

## EVALUATION OF A PROTOTYPE ELECTRIC-POWERED PARTIAL-HAND PROSTHESIS

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### ABSTRACT

A prototype partial hand mechanism has been developed for fittings at the trans-metacarpal level. Subjects selected for evaluation of the prototype device have absence of all fingers of the affected hand, all or some portion of the metacarpals present, at least one active intrinsic hand muscle, and relatively unimpaired wrist movement. The presence of one or two intrinsic hand muscles allows for proportional myoelectric control without resorting to forearm muscles that would be recruited during wrist positioning. The mechanism is suspended from the hand structure with a custom silicone socket. The socket extends no more proximal than the styloids so that the physiological wrist motion is unencumbered, allowing for orientation of the hand in a near physiological manner.

### BACKGROUND

The hand mechanism is shown in Figure 1. It uses a single motor with a gear transmission and bi-directional backlock [1]. The motor and transmission are placed in the volume corresponding to the knuckles of the ring and little finger. The finger assembly is made up of the index and middle fingers machined as a unit and a separate thumb. The fingers are driven by the gear transmission and a linkage transfers movement of the finger unit to movement of the thumb. Using a 9-volt rechargeable battery, the fingers have a maximum speed of about 2 radians/sec ( $\approx 105^\circ/\text{sec}$ ) with a maximum grip force at the tips of about 53 N ( $\approx 12 \text{ lb}_f$ ).



Figure 1. Prototype hand mechanism with socket mounting plate.

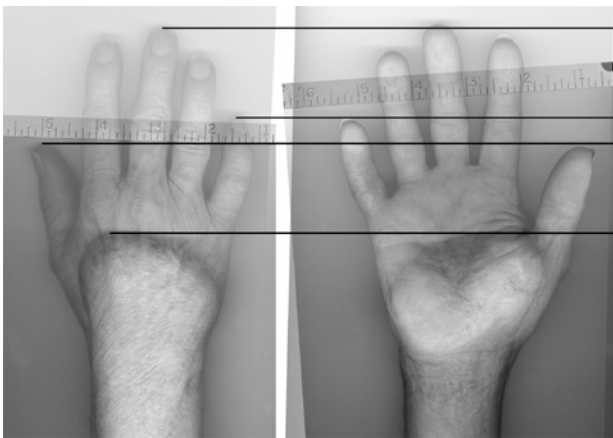


Figure 2. Subject's partial right hand superimposed on a reversed image of her left hand.

Our initial evaluation subject is a 64 year old female with a unilateral traumatic amputation of all fingers and thumb of the right hand through the metacarpals (see Figure 2). The amputation resulted from a burn injury in 1996 and both the residual hand and distal forearm are scarred. However, the skin is in good condition and the wrist is intact and mobile. The left hand and arm are unaffected by the trauma.

The subject has phantom finger sensation and palpation of the hand revealed several intrinsic muscles responding to her efforts to move the phantom fingers. Specifically, the Abductor Pollicis Brevis, the Flexor Pollicis Brevis, and the Abductor Digiti Minimi appear to be functional. Myotesting showed consistently moderate to strong signals from the Flexor Pollicis Brevis (elicited by imagining the thumb flexing across the palm) and the Abductor Digiti Minimi (elicited by imagining the fingers extended and spreading apart).

## **SUSPENSION**

With functional intrinsic hand muscles, it is possible to have myoelectric control without resorting to signals from forearm muscles. Consequently, the physiological wrist can be used for positioning of the hand prosthesis without compromising control. To achieve this, the suspension system must be secure enough to hold the mechanism to the residual hand but without encumbering the wrist.

A surlyn check socket was constructed having a proximal trimline distal to the styloids. The check socket was used to evaluate placement of electrodes over the intrinsic muscles and control interference during wrist movements. Using Otto Bock 13E125 electrodes and a custom VASI Single Programmable Module (SPM) as a controller, the subject demonstrated the ability to proportionally open and close the hand at will and to rotate the forearm, flex and extend the wrist, and move the wrist in radial and ulnar deviation without inadvertent operation of the hand.

Confident of the subject's control capability, two custom silicone sockets were fabricated by the Custom Silicone Service of Otto Bock Canada. One socket had the hand mechanism mounting plate formed into the silicone. The second socket interfaced with a laminated shell that incorporated the mechanism mounting plate. The silicone socket with laminated shell was an alternative in the event that the silicone only socket did not offer enough rigidity to maintain the position of the hand mechanism when acted upon by external forces.

The subject was evaluated with both sockets and both provided excellent suspension. The sockets were able to remain on the subject's residual hand up to a maximum test loading of 11.4 kg<sub>f</sub> (25 lb<sub>f</sub>) with minimal displacement.

## **RESULTS**

Our initial subject has been able to demonstrate good proportional myoelectric control of the prototype hand mechanism using intrinsic muscles of her residual hand. A custom silicone socket with myoelectrodes and mounting of the hand mechanism has been constructed. The next phase of the project is to complete the cosmetic covering of the mechanism and begin the field trial.

## **ACKNOWLEDGEMENT**

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## **REFERENCES**

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