Electric Digits Case Studies:
Unique Prosthetic Solutions for Contrasting Limb Presentations

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Advanced Arm Dynamics

INTRODUCTION

Electric digits that restore functional grip to partial hand amputees are a major technological breakthrough in upper limb prosthetics. Statistically, individuals who are missing multiple digits comprise the majority of upper limb amputees—75+ percent—and this patient population is increasing by an average of 20,987+ cases per year (www.hcup-us.ahrq.gov/databases.jsp 2011). Until recently, prosthetic solutions for this population have consisted primarily of passive cosmetic restorations and body-powered fingers. The release of the latest generation of advanced electric digits has increased functional prosthetic options, enabling more people who are missing digits to achieve biomechanical opposition to the thumb, restored grip and pinch, and increased personal independence. The electric digit case studies included four patients who were fit with i-limb digits. The purpose of these case studies was to use clinically objective measures to compare and contrast prosthetic design and control strategies for electrically powered finger components for a variety of limb presentations.

METHOD

A clinical team of upper limb prosthetists, and occupational and physical therapists who specialize in upper limb prosthetic rehabilitation, conducted the case studies. Informed consent was obtained from all subjects prior to participation.

Subjects: Four males with unilateral traumatic partial hand amputation involving the loss of two or more digits.

Procedures: At the outset of the study, patients and clinicians identified specific goals and challenges. Patients stated a desire for the prostheses to provide: restored functional grip, the ability to reach/grasp in a normal manner, and an aesthetically pleasing appearance. The clinical team identified challenges as: highly variable residuum presentations, the need for sophisticated control schemes, and biomechanical opposition to the thumb. The study was divided into three phases: pre-selection (prior to fitting), fitting (preparatory), and final (definitive). In pre-selection phase, a written patient history and therapy history were established. In fitting phase, subjects were educated in regard to prosthetic components, and therapeutic training (OT/PT) was provided for basic functional use of the device. Therapeutic training encompassed full finger grip mode, switching between selected grip modes, and use of prosthesis during functional activities. In fitting and final phases, written descriptions of prostheses were created. During all three phases, a data table was created for each subject that reflected their individual physical challenges, fitting challenges, therapeutic challenges and programming challenges.

Data Analysis: Various measures of functional ability were administered during all three phases of the study. In addition to clinical observation, these instruments were used for outcome measures: an upper limb functional activity checklist; Box and Blocks; Trinity Amputation and Prosthesis Experience Scales; Comprehensive Arm Prosthesis and Rehabilitation Outcomes Questionnaire (CAPROQ-R); and the Communication for Continuing Care (C3) satisfaction survey.

RESULTS

Goals and challenges met:

- Biomechanical opposition to thumb (clinical observation, Box and Blocks)
- Improved functional grasp (clinical observation, Box and Blocks)
- Functional wrist range of motion (clinical observation, CAPROQ-R, C3)
- Socket and frame design for unique presentations (clinical observation)
- Unique programming needs (clinical observation)
- Cosmesis exceeding patient's expectations (CAPROQ-R, C3, interview)

Necessary improvements identified:

- Increased speed (CAPROQ-R, C3, interview)
- Consistency of operation (clinical observation, CAPROQ-R)
- Restored functional grip/pinch strength (functional activities, clinical observation)
- Improved cosmesis (CAPROQ-R, C3, interview)

DISCUSSION AND CONCLUSION

With no prosthesis, partial hand amputees have compromised hand function on the injured side. Electric digits restore significant functional ability to the injured hand. CAPROQ-R responses also indicate that with electric digits, subjects rely less on others and perceive a reduction in phantom pain/sensation. Subjects responded favorably to the features and function of their prostheses, and also indicated the desire for more speed, better control and stronger grip.

CLINICAL APPLICATIONS

The prosthetic design and control strategies that are analyzed in these case studies are relevant to and applicable in clinical settings where prosthetists are faced with creating prosthetic solutions for partial hand amputees. Current technology, in conjunction with future advances in electric digits, prosthetic design, and control strategies, has the potential to advance hand function and personal independence for many existing partial hand amputees and the 20,987+ people (Avg.) who will endure partial hand

amputation each year (www.hcup-us.ahrq.gov/databases.jsp).

REFERENCES

HCUP Nationwide Inpatient Sample (NIS). Healthcare Cost Utilization Project (HCUP), Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/nisoverview.jsp 2011.