Research team develops treatment algorithm for bionic hand reconstruction

January 18 2017, by Johannes Angerer

A research group led by Oskar Aszmann of the Department of Surgery at MedUni Vienna and Vienna General Hospital has developed a treatment algorithm or protocol that can be used to establish which patients with global injuries to the plexus brachialis (plexus brachialis syndrome) will most probably benefit from having their numb and non-functioning hand replaced by a myoelectric (bionic) prosthesis.

The plexus brachialis is a network of sensory and motor nerve fibres emanating from the spinal nerves in the lower cervical spine and upper thoracic spine and converging to form the nerves of the shoulder, arm and hand. A whole range of surgical procedures are available to restore nerve and muscle function following injuries to the plexus brachialis associated with nerve root avulsion. These can often restore stability and mobility to the shoulder and upper arm and, in a few cases, also mobility of the hand and fingers. In some cases, however, the hand is left as a useless appendage.

The authors have called upon their experience with patients who presented at the Division of Plastic and Reconstructive Surgery at MedUni Vienna/Vienna General Hospital with global plexus brachialis injuries between 2011 and 2015. In 16 of these cases, the nerve damage was so severe that no surgical intervention was able to restore adequate functionality of the hand. These patients were offered a bionic alternative: replacement of their useless biological hand by a myoelectric prosthesis – a bionic hand.

When it was learned that this novel treatment has been offered to the first patients in the world to receive such bionic reconstruction, it was widely reported by the international media, for example in the Wall Street Journal, The Guardian, NY Daily News, by the BBC and many other print, online and TV media.

The authors have developed a treatment algorithm for bionic hand construction consisting of the following steps:

1. Physical and psychological assessment of the patient. The patient must still be able to use their shoulder and elbow but no longer have any motor or sensory capability in their hand. Furthermore, the patient must be sufficiently psychologically robust to cope with the associated emotional challenges.

2. Recording of the electromyographic signals of the muscles in the lower arm. Two separate signals are required to control a bionic hand. If there are fewer than two signals present, surgical procedures can be used.

3. Optionally: Operation to perform a selective nerve transfer and/or transplant of the healthy muscle to improve nerve conduction and muscle activation in the lower arm, where there are not at least two electromyographic signals.

4. Brain training: This biofeedback training makes it possible to respond to re-innervated muscles to control the movement of the hand and lower arm.

5. "Trying out" a hybrid hand: The patient learns to control the prosthesis with their own electrical signals before their hand is amputated.

6. Amputation of the useless biological hand.

7. Replacement of the biological hand by a myoelectric prosthesis, followed by additional training and checking of the bionic hand function.

The results are now available for five patients operated on sufficiently long ago (at least three months after the last prosthetic adjustment). These functional results were recorded using the "Action Research Arm Test" (ARAT), the "Southampton Hand Assessment Procedure" (SHAP) and the "Disabilities of the Arm, Shoulder, and Hand" (DASH) questionnaire. All five patients displayed a significant improvement in hand function, which was maintained over the entire follow-up period.

Says lead investigator Aszmann: "Once the patients had got used to working with the bionic hand, the deafferentation pain (Note: chronic pain felt by people with severed nerves), which was severe in three of the five patients, diminished." According to the authors, "the patients reported a subjective correlation between the length of time they wore the prosthesis each day and the reduction in pain. If they were unable to wear the prosthesis because it was undergoing regular 'maintenance', the pain increased again within a few days."

At the time the study paper was written, the remaining eleven patients were still in the early stages of the algorithm.

Says Aszmann regarding the study results: "For more than 25 years I have been treating patients who have suffered serious peripheral nerve lesions. A bionic reconstruction such as that described in the study paper represents a real turning point, because it actually helps patients who have no other alternative open to them and gives them back hope."

More information: Laura A. Hruby et al. Algorithm for bionic hand reconstruction in patients with global brachial plexopathies, *Journal of Neurosurgery* (2017). DOI: 10.3171/2016.6.JNS16154

Provided by Medical University of Vienna