DESIGN AND EVALUATION OF A NOVEL SENSORY-MOTOR TRANSHUMERAL PROSTHETIC SOCKET: A CASE STUDY

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ABSTRACT

This work describes a novel myoelectric transhumeral prosthetic socket designed to integrate a custom vibration tactor with improved fit, suspension, and secure electrode contact. A quantitative analysis was performed to evaluate the impact of the novel socket on the interface pressures between the socket and residual limb (RL).

A fundamental challenge in the implementation of advanced upper limb prostheses is the lack of sensory input. In response, haptic systems have been developed; however, practical barriers still exist in translating these systems beyond the benchtop into functional wearable prostheses. Most non-invasive systems employ mechanical devices (tactors) that stimulate strategic locations on the user's RL. A primary challenge lays in the development of prosthetic sockets allowing tactors access to the RL, while maintaining or improving socket fit. A well-fit prosthetic socket will secure the prosthesis to the limb ensuring suspension and security. Yet even well-fit traditional sockets are prone to slip during normal use. In myoelectric systems, this can create a loss of electrode placement resulting in poor or inconsistent control of the components.

Our approach integrated a previously developed tactor into a transhumeral socket, such that a predetermined distal anterior region of the participant's RL could be stimulated. A ¾" diameter window was created allowing the tactor access to the limb. The corresponding region on the participant's prosthetic liner was thinned. A flat build-up was added between the socket and prosthetic elbow providing a mounting surface. Custom brackets allowed attachment of Velcro strapping, providing adjustable affixment of the tactor. To ensure socket fit and electrode contact, a BOA Lace (Denver, USA) and an electrically conductive panel system were implemented. This system provided adjustable compression of strategic areas within the socket, with the panels also serving to make contact with the electrodes in the prosthetic liner. Therefore, tensioning the BOA system ensured firm electrode contact and distribution of pressure, while providing flexibility in the event of socket slip.

To evaluate the impact on socket fit, RL-socket contact pressures were captured using a Tekscan VersaTek system (Boston, USA). Relative pressure magnitudes and corresponding anatomical locations were compared across the novel socket and the participant's well-fit body powered prosthetic socket. Results highlighted reduced maximum pressure magnitudes spread more evenly across the RL while wearing the novel socket.

This work presents a unique solution to practical integration challenges associated with the development of functional sensate prostheses, with further applicability to myoelectric socket design in general.