Targeted Muscle Reinnervation for Transhumeral Amputees: Modified Surgical Technique for Operating Multiple Joints in A Prosthetic Arm

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Introduction: Kuiken et al. found that an amputated nerve transferred into a nearby muscle produced a transcutaneously detectable electromyographic signal corresponding to the transferred nerve, the targeted muscle reinnervation (TMR) technique, for controlling the prosthesis. However, it is ideal to select and transfer each motor fascicle to achieve highly developed myoelectric arms with multiple degree-of-freedom motions.

Methodology: We treated 4 men with post-injury transhumeral amputation. We first identified the amputated median and radial nerves. The sensory fascicles were identified using somatosensory evoked potential. The motor fascicles were divided into an innervating digit flexion and an innervating forearm pronation/wrist flexion in the median nerve; and into an innervating digit extension and an innervating forearm supination/wrist extension in the radial nerve. Each median nerve fascicle was transferred to the biceps short head or the brachialis branch while the biceps long head branch was retained for elbow flexion. Each radial nerve fascicle was transferred to the triceps medial or lateral head branch while the triceps long head branch was retained for elbow extension. EMGs and physical test results were evaluated.

Results: In needle EMG, myogenic potentials were detected at all six motions such as digit flexion/extension, forearm pronation/supination, and elbow flexion/extension within 6 months postoperatively in all cases. In surface EMG, the identification rate was 97.7%, i.e. one-to-one correspondence was almost achieved 12 months postoperatively. Holding functions, VAS, and DASH significantly improved after acquiring six motions with the surgery compared with only two motions of digit flexion/extension before surgery ($p<.05$).

Conclusions: We noted functional improvement with marked identification rate for each motion after the selective nerve transfers as well as pain relief after neuroma excision and detection of favorable myogenic potentials after subcutaneous fat tissue removal. Thus, more selective nerve transfers are required for highly developed prostheses with multiple degrees of freedom.