Selective Motor Fascicle Transfers and Nerve-Machine Interface

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Transverse deficiencies (Congenital amputees)
Traumatic amputees
(Acquired amputees)
Hand transplantation

Fig. 3. The appropriate length of graft to be planted is determined by comparison with the limb in a unilateral hand transplant.

Fig. 4. Two teams work simultaneously during a unilateral hand transplant.

Fig. 17. If necessary, a full-thickness skin graft is used to prevent unnecessary tension on flap inset.

Hartzell TL, Hand Clin 2011
Hand transplantation

Fig. 2. Grade 2 AR. Maculopapular rash in distribution to the radial dorsum.

Fig. 3. Grade 2–3 AR. Diffuse erythema and edema with rash delimited to the suture line.

\textcopyright{} Gorantla VS Hand Clin 2011
Limitation of surgical treatment??
How about the prosthesis?
Myoelectric hand
Control with the electrical signals generated naturally by remaining muscles

http://www.audi.jp/innovator/ism/i_20/index.html
Myoelectric hand

Below-elbow amputee
(transradial amputee)

Good for acquiring electrical signals for hand motions

Muscles working hand are preserved in proximal forearm.
Myoelectric hand
Above-elbow amputee??
(transhumeral amputee)

Muscles NOT preserved
Nerves still left!!!
Targeted muscle reinnervation (TMR)

The amputated nerves transferred to the muscles to myoelectric hand motions.

Kuiken TA., et al. JAMA 2009
After successful neurotization, the newly reinnervated muscle serves to amplify the electric signal from the amputated nerve.

http://www.ric.org/research/research-centers—programs/bionic-medicine/Video/
Problems

1. Caliber mismatch
2. Selectivity

Kuiken TA et al. Tech Orthop. 2017
1. Caliber mismatch

2. Selectivity

Median nerve includes the fascicles to pronator (PT), digits flexion (FDS/FDP), wrist flexion (FCR/PT/FCU), and sensory.

Sunderland S, Nerve injuries and their repair, 1991

Kuiken TA et al. Tech Orthop. 2017
1. Caliber mismatch

2. Selectivity

Need for more Selective Motor Fascicle Transfer??

Caliber matched More effective
Biceps/ Triceps

Transhumeral amputee
Identification of sensory fascicle using SSEP(somatosensory evoked potential)

After dividing sensory fascicle, we can divide motor fascicles using topogram.
Radial nerve

- Long head, *for elbow extension*
- Medial head, *for digits extension*
- Lateral head, *for wrist extension/supination*

PIN (posterior interosseous n.) fascicle
ECRB/L-supinator fascicle

(We keep the long head of triceps as it is for elbow extension.)
Musculocutaneous nerve

- Biceps brachii muscle (short head), *for elbow flexion*
- Biceps brachii muscle (long head), *for digits flexion*
- Brachialis muscle, *for wrist flexion/pronation*

AIN (anterior interosseous n.) fascicle
FCR/PT fascicle

(We keep the short head of triceps as it is for elbow flexion.)

Biceps brachii muscle (short head)

( long head )

Brachialis muscle

AIN fascicle

FCR/PT fascicle

Needle EMG
6 months after op

Elbow flexion
(Biceps long head)

Elbow extension
(Triceps long head)

Digits flexion
(Biceps short head)

Digits extension
(Triceps medial head)

Supination
(Triceps lateral head)

Pronation
(Brachialis)

Reinnervating target muscles!!

Elbow extension
↑
Fingers extension
↑
Supination
↑
Elbow flexion
↑
Fingers flexion
↑

Functional evaluations

Subjective evaluations

I collaborated with prosthesis engineers. They developed 6-motion prosthesis for above-elbow (transhumeral) amputees.
Myoelectric hands may give “useful hands” to amputee patients.

Selective muscle fascicle transfer is a novel approach of hand surgeons for amputee patients.
Thank you!!

At Kato lab, Division of Systems Research, Faculty of Engineering, Yokohama National University