

## FOREQUARTER PROSTHESIS WITH INTERCHANGEABLE ELBOW, FOREARM, AND HAND

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### ABSTRACT

Fitting of individuals with forequarter amputations is often a challenging and fruitless effort. In order to provide optimum function for the patient, it is necessary to fit these individuals with either externally powered prostheses or hybrid prosthetic designs. These prostheses are oftentimes heavy and bulky and are not accepted by the patients for full time wear. There exists another population of individuals with forequarter amputations that are more interested in the cosmetic restoration of the prosthesis rather than its functional capabilities. Passive prostheses are typically fabricated for these patients in order to fulfill their particular desire. In an effort to increase acceptance and wearing time, the prosthetic design being discussed in this paper is an attempt to meet both criteria: provide function and acceptable cosmetics. By utilizing existing components, this prosthetic design enables the user to readily switch from a heavier, externally powered prosthesis to a lightweight, passive prosthesis.

### INTRODUCTION

"Conventional" prostheses for individuals with forequarter amputations have consisted primarily of two designs. The passive prosthesis is typically the lightweight cosmetic alternative, although it has many merits beyond just "filling the shirt sleeve." Most forequarter passive prostheses have a universal shoulder joint or a combination of bi-axial shoulder joint and internal rotation and external rotation available at the elbow turntable to simulate the tri-planar joint motions. The elbows can be either free-swing or friction, with or without a locking feature. The most crucial part of these passive prostheses is the terminal device (TD). The TD is almost always a lightweight passive hand with formable fingers. These hands can be covered with a relatively inexpensive glove which provides fair cosmetic results, can be covered with custom silicone gloves which offer excellent cosmetic restoration, or something in between these ends of the "glove spectrum."

It is possible to fabricate and fit completely cable driven or hybrid prostheses to individuals with intrascapulothoracic amputations. The difficulty, however, arises from the amount of excursion that the user can generate. Most cable driven elbows require 2½" to 3" of excursion to flex through the entire range of 125°, while voluntary opening and voluntary closing TD's require approximately 1¾" and 2¼" of excursion respectively. The addition of excursion amplifiers such as the APRL Sheave<sup>TM</sup>[1] or a simple class three lever system are often utilized to decrease the amount of excursion that the user must generate. This, however, is at the expense of increased force required to operate the prosthesis. Although this is a viable option for completely cable driven prostheses, it is often difficult to find an appropriate placement for the excursion amplifier. Exoskeletal prostheses, covering a large amount of the body had been historically used for this design. These designs enabled the prosthetist to place the excursion amplifier in a variety of locations. The problem with this is that these types of prostheses are heavy, uncomfortable for the wearer, and cover a large surface area of the body. With the forequarter amputation itself, the body already has less surface area, thus there is a decrease in the body's ability to dissipate heat. This massive covering further complicates matters by adding to the heat retention. When the socket is fenestrated, i.e. Sauter frames, the wearer is more comfortable because the prosthesis is lighter in weight and cooler; however,

placement of the excursion amplifier is somewhat limited. The hybrid prostheses help to eliminate the need for as much excursion as the completely cable driven design requires. Several prosthetists have had good success with this type of design incorporating a cable driven elbow and externally powered TD or an electric elbow and a cable driven TD.

The other obvious option is to fabricate a prosthesis that is entirely externally powered. The Utah Artificial Arm™[2] and the Boston Elbow™[3] are "systems" which easily allow for this combination. Either of these systems can be utilized for a forequarter prosthesis very successfully. The difficulty with them is that they are heavier than the cable driven or hybrid designs, and much heavier than the passive designs. This issue of added weight contributes to the wearer's limited use of the prosthesis and in some instances, an ultimate rejection of the entire prosthesis.

## DISCUSSION

The design that we are using is intended to increase the patient's acceptance and utilization of the prosthesis. This is being attempted by allowing the user to easily interchange a passive prosthetic design with an externally powered prosthetic design with the "push of a button" and plugging in of two wires. These two designs are incorporated into a single prosthesis which maintains a consistency with the feel of the socket as the user changes from passive to externally powered components and vice versa. The advantages of each system have been previously described, and we feel that these will contribute to the wearer's increased acceptance of the device.

The components of the prosthesis are many and can be seen in figure 1. Beginning proximally, is: a Servopro and wire harness™[2], an endoskeletal model, shoulder flexion abduction joint™[1], pylon tube kit™[1], passive wrist™[1], knurled plate™[4], and quick disconnect insert™[1]. These components are germane to both the passive and externally powered prosthesis. Below the quick disconnect insert for the passive components are: quick change wrist™[1] laminated to a 2" diameter, UCLA CAPP Delrin Body Friction Wrist™[1], passive CAPP elbow,™[5], threaded cpvc tubing, knurled plate™[4], passive hand and glove™[4]. For the externally powered prosthesis the components below the quick disconnect insert are: quick change wrist™[1] laminated to the lamination collar™[2], Utah Artificial Arm™[2], system electric hand and glove™[4].

The selection of these components is designed to enable the user to easily convert his or her prosthesis from a passive prosthesis to an externally powered prosthesis. First, the user is required to unplug two pre-amp cables™[2] coming from the Servopro controller™[2] to their corresponding connectors on the Utah Artificial Arm. In addition to their pin connection pattern, the cables have been color coded to prevent inadvertent attempts to plug them together inappropriately. Secondly, the wearer pushes the button on the quick change wrist, in the same manner as it is designed for terminal devices, which will release the electric elbow and terminal device. The passive prosthesis is then installed by pushing the insert into the quick change wrist that is on the proximal end of the "passive components." Obviously, the reverse order would hold true for interchanging the passive components back to the electric components.

## RESULTS AND CONCLUSION

At present, it is too early for us to tell whether or not this design will prove beneficial in the quest for acceptance of forequarter prostheses. The patient using this prosthesis still has it in the temporary stage but has demonstrated the ability to easily switch from the electric design to the passive design. It will be some time before we can determine whether or not she will accept the prosthesis. Also, each individual's ability to tolerate forequarter prostheses differs. This design, however, offers the ability for people requiring these types of prostheses to have both passive and electric designs in one. This factor, in addition to the weight difference of approximately 2½

pounds between the two sets of components should prove to increase the user's acceptance and wearing time of the prosthesis. This, or similar designs may also prove beneficial for people with transhumeral amputations to have different designs within one prosthesis, provided their residual limbs are short enough to allow for the components.

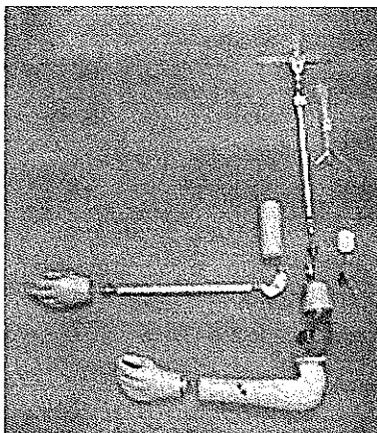


Figure 1

- 1 Hosmer Dorrance Corporation, 561 Division Street, PO Box 37, Campbell, CA 95008
- 2 Motion Control, Inc , 2401 South 1070 West, Suite B, Salt Lake City, UT 84119
- 3 Liberty Technology, Prosthetics and Orthotics Group, 71 Frankland Road, Hopkinton, MA 01748
- 4 Otto Bock Orthopedic Industry Inc. , USA, 3000 Xenium Lane North, Minneapolis, MN 55441
- 5 United States Manufacturing Company, 180 North San Gabriel Boulevard, Pasadena, CA 91117