SUCTION SOCKET FITTING FOR AN ELECTRONIC TRANSHUMERAL PROSTHESIS UTILIZING THE FLEX-SEAL™: A CASE STUDY

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ABSTRACT

Suction sockets for transfemoral prostheses have been in existence for many years but, individuals with upper extremity amputations have only recently been re-introduced to such advancements in prosthetic fittings. The gentleman in this case study has been wearing a transhumeral cable driven prosthesis for many years with some past experience using myoelectric systems, both transradial and transhumeral. He presented, after researching component options quite well, asking for a myoelectric transhumeral prosthesis with electric elbow, wrist rotator, hand and hook terminal device. Most of the components had already been chosen, however, he requested the design of the prosthesis be such that he would not require a harness for suspension. This is where the challenge began. A variety of socket designs were attempted using conventional means of donning suction sockets. After several fittings and discarded designs, the Flex-Seal™ became the solution to a difficult request.

HISTORY

The gentleman in this case study presented with a right, standard transhumeral amputation secondary to trauma and surgical revision. He sustained a gunshot wound of the arm in the late 1960's. Following multiple surgeries and limb salvage procedures, he had a transradial amputation performed. Subsequent to his amputation, he was fitted with both conventional (body powered) and myoelectric prostheses. Further complications continued with his residual limbs creating the necessity for a transhumeral amputation in the distal 2/3 region. Once again, this gentleman wore both conventional and myoelectric prostheses. He had a Boston Elbow previously and continues to wear cable driven transhumeral prostheses for both work and recreational activities. Wearing either a 3-ply or a gel-sock, he uses a prosthesis that consists of a modified figure 8 harness with chest strap and shoulder saddle, Lanidor in the distal 2/3 of his standard socket, rigid laminate proximally, Hosmer E400 Internal Locking Elbow™, exoskeletal humeral and forearm sections, Hosmer forearm lift assist™, Hosmer FM Quick Disconnect Wrist™, Sierra Wrist Flex Unit™, and a variety of Hosmer-Dorrance hooks.

DISCUSSION

This client presented for a consultation with a prescription for a transhumeral myoelectric prosthesis and with a clear understanding of the components that he desired in his prosthetic design. After speaking with the manufacturers/distributors of myoelectric elbows/wrists/hands, he had concluded which system would be the most beneficial for him. The difficulty for us now was to decide on how to design and fabricate such a system which would be "harness-free" for him. The major concern of this gentleman was that we design a system that would reduce the amount of pressure under his contralateral axilla while maintaining control and suspension of the prosthesis and to eliminate discomfort throughout the full range of shoulder motion. The components that this gentleman wanted were a Boston Elbow II™, SteeperLite Hand System™, and an Otto Bock Electronic Wrist Rotator™. In order to control this without using a harness, we decided to use myoelectric control for both the elbow and hand, and the Dillon RotaTilt Wrist

Rotation Controller™ to control pronation/supination

The next dilemma that proved challenging was the design of the suction socket to provide suspension, comfort, rotary control, and control of the hand and elbow via electrode contact. Myotesting proved uneventful, and adequate biceps brachii and triceps brachii signals were easily isolated by the client. Casting and modifying were performed similarly to that described by J. Thomas Andrew, C.P.[1] Suction and comfort were achieved using this technique, however, upon donning the test socket with the electrodes in place the signals became weak to non-existent. This is thought to have occurred as a result of the re-distribution of the muscle bellies due to donning of the reduced volume socket. As the volume of the socket was incrementally increased the signals became stronger. At this point, suction was no longer adequate to suspend a myoelectric transhumeral prosthesis, and therefore a different approach had to be taken

We then attempted to fit this gentleman's residual limb using the Flex-Seal™ by Flex-Foot inside of his socket for suction suspension. Several clinicians were contacted along with Flex-Foot Inc, for information on utilizing this component for a transhumeral fitting. There was no indication that this had been previously attempted by one of their clients and little suggestion of how to approach this other than the instructions for the lower extremity, supplied with the seal itself. The location of the template was difficult to achieve because of the location of the myosites. They were quite proximal, making it challenging to place the template far enough distally in order to achieve purchase on the limb for suction. The template was first fabricated over the oval shaped model. The fitting groove was adequately vacuum formed, however, when attempting to place the Flex Seal™ into the fitting groove, it would not properly seat itself. The model, therefore, had to be re-modified to have a more circular shape in the transverse plane in order to accommodate the shape of the seal itself (Figure 1) After this problem had been rectified, we began by having the client don the socket using a pull sock. This proved both challenging and frustrating because the seal became dislodged from the fitting groove and/or total contact distally was not achieved. The solution to this was fairly easy: the seal was permanently secured to the socket with silicone adhesive sealent. This eliminated the problem of the seal dislodging. However, another problem then arose.

Although the client could now pull into the socket more aggressively and achieve total contact, the seal would not hold well. Lotion was used to create a suction fit. This worked well with the exception of two things. First, the suction would not begin until the seal had flipped from having the material rolled inferiorly, due to the donning method, to the material rolled superiorly due to the distraction of the prosthesis on the residuum. Second, what lotion could be used without greatly interfering with the desired signals? To resolve the first issue, the inner diameter of the Flex-Seal™ was increased to reduce the amount of rolling of the material. This allowed a greater suction to occur with minimal to no slipping of the socket. The other issue was resolved by using Liqui-cor™, a conductive liquid used for ECG applications. This liquid helped create an excellent suction seal, allowed transmission of electrical signal to the electrodes, and was wiped clean with alcohol between wear.

The other immediate concern was that the suction was so good that the seal might create a "choking" affect on the residual limb. The client's arm appeared to be discolored distally following the first fitting of the socket with the elbow, etc. temporarily attached. This proved not to be a problem after using the temporary set up for one week.

The final design did not satisfy our original intent of being harness-free but did eliminate the pressure exerted on the contralateral axilla. The final prosthesis, Figure 2, consisted of chest strap to prevent proximal gapping of the wings laterally, Surlyn inner socket with Flex-Seal™ and USMC Small Suction Valve-SFS Style (Push)™, laminated humeral section, Boston Elbow II™ with myoelectrically controlled elbow and hand, Dillon RotaTilt™ Wrist Rotation Controller, Otto Bock 10S12=6 Electric Wrist Rotator™, SteeperLite Hand System™, and glove.

PROGRESS

Several issues have arisen from the date of delivery approximately eight months ago to present. Some of these problems have been addressed and others are presently being investigated. The selector bump switch mounted on the medial side of the humeral section was too far posterior. It was moved anteriorly, but still may not be large enough for the user to contact when wearing a shirt and suit jacket. The sensitivity pots have been stripped or broken off twice already. The wearer is very aware of the changes in his limb on a daily and continuing basis. He would like to change the sensitivity of the electrodes to suit the changes in his signal output. In doing so, he has either stripped the pots, and/or broken them off of the board. He has also requested a stop in the wrist rotator. Approximately 180° is sufficient, in his opinion, for the rotator to drive. He does not like it spinning completely around continuously if he doesn't stop it himself. Lastly, the SteeperLite™ hand that he has is not functioning proportionally, nor does it have much of a pinch force. He would be willing to sacrifice the light weight for a hand that would have these features.

The gentleman in this study is a very good user and offers fantastic feedback. He had done his own research on the available components and has decided on what is best for him. The suction socket, although it has not entirely eliminated his need for a harness, has satisfied the criteria of reducing the axillary pressure and is comfortable throughout a full range of flexion/extension and abduction/adduction. He has subsequently been fitted with two conventional prostheses for work and recreation, both utilizing the same socket design and suspension mechanism for the purpose of alleviating axillary pressure and providing comfort throughout the full range of shoulder motion. This method of suspension may prove beneficial for other levels of upper extremity amputations as well. At present, this is the only person that I have fit with the Flex-Seal™

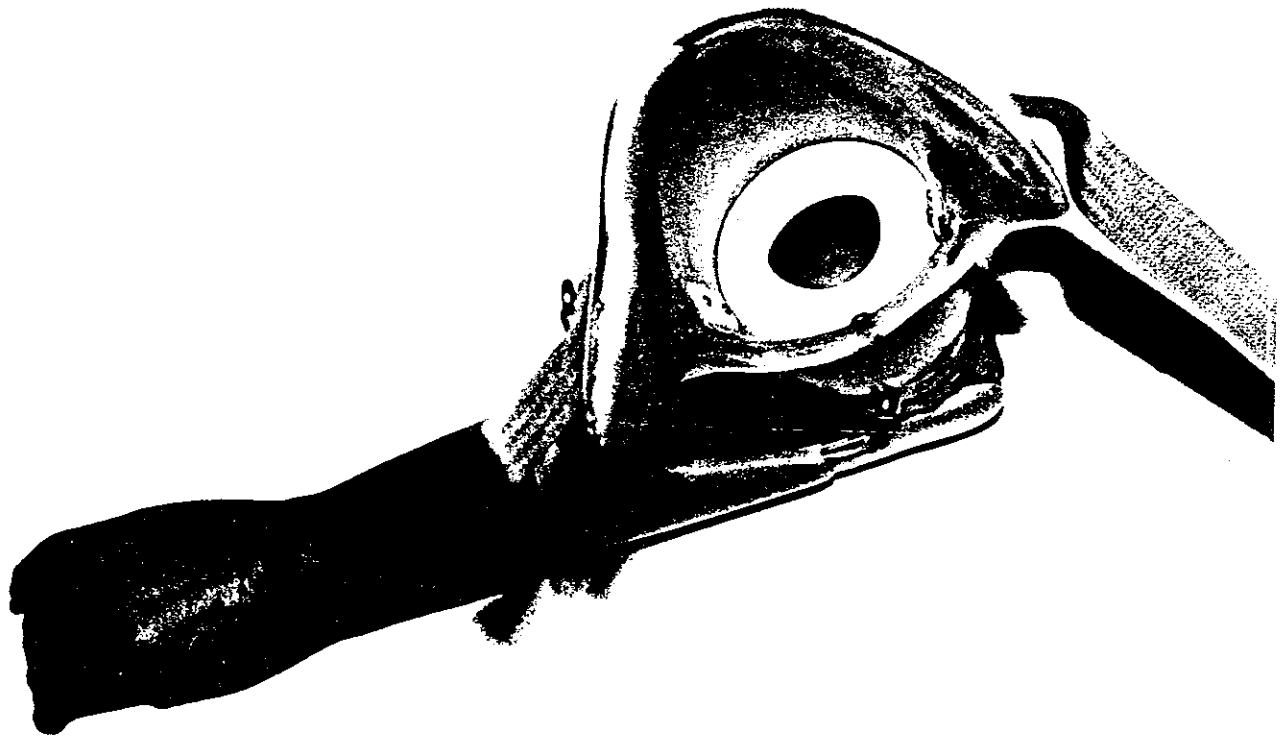

Figure 1

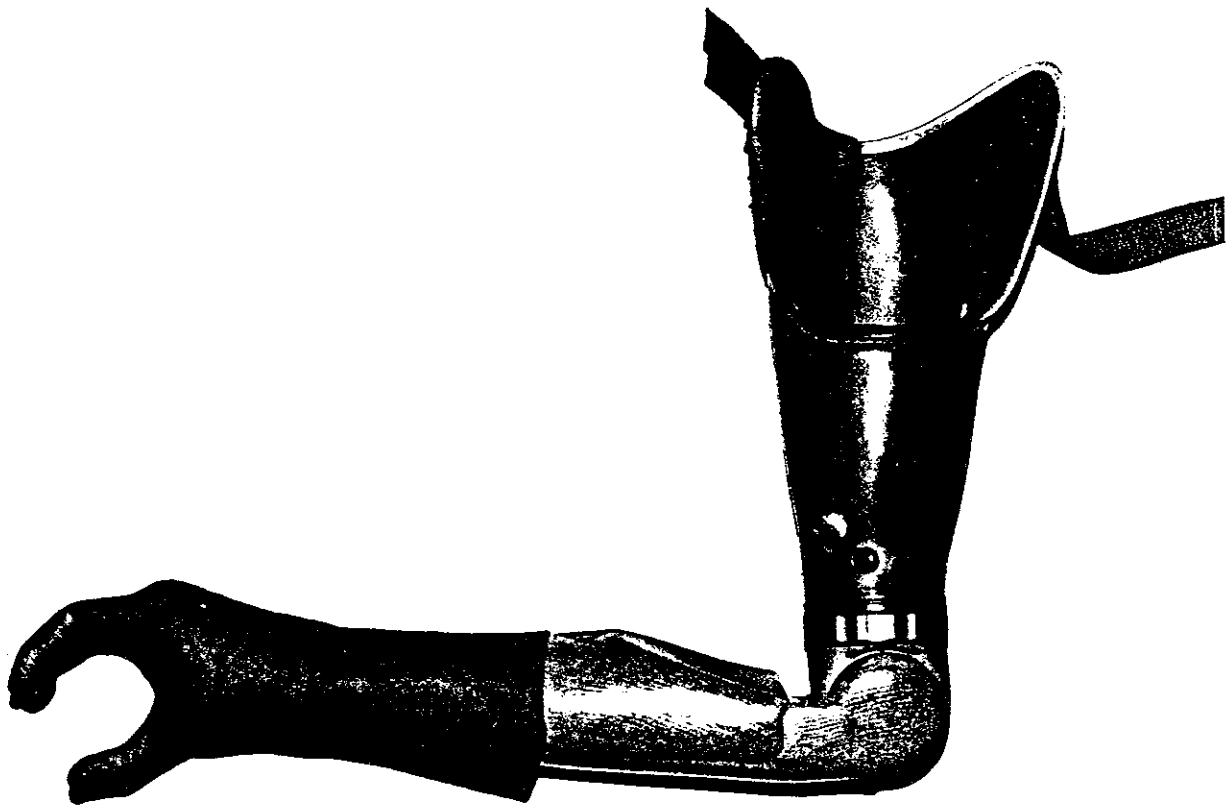

Figure 2

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Manufacturers

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