Scand J Rehab Med 19: 85–87, 1986

PROSTHETIC REHABILITATION IN BILATERAL HIGH ABOVE ELBOW AMPUTATION

Per B. Johansen,[1] Margita Breitholtz,[1] Roberto Cavrini,[2] Bo Johansson,[1] Hannes Schmidl[2] and Mikael Thyberg[1]

From the [1]Department of Rehabilitation Medicine, University Hospital, Linköping, Sweden and [2]I.N.A.I.L. Prosthetic Centre, Officina Ortopedica per Invalidi del Lavoro, Vigorso di Budrio (Bologna), Italy

ABSTRACT. Rehabilitation in patients with bilateral high above elbow amputation presents a considerable prosthetic problem. A patient with high upper arm amputations after a high-voltage injury is presented. He was successfully fitted with multifunctional myoelectric hand prostheses. The problems in rehabilitation of adult bilateral arm amputees are discussed and the value of fitting these patients with electrically powered prostheses is assessed. The balance between technical and clinical aspects is discussed in relation to patient acceptance. In our case good acceptance and functional benefit was noted. The fact is stressed that the bilateral upper extremity amputee can regain considerable physical function with the fitting of suitable prostheses, even if the limb remnants are short and provide little or no function. An extensive team approach at specialized centres will favour the results.

Key words: amputation, prosthesis, rehabilitation

INTRODUCTION

Amputation of the upper limbs are usually the result of trauma. Severe electrical burns of the extremities present difficult problems as surgical amputation is necessary in about 1/3 to 1/2 of these patients (3, 10, 14). Most electrical injuries occur in males and approximately 2/3 of high voltage injuries (currents greater than 1 000 volts) occur in construction workers and electricians (10). Burns of the arms and hands are most common, followed by burns of the legs and feet (3). Traumatically acquired bilateral high above elbow amputations are uncommon but nevertheless represent an important rehabilitation problem since the matter of replacing the function of the lost upper extremities with artificial limbs is difficult both medically, technologically, psychologically and socially. With some exceptions (12, 13, 15) the use of multifunctional externally powered prostheses in high above elbow amputations has still at this time been limited.

CASE REPORT

A 25-year-old Swedish electrician suffered a severe electrical burn mainly through the upper extremities when accidental contact was made with high voltage wires. Bilateral high above elbow amputation had to be performed immediately after admission to hospital. The length of the stumps was symmetrically 8 cm, measured from the lateral parts of the acromions to the distal ends of the stumps (Fig. 1). There was almost normal range of motion of the shoulders. After an initial period of emergency care and basal rehabilitation the patient was admitted to our department in Linköping for prosthetic rehabilitation, 6 months after injury. Because of the considerable experience of prosthetic technology in Bologna (12) an Italian-Swedish teamwork was organized. A pair of myoelectrical multifunctional prostheses was prescribed. The prostheses were manufactured in Italy and the prosthetic training and evaluation took place in Sweden.

The aim was to get bilateral externally powered hand, wrist and elbow functions. The first problem was to find a sufficient number of sites for the electrodes. To avoid interference from body movements the electrodes had to be placed as distally as possible. The patient was trained to produce myoelectric signals with sufficient amplitudes from the upper part of the trapezius, the lateral part of the deltoid, the proximal part of the biceps brachii and the proximal part of the triceps. The pairs of skin electrodes were first applied manually and later placed in specially fabricated training sockets. The electrode cables were attached to a simulator with potentiometers, light signals and a prosthetic hand with electrically powered grip and wrist rotation capabilities.

After two weeks the patient was able to activate each electrode pair without simultaneously activating the others. Thus four myoelectric control sites could be used on each side. To control opening and closing of the hand, pronation and supination of the wrist and elbow motion in two directions, six pairs of electrodes or two-state control would have been possible to use. In two-state control, changes in the character, e.g. the amplitude, of the myoelectric signals are used to control two functions by the same pair of electrodes. However, in this case, the problem was solved by connecting the posterior straps to switch controls. By this arrangement a hand movement, e.g. opening, and a wrist movement, e.g. supination, could be controlled by the same myoelectric signal and selected by a preceding shoulder movement. Another two weeks were needed for fabrication of the prostheses. To permit optimal positioning of the prosthetic hands the motorized functions were supplemented with passive friction joints in the prosthetic upper arm and forearm (Fig. 2).

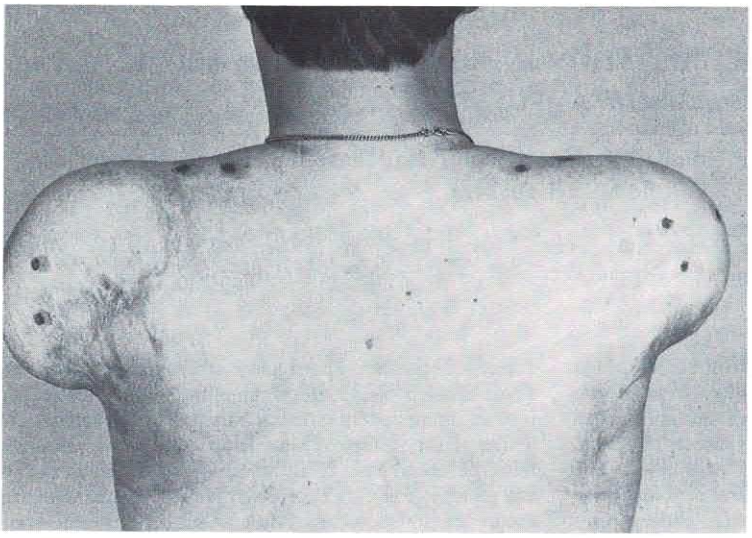

Fig. 1. Posterior view showing the limb remnants. Some of the sites of the electrode pairs are marked on the picture.

After fabrication a special training program was performed during four months. The formal part of the training which took place at the department of occupational therapy consisted of 20 days divided in six periods. Between these periods the patient trained at home. The training started with controlling single prosthetic functions. Later these were combined into patterns of movements with increasing complexity (Fig. 2). The goal was to learn different movements by repetition of suitable activities. The patient trained daily activities at home and the difficult parts were analyzed during the following period at hospital. The training program was finished 19 months after injury. The patient has returned to work at the state railways although his work responsibilities have become mainly administrative. Complementary technical aids have been installed at home and at his office.

The acceptance and the functional benefit from the prostheses were assessed a year after the training program was finished. The prostheses were reported to be used more than eight hours daily, mainly at work and outdoors and less at home. Among the functional benefits received, the patient appreciated the ability to eat with a knife and fork. Other advantages connected to personal comfort were also reported. Applying the Katz index of ADL (6) the functional benefit could be verified by an improvement from grade D to grade C. However, the most striking benefit was not in basal daily activities but at work and in social activities. This was evaluated merely by interviews since no suitable standardized test was available. The patient missed his prostheses during short periods of repair and a pair of extra prostheses is now under fabrication.

DISCUSSION

In unilateral amputees the remaining hand compensates for many of the functions of the lost hand, but in bilateral amputees the patient is more or less dependent on others. These patients have also lost the sensory feedback of the upper extremities. Prosthetic development has been discussed by several authors (4, 5), and technically sophisticated solutions such as electronic pattern recognition and

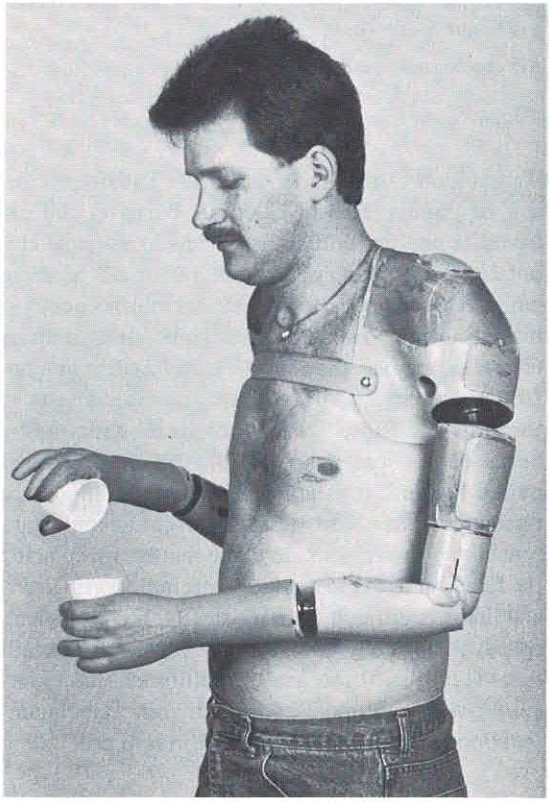

Fig. 2. The prostheses. The locations of the passive ball joints in the upper arm and forearm are clearly visible.

adaptive grip have been proposed, not only for this type of patients but also for those with unilateral below elbow amputations. An advanced prototype is interesting from a technical point of view and is a compulsory part of the continuous development in this field (1, 7). However the complex question of the clinical significance (2) must not be excluded from the discussion since this is the basis of the acceptance of a prosthesis (15). Factors as patient consensus during the prescription, technical properties of the prosthetic components, skillful socket fabrication, a comprehensive training program and an adequate service organisation favour the acceptance (9). The patient must also be satisfied with the comfort and cosmetic appearance of the prosthesis. Of course, the usefulness of the artificial arm in daily life is the principal criterion for the evaluation. A prosthesis is not likely to be worn if the subjective benefit is less than the inconvenience associated with it. Prostheses acceptance in the bilateral upper extremity amputee is directly proportional to the increase in efficiency afforded the patient by the device (8). In this case the benefits included basal daily activities and work activities. These prostheses represent a technically rather simple but clinically advanced combination of conventional techniques. The most critical parts were probably the signal training, the socket fabrication and the training in daily activities. In this case the follow-up data suggest that the severely disabled bilateral upper extremity amputee can regain considerable physical function with the help from suitable prostheses. Apart from technology, the development of comprehensive teamwork at specialized centres is an important factor contributing to the positive clinical result (11).

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Address for offprints:

Mikael Thyberg
Department of Rehabilitation Medicine
University Hospital
S-581 85 Linköping
Sweden