MULTI-FUNCTION SWITCHING OPTION FOR THE HIGHER LEVEL UPPER LIMB AMPUTEE
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ABSTRACT

The purpose of this article is to describe an alternative switching option for the higher-level upper limb amputee. Currently available body powered switches allow for only one function which can become quite cumbersome when multiple control methods are used. A multi-functional switch that can activate many different controls either independently or simultaneously could greatly reduce the amount of hardware required to operate all of these devices. When working with bilateral shoulder or interscapulothoracic amputees one of the main goals is to provide as much function as possible while maintaining simplicity in the design. The first patient that was fit with the actuator was currently wearing bilateral shoulder prostheses with seven switches. The result was a reduction in the amount of switches necessary to operate the different controls from seven to two. The switch can also be configured to operate Force Sensing Resistors (FSR’s) or linear transducers to provide proportional control.

INTRODUCTION

Higher-level amputees generally require additional components to help restore their functional ability. The shoulder disarticulation and interscapulothoracic level amputees require the addition of a prosthetic shoulder joint to help preposition the prosthesis to assist them with their activities of daily living. The primary objective for the practitioner and rehabilitation team is to decide on what components and control options are most suitable for the patient while maintaining simplicity in the design. Uellendahl states, when fitting the bilateral shoulder disarticulation amputee, it is advisable to start with as simple a prosthetic system as possible and control complexity should be kept to a minimum [1]. Taking into consideration the patients interests, hobbies and vocational goals is a good place to start when beginning the component selection process. Also, the cognitive and motivation levels of the patient will play a critical role in their outcome. When deciding on what components to utilize for a particular patient you need to consider how they will operate them. Will they be using myoelectric control to operate the prosthesis or do they have enough range of motion to utilize some body-powered components? If weight is a concern, would a passive semi prehensile device be more appropriate or a hybrid design to capture the benefits of both myoelectric and body powered controls? Regardless of the type of prosthetic design used, the higher-level amputee requires the use of multiple components to fully operate the prosthesis at this level. Many of these components work in conjunction with switches to lock or unlock the particular component. Commercially available body powered switches only allow for a single function. The multi function actuator was designed to allow the patient the ability to operate multiple functions with only one switch. The following will describe the progress of a bilateral shoulder disarticulation amputee and how the multi function actuators have improved his efficiency and functionality with his present prostheses.
METHOD

The multi function actuator was fabricated using stainless steel bar stock. The switch dimensions are 4 ¼ X 3 inches as shown in Fig. 1. The nudge pad is made from pelite and is 1 7/8” in diameter (Fig. 1A). The stainless steel bar is contoured to allow for 5/8” of cable excursion, which is sufficient to operate most locking devices. If more cable excursion is necessary the switch can be contoured to allow for more excursion. The center axis is located 1 1/8” from the center cable attachment. The center cable attachment (Fig. 1B) is slotted to allow the outside cables to travel without activating the center cable. Rotating the switch to the left or right will activate the outside cables. Triple swivels were used to attach the outside cables to the switch. A ball terminal was used to attach the center cable. A ½” rubber bumper (Fig. 1C) was used along with a #10 copper rivet to attach the switch to the socket and allow the switch to depress, rotate and return to a neutral position. The hole drilled into the switch was slotted to allow the switch to pivot on its axis. Pressing down on the pad will activate the center cable. Simultaneous activation can be achieved by rotating and depressing the switch at the same time.

![Fig. 1](image)

The first patient that was fit with the multi function actuator was presently wearing bilateral shoulder disarticulation prostheses consisting of the following components: The left prosthesis consisted of an X-Frame socket design with a flexible inner socket, an LTI Collier locking shoulder joint, Otto Bock AFB elbow, Rim Jet humeral rotation unit, electric wrist rotator, and a myoelectrically controlled electric terminal device (ETD). Prior to the addition of the multi function actuator the patient was using three separate switches to operate the shoulder lock, humeral rotation lock and elbow flexion lock. The switches were aligned in such a way to allow the patient access to each one with his chin. This configuration will generally place one of the switches in an ideal position and the other switches will be positioned along side. Custom fabricated switch extensions were used to place the switches in a more functional position.

The right prosthesis consisted of an LTI Collier locking shoulder joint, RimJet humeral rotation unit, Otto Bock AFB elbow, 4-function wrist, and a model SS-555 hook. The patient was using four separate switches to operate the shoulder joint lock, RimJet humeral rotation lock, elbow flexion lock and 4-function wrist activation. Custom
fabricated switch extensions were also used on this prosthesis to position the switches in the ideal position.

DISCUSSION

Advancements in upper extremity technology have allowed patients to improve their functional ability and increase their level of independence. Higher-level amputees require additional measures to assure their optimal functional ability. These measures include a socket designed to allow for maximum comfort, range of motion and stability, a lightweight simple design and the proper components to meet their needs and goals. The components necessary to provide the most functionality at higher levels can often times be heavy, cumbersome and difficult to master. Reliability and durability are also very important and necessary for the bilateral amputee. Functional bilateral amputees who rely on their prostheses for independence become dependant upon others when their prostheses are in need of repair. If the overall amount of switches can be minimized by using a multi function actuator we can reduce the tendency for component failure by reducing the overall mechanical components on the prosthesis. The multi function actuator can offer patients increased freedom to manipulate their prosthesis and provide them greater control by being in contact with one switch to perform multiple tasks as apposed to alternating between switches to perform the same tasks.

RESULTS

The addition of the multi function actuator had resulted in an overall reduction of the weight of the prosthesis. We were also able to simplify the design by reducing the amount of switches necessary to operate all of the components. Maintenance requirements were also reduced by the reduction in hardware necessary to perform the desired tasks. The prostheses were more cosmetically appealing under clothing due to the reduction in switches that protruded from the socket, and the patient required less range of motion to activate the switches. His overall control with the locking devices and functional ability with the prostheses had also improved.

CONCLUSION

Higher-level amputees face many challenges with regards to returning to a functional level of independence. Currently available technology is not capable of replicating the intricate and finite control that nature has provided for us. Providing the higher level amputee even with the latest in technology is far from replacing what was lost, but we can provide them with a functional tool to assist them in achieving independence and improve their functional ability. As stated by Uellendahl, whatever control arrangement is used, it should impose the minimum amount of mental loading on the user. In other words, the control of the prosthesis should not be so complicated as to make it the primary object of the user’s attention. Rather, the task the user is attempting to perform should be primary, and the mental effort devoted to the prosthesis should be secondary (1). The multi function actuator was designed to help minimize the complexity of the
system which can allow the patient to focus on the task being performed and less effort on the steps necessary to perform that task.