For the time being, Miles O'Brien's replacement arm is a simple prosthetic with a hook to perform simple tasks. But he's been reporting at a laboratory that's developing genuine robotic arms and hands that can be controlled from an amputee's brain. At this point, he cannot test the robotic arms himself, but another amputee do the testing, and was shown controlling the limb on the PBS News Hour.

The reason for the difference is that, unlike O'Brien, the other amputee has gone through a special type of surgery known as re-inervation. From a certain point above the injury or amputation site the nerves supplying the muscles of the arm, forearm, and hand are healthy and conduct impulses normally. Often, the nerves that still conduct impulses can control muscles near the amputation stump. The trick is to determine how far down in the shoulder or arm an amputee can generate, and receive nerve signals, and lengthen the nerve connections further down the arm with surgical grafting techniques. Because the other amputee that O'Brien features in the report has had the reinervation surgery, in the laboratory he has learned to control a robot hand that can be attached to the stump.

Next steps: Integration with the bone, improved mind control, and sensory input

The amputee who controls the robot hand in the laboratory is further along the way to getting a bionic hand compared with O'Brien, but there is still a long way to go. First of all, while the hand has computer controlled motors to open and close with mechanical fingers, enabling much more function than O'Brien's hook, it is not even close to the complex functions of a healthy biological hand. But robot and miniaturization technology is getting pretty good and there seems to be no end in site, so a hand or arm with precision and power equal to that of a human will probably exist probably not many years into the future, although increased function will mean more challenges in terms of integrating with the patient's nerve impulses and teaching the patient to control the device.

The amputee in O'Brien's report only wears the robot hand during experiments. It is not attached to him permanently. Doing that would require integrating the device with the bone of the amputation stump, but that has not been done on this man, since the purpose of the experiments is to improve integration between the robot hand and the brain.

On the other hand, three people on this planet do have bionic hands that have been attached surgically to their arms. All three patients were victims of a kind of shoulder injury known as brachial plexus avulsion - damage to a weblike complex of nerves in the shoulder. After their injuries, they had hands that were un-amputated, but they had lost the ability to make them move. The went through a painful process of reinervation surgery and therapy in which, through healthy parts of the nerves at the shoulder level, they learned to control virtual hands shown inside a computer, then a bionic hand placed next to their non-functional hands, and finally the non-funcional hand was amputated and replaced with the bionic hand attached to the bone.

While these first bionic hand pioneers all say that they feel better off than they did before they had the bionic hands, the function is still nothing near what their original hands were able to do before their injuries. Nor to these early bionic hands provide the nervous system with much sensory information, and to have complete hand function, huge amounts of information must move in both directions between the hand and the brain.

So, it would seem, the bionic man–whether six million or six billion dollars–is still science fiction in the sense that getting and hand or arm that does EVERYTHING that the lost part could do (or even do it better) is still beyond our capability. On the other hand (excuse the pun), we have come quite a way in the last 40 years. What remains to be achieved seems more a matter of degree than a fundamental breakthrough. More information has to flow between the bionic machine, the nerves, and the amputee's brain, and the mere increase in quantity of that information could end up making all of the difference.

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