

THE APPLICATION OF MYOELECTRIC HAND PROSTHESIS AT DIFFERENT AMPUTATION LEVELS BELOW THE ELBOW

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ABSTRACT. Three types of socket for different lengths of below-elbow amputation stumps are discussed: (i) The "Münster socket" for a short stump, giving some limitation of the elbow movements and no pronation or supination of the hand, (ii) a "Münster socket" with an inner socket for long stumps, facilitating pronation and supination of the hand and (iii) a short "pronation and supination socket" for long stumps, giving freedom of elbow movement and allowing pronation and supination of the hand. A distal location of electrodes with the latter type of socket does give useful signals.

The "Russian hand", with its myoelectric control of the prehension of the artificial hand, was given much publicity about five years ago (3). Perhaps in some places excessive hopes were raised for this new device. The rights of manufacture in England were purchased through a charity organization (Lady Hoare Thalidomide Trust Fund), but for several reasons the practical application of the prosthesis did not prove very extensive in that country.

A thorough technical and clinical test of the "Russian hand" was made at the Rehabilitation Institute in Montreal. When certain components had been replaced in Canada, and modifications made, favourable reports soon followed (6).

Before upper extremity prosthesis for myoelectric control became available commercially, we attempted in Uppsala to gain some experience of our own in this field, in collaboration with the Central Laboratory of Neurophysiology and the Department of Physics. The first application suitable for practical use, which was completed in 1967 and demonstrated at the International Congress of Medical Technology in Stockholm, was an above-elbow prosthesis in which opening and closing of the hand were controlled by signals from the biceps and triceps (1). Although the pa-

tients' opinions on the actual control were, on the whole, positive, the new prosthesis comprised no new achievement compared with previous mechanism with mechanical shoulder control.

Of considerable interest are the attempts which are being made to utilize implantable electronic equipment for the reception and transmission of myoelectric impulses and control of the prosthetic function by telemetry (2, 5).

With regard to below-elbow amputees, it may be said that most people who have lost one arm or hand utilize more fully their remaining hand. Many unilateral below-elbow amputees only use their prosthesis exceptionally, and instead make use of their amputation stump with its sensitivity. In the light of such general orthopaedic experience we have only to a very small extent fitted unilateral below-elbow amputees with active hand prosthesis. Since, however, myoelectric prosthesis have become available commercially during the last two years, through Otto Bock and Viennatone, the indications have been widened as a trial.

On application of these myoelectrically controlled hand prosthesis in below-elbow amputees, the prosthesis has been fixed to the arm by means of special shaping of the prosthesis socket, which is usually called the Münster type as in Fig. 1. Such sockets were developed many years ago at the university clinic in Münster under the leadership of Dr Kuhn. These sockets, with their accurate and high elbow fitting, have been used widely for short below-elbow stumps and also for stump lengths up to the middle of the lower arm. With myoelectric control of prosthesis in these cases, the electrodes have been placed on the upper third of the lower arm, both over the extensor and flexor muscles.

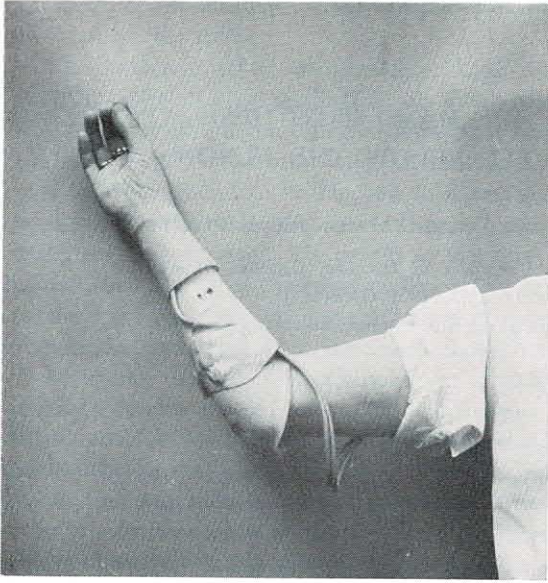
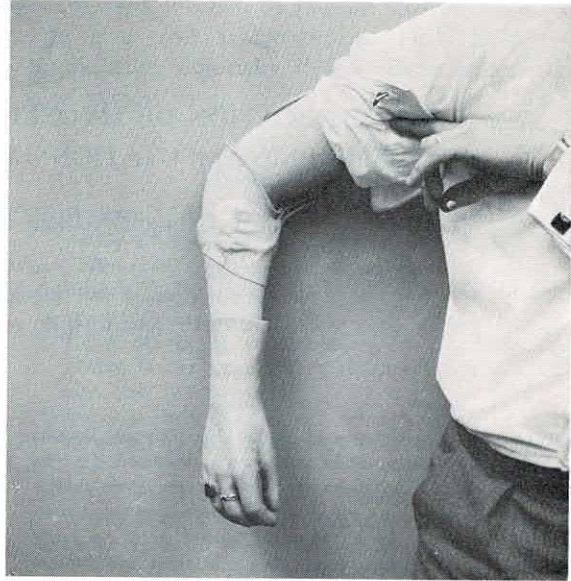


Fig. 1. (Case 8, A. B.) "Münster socket". With its high fit around and above the epicondyles of the humerus, this gives good anchorage of the prosthesis but allows no



pronation or supination. Further, extension of the elbow joint is limited.

Sockets of the Münster type have also been used for long below-elbow stumps in which the pronation and supination capacities have been retained. In order to utilize the rotatory movement of the lower arm in these cases, the artificial hand,

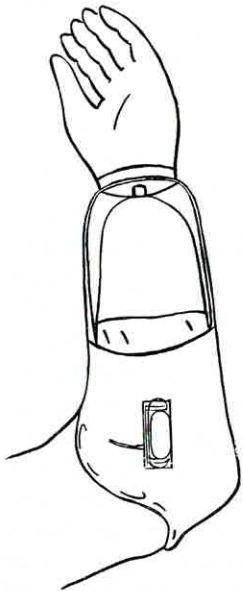


Fig. 2. "Münster socket" for a long amputation stump, supplied with an inner socket for rotation of the artificial hand.

welded to the socket, has been attached firmly to a short inner socket, which rests on the actual stump end as in Fig. 2. When the stump end and the inner socket rotate on pronation and supination, the artificial hand also rotates. The advantages of such an application are, that one still has the very good fixation of the Münster socket. The disadvantages, on the other hand, are resistance and limitation on articular movements of the elbow, and difficulties in achieving good fixation between the stump and inner socket, as well as the size which the outer socket has to have for the inner socket to be able to rotate.

With amputation at the wrist or immediately above it, and where the pronation and supination capacities are retained, the conventional Münster fitting and construction with an inner socket are less suitable. For such cases we have attempted to develop another type of prosthesis. The socket has been shaped so that the amputee is able to utilize his pronation and supination movements and also has full freedom for movements at the elbow joint as in Fig. 3.

If the distal parts of the radius and ulna are retained, a well-fitting socket enclosing the stump end can "take up" force in the longitudinal direction of the stump without any slipping of the prosthesis. A socket length of 12-14 cm is

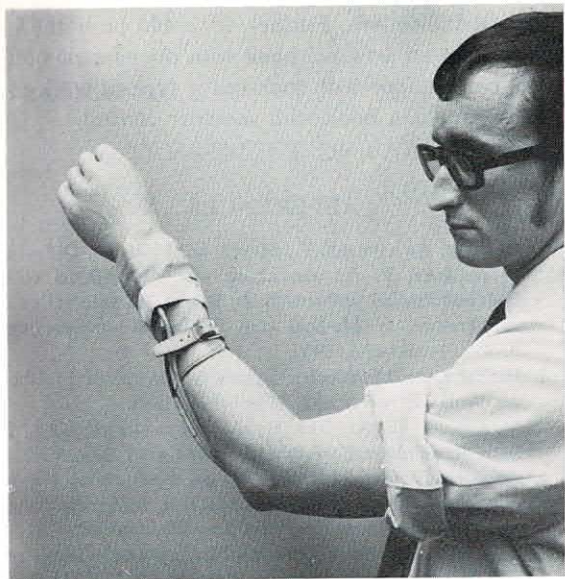


Fig. 3. (Case 3, B.J.) Short "pronation and supination socket" for a long below-elbow stump. The elbow is quite free. The pronation and supination movements of the lower arm are retained.

sufficient for stabilization. The amputee is then able to utilize to a large extent his pronation and supination mobility and has a completely free elbow joint. The plastic socket is supplied with openings to enable the stump to be put in and taken out. These can be made so that the radial and ulnar prominences can pass through easily. The screw connection which is present on the commercial artificial hands has to be removed and the hand cable taken out at the side so that the prosthesis will not be too long. Instead a metal plate with cuffs and with screw-holes can be

fused into the socket. The socket can then be firmly screwed directly to the chassis of the artificial hand as in Fig. 4.

Concerning positioning of the electrodes, we have sought for signals far distally on that part of the amputation stump enclosed by the plastic socket. From the extensor and flexor muscles of the thumb, for example, the signal level can be fully adequate for control of the prosthesis. There need be no interference here from pronation and supination movements. In 3 out of 4 cases the electrodes were placed perpendicular to the direc-

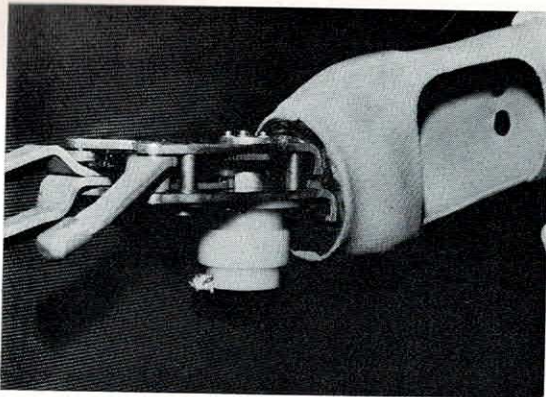


Fig. 4. The chassis of the hand firmly screwed to the short socket with the metal plate.

tion of the muscle fibres, and in 1 case in the same direction as the fibres. No general rule need be adhered to concerning positioning of the electrodes—each individual case should be considered separately.

Our experiences, hitherto, of distal positioning of the electrodes and shaping of the socket so that pronation and supination of the lower arm are not inhibited, have been distinctly positive, even though based on a relatively small number of cases as shown in Table I.

For active patients who use their myoelectrically controlled prosthesis routinely, the wear and tear can be considerable. The need for service, with repairs and exchange of components, is a factor which must be taken into account when consider-

ing the indications. Further, it should be borne in mind that an artificial hand with myoelectric control cannot cope with such heavy type of work as, for example, a hook with shoulder control.

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Table I. Table showing applied myoelectric hand prostheses (12 cases July 1 1968-June 30 1969)

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Case	Stump length			Type of socket			Location of electrode			Pronation and supination mobility
	Short	Medium	Long	"Münster"	Modification	Short	Prox.	Middle	Dist.	
1 K. A.			×							
2 B. L.			×			×			×	+
3 B. J.			×			×			×	+
4 K. B.			×			×			×	+
5 P. T.		×				×			×	+
6 B. J.			×		×					
7 J. S.			×		×		×		×	(+) Coalitio radio-ulnaris
8 A. B.	×				×			×		-
9 N. P.	×				×			×		-
10 R. F.	×				×			×		-
11 G. L.			×							-
12 S. S.	×				×				×	+