A Case Study

Introduction

The success of prosthetic rehabilitation involves a number of facets including optimum therapy, appropriate components, interdisciplinary network, patient motivation, and a good fitting socket. All of these facets get multiplied in severity when more than one ailment is presented in the patient.

This case study will discuss the socket design principles and components that allow for vocational return for a hip disarticulation-shoulder disarticulation patient who is also blind. The design of the myoelectric shoulder disarticulation prosthesis had to be lightweight and provide as much feedback as possible to control the elbow, terminal device, and wrist rotator—as well as aid in balance while ambulating with a sight cane.

History

At the time of fitting, the patient was a 41-year-old male who has a right humeral-neck level shoulder disarticulation amputation secondary to a motorcycle accident. He is a healthy individual who is involved in a variety of activities where superior function and a positive self-image are very important. Prior to his amputation, he was employed as an Aircraft Mechanic. Since then, his job has changed to a Telephone Operator/Scheduler in order to accommodate his lack of dexterity and bimanual function. He is employed at a local company, where his job duties include answering phones, taking messages and scheduling appointments using a computer. Aside from his independence in ADLs and maintaining his home, his hobbies include customizing show cars and attending the car shows, as well as fishing. For all of his daily activities, he utilizes an upper extremity prosthesis for his missing right arm. The utilization is important for balance while walking, as well as carrying any object for he uses a sight cane in his sound hand.

As a result of the motorcycle accident, he lost his vision do to an optic nerve injury. He also sustained a right hip disarticulation and has been fitted with a state of the art hip disarticulation prosthesis with a microprocessor knee unit. The blindness causes unsteadiness in his ability to walk. Due to his intense motivation to progress, he has successfully learned how to use the microprocessor knee prosthesis and has been able to discontinue the use of his wheelchair and return to ambulating, and an active and productive lifestyle. This is typically not seen in hip disarticulation patients alone, especially when adding ailments such as blindness and a shoulder disarticulation amputation. Because of his vision complications, his left hand gets overcompensated assisting in sensory feedback. Without an upper limb prosthesis, his balance is sacrificed and he won't be able to carry anything.
He currently has a cable-operated prosthesis that was over three years old. Although this prosthesis is worn consistently, the functional outcome is not sufficient and this prosthetic design is creating further problems. Evaluation of his current cable operated prosthesis revealed a poor socket fit resulting in discomfort as well as poor control. Control is also compromised due to a limited Gleno-Humeral motion. All control is obtained by Scapular-Thoracic motion. The harness is causing axilla pressure and discomfort. His residual shoulder has no lever arm, which decreases his range of motion and limits his ability to control a cable-operated device.

Fitting Process

The first part of the fitting process was a thorough evaluation of the patient, patient lifestyle, and his goals. An electric system was indicated due to the lack of G-H motion and small amount of S-T motion. EMG signals were sub par on deltoids, but more than sufficient EMG was found with good separation on Pectoralis and inferior Trapezius. Oftentimes, the inferior Trapezius can cause unwanted signal while ambulating or movement while seated, in which case superior Trapezius with shoulder elevation is an excellent option. With the EMG results and the need for better control of the device and increased grip force, the patient decided to forgo the kinesthesia and proprioceptive feedback obtained with the cable-operated system and opt for a myoelectric system.

A Utah3 electric system was indicated for two reason: 1) Usage of a wrist rotator without incorporating an additional switch. The rate of contracting a single input muscle will operate either the hand or the wrist and allow cocontraction for unlocking the elbow. An advantage of this setup is that it does not incorporate any external switch. 2) Because of the vision complication, the patient and rehab team considered that the autograsp feature of the Sensor Speed hand would be advantageous. Also, the patient wanted the ETD. The Utah3’s Auto-Detect feature permits the patient to use either of these devices by a detection circuit that allows an in-hand controller to be used on the elbow system.

The patient was also given the option of a third terminal device. A Motion Control hand with a flexion unit was chosen to assist with midline activities. This hand was eventually the hand of choice for the patient for two reasons. The first reason was the ability to hold onto objects closer to midline by using the flexion unit. The second reason was that the sound and speed of Motion Control hand were more similar to the ETD; the patient had a more consistent knowledge of opening and closing between the two devices.

An electric wrist was chosen using Fast Access to eliminate the need of additional input or toggle switches. Cocontraction, therefore, would be specific to elbow unlocking. All of these controls are easy for the prosthetist to adjust, and visually friendly via a computer.

An older version of the LTI shoulder joint was used because the desire to incorporate electronic locking and unlocking. Although the electronic shoulder lock is typically used for bilateral applications, it was deemed worthy in this case. Many
sensory inputs are performed with the sound left hand; therefore, the team didn't want to remove the hand from any task to lock/unlock the shoulder.

The socket design was critical to achieve a good anatomical purchase to transmit as much proprioception and prosthesis knowledge as possible to the patient. To ensure an accurate and identical mold was achieved, a laser scanning process with Insignia was performed. With very little modifying to the carved mold received from the CAD/CAM method, a snug fit was quickly received. Eventually, a thin, corrugated frame with Carbon over a thin flexible inner liner socket was made that gave the patient the necessary feedback provided by an electric system. The design incorporates a good Delto-pectoral purchase countered with posterior support on the Scapula. Adequate relief on the scapular spine allows the very slight motion for control of the system to not cause discomfort.

A flexible strap was placed over the shoulder for comfort providing minimal suspension assistance. Although minimal, the socket was able to provide feedback of a real-time spatial recognition of the entire system.

Conclusion

The shoulder disarticulation socket design coupled with the new Utah3 elbow with Auto-Detect and Fast Access wrist control has allowed the patient to return to work and able to carry boxes and papers while he walks. He is able to interchange easily between the ETD, Motion Control Hand, and Sensor Speed Hand, while the onboard computer can detect which type of TD is attached and makes the necessary microprocessor control it. Additionally, the Fast Access to wrist allows him the best control of the electric wrist without complicating the device with switches.

This case study exemplifies the need for good OT, appropriate component selection, as well as the need for a good fitting socket on such a high level, multi-limb complex situation.