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 as reasons for abandonment of a myoelectric prosthesis *(Biddiss, 2007)*. At the shoulder disarticulation (SD) level, this is particularly true. Traditionally, externally powered SD prostheses have used a rigid shoulder cap socket, or X-frame style socket with two site myoelectric control. These prostheses can be heavy, uncomfortable, and challenging to control.

Pattern recognition control in the COAPT Complete Control (Coapt LLC, Chicago, IL), has been shown to provide more intuitive control (Deeny, 2014). At the SD level, pattern recognition allows for the direct control of elbow flexion/extension, wrist pronation/supination, and terminal device open/close.

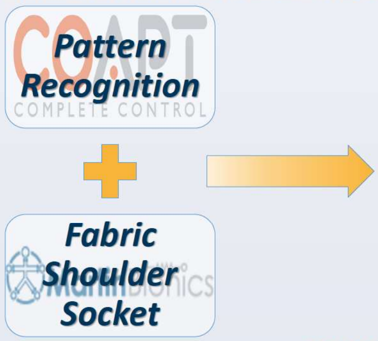
A new style of SD socket, the Fabric Shoulder Socket (Martin Bionics, Oklahoma City, OK), has been developed that uses a mesh fabric to conform intimately to the shape of the amputee's shoulder region and torso. A minimalistic rigid frame is then suspended like a hammock on this fabric socket. The prosthesis' components are then attached to this frame. This socket is very light weight and breathable.

As both COAPT Complete Control and the Fabric Shoulder Socket are new innovative technologies, they had never been used together clinically. It was hypothesized that combining the COAPT system with the Fabric Shoulder Socket would produce an external powered SD prosthesis that is lighter weight, more comfortable, and more intuitive to control. By improving the weight, comfort, and control complexity the likelihood of prosthesis abandonment should be decreased.

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.

Various conventional socket designs and control strategies were attempted with marginal success. Ultimately the patient was fit with a custom Fabric Shoulder Socket, COAPT Complete Control, Dynamic Arm TMR (Otto Bock, Austin, TX), Electric Wrist Rotator (Otto Bock, Austin, TX), ETD (Motion Control, Salt Lake City, UT), 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.



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 a larger area of skin to be covered than a rigid socket would allow, while still being comfortable and cool. The greater skin coverage allowed for EMG signals to be obtained from regions not possible in a rigid socket.

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 the patient's weight fluctuations.

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. The mesh of the Fabric Shoulder Socket made locating and adjusting the positions of the electrodes much easier than in a traditional rigid socket. Pattern recognition was shown to provide consistent intuitive control of a prosthesis with multiple externally powered articulating components.

*Due to changes in overall health condition of the patient, he is no longer using the prosthesis at this time.

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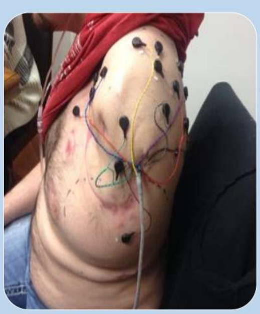
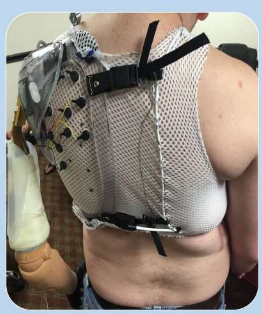


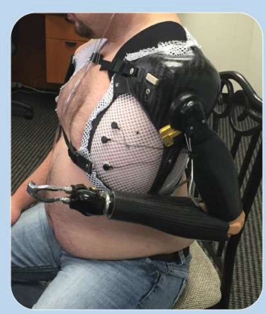
Initial COAPT testing showed consistent direct control of elbow and terminal device

COAPT failed when added to a rigid socket due to poor skin/electrode contact



Combination of COAPT with Fabric Shoulder Socket maintained skin/electrode contact

Foam discs were needed between the fabric and the snap electrodes for stabilization



Definitive prosthesis is light-weight, comfortable, and intuitive to control