



## **Targeted Muscle Reinnervation (TMR) Fact Sheet**

### **About TMR**

- Targeted Muscle Reinnervation (TMR) is an innovative surgical procedure that reroutes signals from nerves severed during amputation to intact muscles, allowing patients to control their prosthetic devices by merely thinking about the action they want to perform. The muscle contractions produced by the neural signals are able to control a prosthetic limb.
- Currently with motorized prostheses, individuals who have experienced limb loss are only able to operate one motion at a time. With the TMR procedure, amputated nerves are transferred to spare muscles in the residual limb and grow into the muscle to provide additional control signals for prosthetic limb operation. This allows patients to simultaneously control multiple functions in their prosthesis in an easier, more natural manner.
- Since the inception of the TMR controlled bionic arm in 2002, more than 50 patients worldwide have received the surgery, including over a dozen military veterans who have lost limbs in combat. Dr Martin Baechler, LTC is a surgeon at Walter Reed Medical Center who performed the TMR procedure on Glen Lehman, at the time a sergeant in the army who lost his arm in combat in Iraq.
- TMR was developed by Todd Kuiken, M.D., Ph.D., director of the Center for Bionic Medicine (CBM) at The Rehabilitation Institute of Chicago (RIC) and Gregory Dumanian, M.D., Ph.D., chief of the department of plastic surgery at Northwestern University. The center's collaborative staff includes biomedical engineers, electrical engineers, physiatrists, surgeons, prosthetists and therapists. The CBM aims to improve function and quality of life for people who have suffered limb loss.

### **Expanding Access to TMR: To the Military and Beyond**

- To increase access to the TMR procedure, RIC has partnered with the military to provide the surgery to returning veterans. This work is being done with Walter Reed Army Medical Center in Washington, DC, and Sam Houston Military Medical Center in San Antonio, TX.
- Between these two hospitals, several surgeons have been trained to perform TMR surgery for servicemen and women who have lost their arms in combat.
- RIC, in collaboration with the Department of Plastic Surgery at Northwestern University, has also launched the first-ever educational training video for TMR. The training video provides an overview of the surgical procedure, basic principles for the science behind TMR, information about patient selection and insight into results and rehabilitation post-surgery. The 20-minute video is available for viewing or downloading at <http://www.ric.org/research/centers/cbm/Video.aspx>.

## **The Beginning: The Bionic Arm**

- In 2002, Jesse Sullivan – dubbed the “Bionic Man” – became the first person to undergo the then experimental TMR procedure after losing both of his arms in an electrical accident. In order to regain movement, the nerves in his amputated arms were transferred to spare muscle and skin in the left side of his chest. The surgery eventually helped him control and independently move different joints of his prosthetic arm intuitively.
- Jesse also felt his missing hand when the skin over his TMR muscles was touched. This enabled scientists at the RIC to give feeling to a prosthetic hand—when sensors in the hand touched an object, the reinnervated skin was pressed and Jesse felt his missing hand being touched. This prompted the research team in 2005 to deliberately attempt to bring sensory function to the first Bionic Woman, Claudia Mitchell.
- After the first six patients received TMR surgery, their functionality and prosthetic control improved significantly, and four patients regained sensory function. These accomplishments paved the way for additional research and the more than 50 surgeries that have been conducted to date worldwide, including over a dozen that have been performed on military veterans who have lost limbs in combat.

## **The Future of TMR Technology**

- Work is now underway to further refine robotic arm control. Rather than using individual muscle sites to control each movement, a computer can be trained to recognize different movements from the pattern of electrical signals recorded from all reinnervated muscles. Although this “pattern recognition” technology is currently only used as a research tool, researchers are hopeful that it could be incorporated into prosthetic devices for control of multiple functions at the same time and in an easier, more natural manner.
- Sensory reinnervation has shown to take place following the TMR procedure, where patients perceive different sensations on their missing limbs, such as temperature, sharpness of objects, vibration and pressure. Through additional study of sensory reinnervation, RIC researchers are in the process of developing a state-of-the-art prosthesis with functionality for the shoulder, elbow, wrist and hand, as well as interfaces to supply sensory feedback.
- Research with TMR continues in many areas, including the refinement of computer decoding algorithms, the revision of advanced control systems to allow them to be used by patients at home and at work, the development of robotic arms with more motorized joints, the potential use of TMR for motorized leg prostheses, and the effects of TMR on the brain.