EVALUATION STUDIES OF NEW ELECTRIC TERMINAL DEVICES

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INTRODUCTION:
Two new electric terminal devices (TDs) have been developed for use with myoelectric prostheses of the upper limb, at all levels. They each feature a quick disconnect wrist connection, so they may be interchanged with each other, and also with existing electric TDs from other manufacturers. The two TDs studied are:

1. The Motion Control (MC) Hand with Flexion Wrist.

   • The wrist will lock in three positions- 30 degrees of flexion & extension, as well as neutral position.
   • The lock/unlock of flexion is performed by the wearer pushing a simple spring-loaded button on the TD, which allows repositioning of the wrist, which then will relock into a new position. The button is intended to be easy even for bilateral arm amputees to push.
   • The flexion lock has high strength – it will support leaning on the TD, with loads up to 25 kg.
   • No additional length is required for the Flexion Wrist in the Hand, compared with standard adult electric hands.

   Figure 1. The Motion Control Hand with 30° flexion and extension
2. The Electric Terminal Device (ETD), intended for rugged work and hobby situations.
   • The ETD utilizes the same motorized drive as the MC Hand, which typically produces a maximum of 10 kg of pinch force.
   • Classic hook-shaped fingers are used, specifically the APRL design manufactured by Hosmer, Inc. These hook fingers were used on the earlier Hosmer product, the Synergetic Prehensor, which was successful with many wearers.
   • The housing for the ETD is water-resistant, so that water or dirt will not enter the gear and drive area. The quick disconnect contacts could be susceptible to water or dirt, and a protective sleeve is available optionally to cover the wrist and forearm of the prosthesis.
   • Flexion Wrist is available in the ETD, although it adds approximately 2.5 cm. of length, additional to the hand. Only one of these ETD subjects has the Flexion Wrist in the ETD.
   • Quick disconnect attachment at the wrist will allow the TDs to interchange.
Figure 3 – The Electric Terminal Device (ETD), pictured with the flexion wrist (right), and without (left). Because of the longer length of the hook fingers, compared to the hand, flexion increases the length of the ETD by about 2.5 cm.

DESIGN OF SHORT-TERM EVALUATION STUDIES:

The initial surveys were conducted of both TDs, with six wearers in each group. No subjects participated in both surveys.

Composition of MC Hand with Flexion Wrist study:
• 6 wearers: 5 male, 1 female
• 2 Bilateral BE’s, 4 Unilateral (1 AE, 3BE)
• All were regular wearers of electric hands previous to the study; the only change to their prosthesis was the addition of the new hand with Flexion Wrist.

Composition of Electric Terminal Device Study:
• 6 wearers: all male
• 2 bilateral BE’s, 4 Unilateral (1 SD, 3 BE)
The purposes of the study may be summarized as:

• To document the use of the TDs, in terms of:
  Hours per day, Usage during wearing, Use of Flexion/Extension

• To learn how typical tasks are performed with each TD. Categories included: Grooming, Daily Activities, Kitchen, Work, Hobbies

• Ratings of TD Performance were performed for relevant functions of each survey. Ratings are made in comparison with the previous TD.

Discussion of a “Small n” survey.

Though the number of subjects is small and statistical significance is low, a great deal of useful data is collected from these subjects. In a development context, important results are, one, to guide development, and two, to validate that design goals are met.

SUMMARY OF SURVEY RESULTS:
MC Hand with Flexion Wrist:

The most valuable results for our use were to learn from these active wearers about the actual performance of activities assisted by the Flexion Wrist. Activities improved by the Flexion Wrist included:

• Dressing - buttons, zippers, pulling socks, tying necktie, etc.
• Hanging up & folding clothes
• Opening/closing doors
• Holding books or papers
• Using hand tools - tweezers, camera, sewing, pens, etc.
• Handling briefcase and bags
• Steering - cars, shopping carts, etc.
• Handling children
• Caring for livestock- milking cows, holding collars, etc.
• Opening bottles, holding a cup, using utensils, etc.

Estimating from memory, the subjects guessed that they used the Flexion Wrist in performance of one-fourth to two-thirds of the tasks they performed. The Flexion Wrist often gave better positionability near the subject’s mid-line, e.g., for dressing and eating tasks. Also mentioned frequently was the ability to hold flat objects, like trays and books, at a convenient angle without requiring unnatural shoulder or torso positions.
Fig. 4. The use of the Flexion Wrist allows the wearer to position the Hand closer to the midline.

All ratings obtained from the subjects cannot be mentioned here, because of space, but the overall rating of “Contribution of the Flexion Wrist to Function of the TD”, achieved a rating of “much better” from four subjects, and “better” from the remaining two.

**Results of the Electric Terminal Device (ETD) Survey**

The range of activities which utilized the ETD was extremely broad. As above, the actual activities of the subjects were the biggest lesson for the development team. Examples of activities improved by the ETD:

- Holding utensils: Knife, Fork & Spoon; Pen & Pencil
- Grasp of a variety of Tools: Nuts & Bolts, Tool Handles
- Reaching into pockets
- Turning pages
- Holding large objects: mugs, briefcase, etc.
- Driving
- Change diapers
- Keyboarding
- Scratching an itch
- Carry dishes
- Handle papers, money, etc.
Advantages mentioned were the fine tips, visibility of the curved shapes, high gripping pressure possible with the narrow finger shapes, and wide opening. Important to many was the similarity of the hook shapes to earlier body-powered TDs they had used, or still used for part of their daily activities. Several subjects, with both bilateral and unilateral loss, continue to use both their body-powered and their electric prostheses for significant parts of the day. The weight was an advantage for most – the ETD is lighter than other electric TDs, and although heavier than a body-powered TD, was not found to be awkward.

All of the ratings which were collected will not be discussed, except the rating of “Overall TD performance”. Five of the six subjects rated the ETD “much better” than their previous TD, and the sixth subject rated it “better” overall. The TD of comparison was in four cases the Greifer, in one case the Synergetic Prehensor, and in one case the body-powered hook TD (#5XA).

Fig. 5 Some of the advantages mentioned by ETD wearers were the fine tips, visibility of the curved shapes, high gripping pressure possible with the narrow finger shapes, and wide opening.

Fig. 6. The ETD compared to the Otto Bock Greifer and Hosmer Synergetic Prehensor.