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Combined Utilization of Fabric Prosthetic Socket Design and Pattern Recognition Control in Shoulder Disarticulation Prostheses

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INTRODUCTION

Weight, comfort, and control complexity have all been indicated in reason for abandonment of a myoelectric prosthesis *(Biddiss, 2007)*. At the shoulder disarticulation level, traditional two site myoelectric control can be utilized to control the prosthetic components of the shoulder, elbow, wrist, and hand. However, this relies on a sequential control strategy where the patient must toggle control between each of the components in the system. This becomes quite mentally exhausting. In the shoulder disarticulation patient population, it is not uncommon to have significant trauma to the brachial plexus. This trauma can make finding two isolated myosites for traditional control challenging. Depending on the extent of the injury to the brachial plexus and other comorbidities, the patient may not be a candidate for targeted muscle reinnervation (TMR) to establish strong distinct myosites.

The recent introduction of a commercially available pattern recognition control system for myoelectric prostheses, the COAPT Complete Control (Coapt LLC, Chicago, IL), has expanded the patient population that can potentially benefit from myoelectric control, who only a few years ago would not have been considered a candidate.

Without TMR, the COAPT system requires the user to be able to make a distinct muscle contraction pattern for each desired motion. For a myoelectric system with an elbow, wrist rotator, and terminal device, this may require up to 6 distinct muscle contraction patterns. This case presentation provides useful insight into how advanced fabric socket design, combined with pattern recognition, and intuitive easy to remember gross shoulder girdle movements can provide patients with shoulder disarticulation amputations and brachial plexus injuries the ability to easily control an advanced myoelectric prosthesis with a powered elbow, wrist rotator, and powered terminal device.

METHODS

This is an observational case study based on patient and prosthetist experience during the prototype, delivery and continued treatment for a single patient treated by Handspring. The patient is a 30-year-old male that sustained a crush injury resulting in a shoulder disarticulation, brachial plexus injury, and TBI. Various conventional socket designs and control strategies were attempted with marginal success. Ultimately the patient was fit with a custom Fabric Shoulder Socket (Martin Bionics, Oklahoma City, OK), COAPT Complete Control, Dynamic Arm TMR (Otto Bock, Austin, TX), Electric Wrist Rotator (Otto Bock, Austin, TX), and a Bebionic3 terminal device (Steeper USA, San Antonio, TX). During the prototype phase and subsequent to delivery of the definitive prosthesis the patient was followed by a comprehensive team including his physician, occupational therapists, and prosthetists. Because of the TBI a simple, intuitive, easy to remember gross shoulder girdle movement was implemented with the patient.

RESULTS

The combination of utilizing a fabric socket design, pattern recognition, and intuitive easy to remember gross shoulder girdle movements produced intuitive prosthetic control of an advanced myoelectric prosthesis for a patient with a shoulder disarticulation, brachial plexus injury, and TBI. At present, independent control of terminal device and elbow are successful.

DISCUSSION

Due to the brachial plexus injury, the patient had no EMG signals over the pectoralis muscle. The patient was also not a candidate for TMR. Conventional myotesting indicated that dual site conventional control would not be possible. Initial fitting with a conventional X-frame socket design and COAPT system was unsuccessful primarily due to the gross shoulder girdle movements required by the patient to produce distinct EMG patterns. The gross shoulder movements caused the electrodes in the COAPT system to lose contact with the skin which resulted in sporadic movements of the components of the prosthesis.

The utilization of a fabric shoulder socket allowed the electrodes of the COAPT system to maintain contact with the skin during the gross shoulder movements resulting in consistent control of the prosthesis. The fabric socket allowed for placement of electrodes over the trapezius muscle without being uncomfortable or restrictive to the patient. The additional EMG signals obtained from this muscle belly significantly improved the consistency of the control of the prosthesis.

The fabric shoulder socket had the benefit of being lighter weight and more breathable than the traditional X-frame socket. The patient was able to don and doff the prosthesis independently and adjust the fit easily even with weight gains.

The effects of the TBI make it difficult for the patient to consistently remember the six motions to control the elbow, wrist, and hand. Ongoing OT training is being conducted in order to help the patient be able to control all three components. If ultimately the wrist cannot be consistently controlled through COAPT, then switch control will be implemented for the wrist.

CONCLUSION

This case study demonstrates how combining advanced fabric socket design and pattern recognition control can aid in restoring function to patients with higher levels of amputation that are very challenging to fit with traditional socket designs and control strategies. Pattern recognition was shown to provide consistent intuitive control of a prosthesis with multiple externally powered articulating components.

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***Required Information ***

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Short bio (about 50 words):
Chris Baschuk, MPO, CPO, LP is an Upper Extremity Prosthetics Specialist for Handspring. Chris holds a B.S. in Biomedical Engineering from the University of Utah and a Master of Prosthetics Orthotics from UT Southwestern Medical Center. Chris serves as the Treasurer for the Upper Limb Prosthetics Society of the American Academy of Orthotists & Prosthetists.

Short Description of Your Abstract (2-3 sentences):

Pattern recognition has proved a viable control strategy for myoelectric prostheses. New fabric shoulder socket technology has allowed for a shoulder disarticulation prosthetic socket that is compliant, lightweight, breathable and comfortable. A case study is presented demonstrating how using these two new technologies together on a patient with a shoulder disarticulation, brachial plexus injury, and TBI produced an outcome that would not have been possible with traditional socket design and two site myoelectric control.