EVALUATION OF A NEW FLEXION WRIST INTEGRATED WITH ELECTRIC HAND
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SUMMARY
A new electric hand has been developed which integrates flexion/extension into an electric hand, with no increase in length over standard-length electric or body-powered hands. The development* has included a field trial with six wearers of the electric hand. All the wearers were surveyed on the actual tasks they performed with the hand, including those utilizing flexion/extension.

Electric Hands have typically operated with a single gripping mode, usually three-finger tip prehension. Our attempt at this stage is to enhance function in the hand, but without adding complexity to the gripping mechanism.

Passive and electric wrist rotation can add an important degree of freedom (DOF), but still provides only one of the natural wrist’s three DOF. Additional degrees of freedom in the hand, however, would offer the amputee broader function of course, but practicality dictates the addition of a DOF without adding to the complexity of the hand.

In the past, integration of a flexion wrist with an electric hand has been accomplished with the addition of a component adding to the length of the hand/wrist combination. Typically, this combination has not been possible without sacrificing the quick disconnect feature of the hand as well, since the flexion components available have not contained the quick disconnect.

The development of the Motion Control Hand was done with a high emphasis placed on reducing the length of the drive mechanism. We sought to integrate a flexion mechanism into the hand, distal to the quick disconnect unit at the base of the hand. The development succeeded in reducing the drive mechanism length by approximately ¾ inch (1.9 cm), relative to earlier electric hands.

The shorter drive length also allows the Motion Control Hand to be configured without the Flexion Wrist mechanism, so that a “Short Hand” can be used for patients who require minimum length of the hand, e.g., wrist disarticulation or long trans-radial amputation length.

A simple flexion mechanism was sought, which would allow the wearer to easily lock or unlock the wrist position, and reposition the wrist in either a flexion or extension position. The mechanism that resulted allows the wrist to be flexed or extended to 30 degrees in either direction, and locked in each of the three positions.

The functional advantage of the flexion/extension joint is generally to allow greater positionability of the hand, for a much wider range of gripping positions. This allows positioning of the finger tips (the main gripping surfaces) closer to a wearer’s mid-line, as well has more convenient gripping of an object which must be held level, e.g., trays, plates, pans, etc.

SURVEY RESULTS
Six experienced prosthesis wearers used the hand with flexion. At the time of the field trials, the MC Hand required either a Utah Arm or a ProControl to operate it, so it happened that three subjects used Utah Arms (all transhumeral level amputees), and three used ProControl 2 controllers (all transradial level, including two bilateral amputees).
All of the six subjects were adults, including 5 males, and one female. The average period of usage was 15.5 hours per day, so obviously, the group was composed of very active wearers.

We attempted to collect from the wearers a list of the typical tasks performed during their days, by asking about tasks in the categories of: “Grooming, Daily Activities, In The Kitchen, On The Job, and Hobbies”. Out of an average task count of 18 per person, the average percentage of tasks in which the subjects would bend the wrist in flexion or extension was 55%. We felt this was quite a significant number, considering that prior to their use of the test hands, the function was simply not available to them.

Examples of tasks using the flexion feature included: donning/zipping coats, pulling doors open (more conveniently grasping the handle), holding books or reading materials (allowing the book to be held in a convenient position for reading), driving, and many others. The extension was used less frequently, but was specifically mentioned for eating, to grasp and turn a key, holding a nail, and even removing a gas cap!

Problems mentioned in the survey included some difficulty in reaching the release button for the flexion joint, which led us to redesign the button for easier reach. Also, the on/off button for the hand proved difficult for some subjects to reach early in the trial, which also was redesigned for easier access.

**CONCLUSION**

A great deal has been learned about the ways in which the prosthetic hand wearers utilize their hands for two-handed tasks, and the usefulness of the flexion/extension component. Design changes were made in response to the feedback from the wearers, and the device has evolved to the stage of a commercially released product.

Other versions of the electric hand have also evolved, including three shortened versions, and an integrated controller/hand version.

![Figure 1. Three positions of the flexion/extension wrist, which are 30 degrees in each direction.](image)

![Figure 2. Three examples of usual tasks made easier by the flexion or extension feature.](image)

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