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A three-quarter type below-elbow socket for myoelectric prostheses

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Abstract

The Muenster and Northwestern sockets have become universally prescribed for below-elbow amputees with myoelectric prostheses. The most attractive feature of these sockets is that they are self-suspending, thereby obviating the need for a harness. The sockets are designed to encompass the patient's whole elbow. Because of the intimate fit, heat build-up inside the socket is a problem. Patients with myoelectric prostheses are denied the benefit of a stump sock. Ventilation inside the socket is almost zero and excessive perspiration occurs. This leads to maceration and skin problems which negatively affect control, comfort and wearing time. This paper reports on a technique whereby the problem of no ventilation is overcome through the removal of the proximal-posterior quadrant of the socket.

Introduction

An attractive feature of the myolectric below-elbow prosthesis is the complete absence of any harness. This factor has been emphasised repeatedly by the many amputees who converted from conventional to myolectric prostheses. The use of externally powered terminal devices together with self-suspending sockets such as in the myolectric below-elbow prosthesis has made the much disliked dual-purpose harness of the conventional prosthesis obsolete. Two major designs for self-suspending below-elbow sockets have emerged and are widely recognized by the prosthetic practitioner today. Named for their places of origin, they are the Muenster and Northwestern type sockets.

The Muenster Socket, originally conceived by Drs. Hepp and Kuhn of the University of Muenster and described by Kay et al (1965) is most widely used for short to medium length below-elbow stumps and is designed to grip the stump in the sagittal plane between the ante-cubital fold and the olecranon fossa. The Northwestern type socket (Billock, 1972) is advantageously employed on long below-elbow stumps and provides suspension through a medio-lateral grip of the stump just superior to the epicondyles of the elbow.

Many variations exist between these two major socket designs and depend on stump length and the individual prosthetist. All aim to meet the same criteria:

a) To provide an interface between patient and device, to receive and contain the tissues of the stump.
b) To provide control over and suspension of the prosthetic device without undue limitations to either comfort or range of motion.
c) To accept the electrodes of the myoelectric control system employed.

These criteria are usually met.

Suspension is usually excellent because of the elbow encompassing design of the sockets. The intimate fit provides the amputee with superb proprioceptive feedback.

The range of motion at the elbow is usually slightly reduced from normal. Whilst this has never been a functional problem, it has sometimes been a cosmetic concern (Gordon, 1966).

A serious and constant complaint about the myoelectric prosthesis is heat build-up inside the socket. This is easily understood when one realizes that the patient, because of the

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myoelectric control, is denied the comfort of a stump sock. Air circulation within the confines of the socket is therefore non-existent. Whilst the internal heat build-up eventually plateaus when the socket becomes a heat sink, the problem of perspiration becomes continually more pronounced. Because of this, many patients report a much reduced wearing time in the summer. In addition, this may well be the major cause for the non-use of myoelectric prostheses in the tropics.

This paper examines the below-elbow socket, and the extent of shrouding it provides, and describes a method to increase effective air circulation without lessening the basically sound design of the socket.

Analysis of the below-elbow socket

An analysis of the socket and its dynamics as part of the below-elbow prosthesis is aided by dividing the socket into four sections while looking at it from a lateral view.

The *first* division to be made is circumferential and divides the socket into a distal and proximal half. The *second* division is axial and in the frontal plane, dividing the proximal and distal halves further into anterior and posterior parts or quadrants as shown in Figure 1. The measure of function contributed by each of these quadrants is quite different as further analysis reveals.

The first quadrant or distal anterior part of the socket transmits the forces generated by flexion of the elbow. It lifts the prosthetic forearm into a position at right angles to the humeral portion of the arm. It thus carries the weight of the prosthesis.

The second quadrant, or distal posterior part of the socket responds to the extension of the stump. It extends the prosthetic forearm and assists in stabilizing activities. Together with the distal anterior part of the socket, it contains the tissues of the stump and becomes the guiding portion of the prosthesis for movements in both the sagittal and coronal planes.

The third quadrant or proximal anterior part contains the socket brim and thus provides suspension of the socket and the prosthesis. It also connects to the distal socket half and therefore secures the socket axially.

The fourth quadrant or proximal posterior part of the socket, however, has apparently no functional value and does not contribute to the quality of the socket in any way.

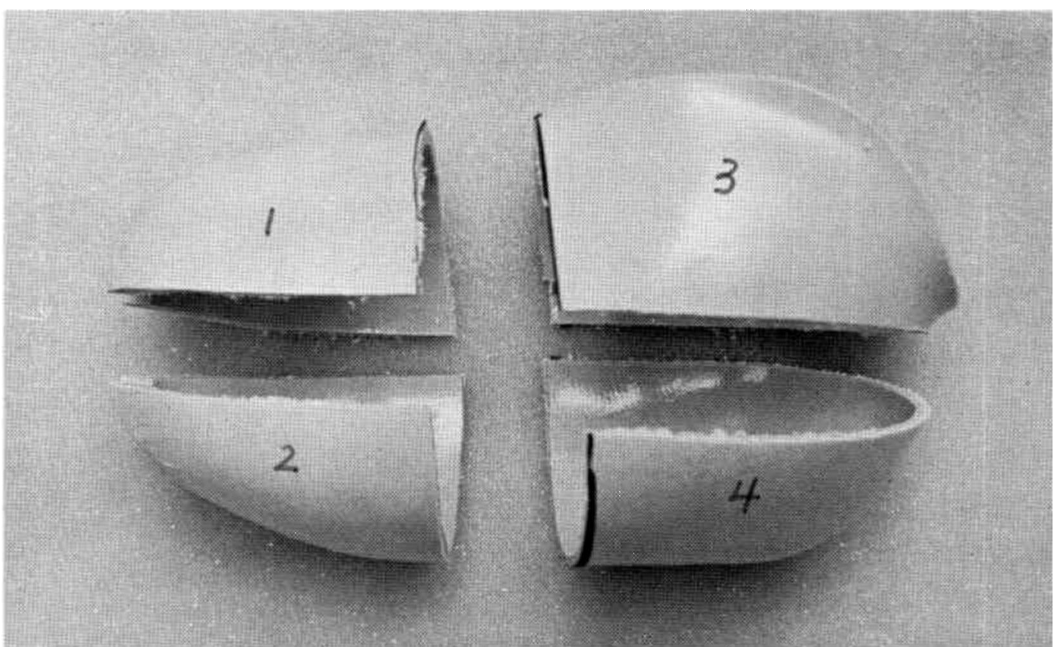

Fig. 1. The first and second quadrants are the guiding portions of the socket; the third quadrant provides suspension and stability; the fourth quadrant is non-contributory.

The three-quarter type below-elbow socket

At the Hugh MacMillan Medical Centre, the area falling into the boundaries of the fourth quadrant is cut away as much as possible as shown in Figure 2. This simple measure successfully removes the most important single complaint about the myoelectric below-elbow prosthesis, which is about excessive heat and perspiration inside the socket. This has been caused by the amputee's tissues being confined in an intimately fitting socket without the benefit of a stump sock. In the new three-quarter type below-elbow socket, ventilation has been greatly improved, therefore the skin of the stump remains dry making for a cooler socket in the summer and a warmer stump in the winter. Skin problems that have previously been caused by maceration are eliminated while comfort and wearing tolerance are greatly improved.

Suspension is also improved because excessive perspiration sometimes causes an otherwise well-fitting prosthesis to slip off. Improvements in performance are seen as well because both slippage and perspiration previously interfered with control.

In addition to these more direct and expected improvements, it has been found that, since the anatomical elbow is now free to move into the cut-out, a definite increase in the flexion range can be observed. In retrospect, it seems that many below-elbow sockets have limited range of flexion due to the restriction at the elbow rather than at the biceps tendon. With the posterior proximal quadrant cut away the socket now shows reduced bulk in the fully extended position and is therefore cosmetically more pleasing. This is seen in Figure 2. In addition, because the elbow is now largely exposed, the patient is able to place the prosthesis quietly down onto a table top.

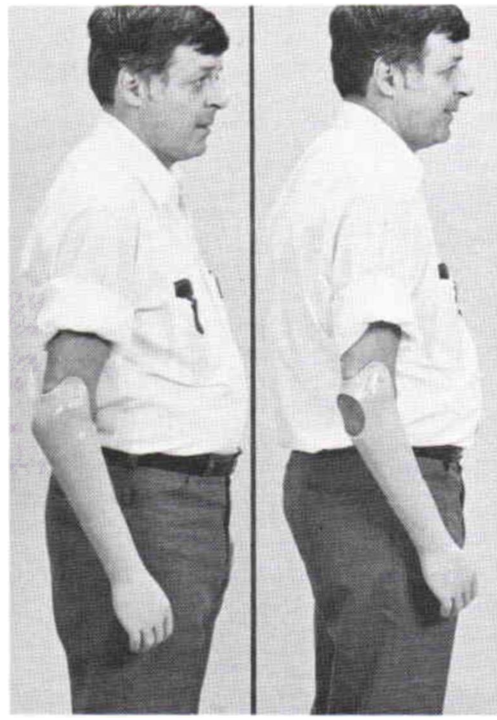

Fig. 2. With the elbow cut away, the socket shows reduced bulk in full extension.

Method of construction

All sockets are made in the normal fashion with no deviation from the usual fabrication procedures. Cutouts may be made as a retrofit. It is worth mentioning that the prosthetist can dispense with the usual modifications made to the positive mould in the elbow area. In cases of users involved in manual labour it may be appropriate to reinforce the olecranon bridge with some extra material, e.g. a couple of patches of nylon tricot to prevent later cracking of the laminate. The actual cutout is made only after having carefully assessed the length of the patient's stump. As a rule of thumb, the cut-out length should not exceed 50% of the axial stump length. If this rule is not followed, the stump may not be contained properly. Before cutting, the outlines of the intended cut-out surface should be drawn on the socket with a grease pencil. Depending on the actual size of the cut-out, a hole can be made with a conical plastic bit* and a router used to gradually enlarge it. In cases of adult patients, the cut-out can be made using a cast cutter. In either case, it is advisable to start conservatively and enlarge the hole gradually. The edges of the cut-out should be smoothed and burnished as are other parts of the socket brim.

Clinical experience

The procedure described above has been used by the authors with excellent results over the past few years on more than 50 patients fitted

*Otto Bock Catalog for Machines and Tools, Conical drill, No. 726W9/20mm.

with myoelectric below-elbow prostheses. The patients involved were both adults and children and were fitted with hard resinous or silicone rubber flexible sockets (Sauter, 1975). No negative side effects were observed.

This simple procedure has proven to be effective in removing the drawbacks of the type of socket used in below-elbow myolectric prosthesis fittings. It has now become standard practice in the powered upper extremity prosthetic programme at the authors' centre. These positive findings have been confirmed by colleagues in other centres.

REFERENCES

BILLOCK, J. (1972). Northwestern University supracondylar suspension technique for below-elbow amputations. *Orthot. Prosthet.* 26(4), 16-23.

GORDON, H. (1966). The Muenster-type below-elbow prosthesis: a field study. I.C.I.B. 6(1), 12-18.

KAY, H., CODY, K., HARTMANN, G., CASELLA, D. E. (1965). A fabrication manual for the Muenster-type below-elbow prosthesis. New York School of Engineering and Science: New York.

SAUTER, W. (1975). Flexible sockets for short below-elbow amputees. *Orthop. Prostheses, Summer,* 19-22.