CLINICAL EXPERIENCES WITH EXTERNALLY POWERED PROSTHESES AND ORTHOSES FOR UPPER EXTREMITIES

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Summary

About 79 patients with arm amputations and 44 patients with fresh injuries of the spinal cord in the cervical region were treated in the last 5 years. The application problems of external power are treated in cooperation with the Institute of Biophysics of the Karl Marx University by the "orthopaedic-biophysical team Leipzig". About 17% of the arm amputees are fitted with externally powered prostheses. About 7% of the quadriplegic patients have been fitted with externally powered hand splints. By assistance of such devices rehabilitation is improved. In spite of this it is useful to remember also conventional possibilities. External power should be used as little as possible, but as often as is needed for special patients. This decision is a medical task. Successful rehabilitation is the result of teamwork.

In the last 5 years 79 patients with arm amputations were treated in the orthopedic hospital of the Karl Marx University at Leipzig. There were 4 children among them. Externally powered prostheses are not available for these. Among the 75 adults there were 9 with bilateral arm amputations or with severe injuries after accident of the non-amputated side.

In the same period 44 patients with fresh injuries of the spinal cord in the cervical regions were treated. At present 27 are alive.

Our experience relates to this case material. All the application problems of external power in rehabilitation of patients with posture and locomotion system diseases are treated in cooperation with the Institute of Biophysics of the Karl Mrax University by the "orthopedic-biophysical team Leipzig".

Experiences with Arm Amputees

Only 13 of our 75 patients, that is 17%, are fitted with externally powered prostheses. Nearly half of all the patients, 46%, are using only cosmetic prosthesis more or less frequently. Eleven patients use body powered prostheses. Most of the unilateral amputees reject such prostheses because of inconvenience by harness and force transmission by Bowden cable. Exactly the same number of patients use generally no prosthesis.

In all modern industrial states there are so many possibilities for working, that even patients with not too highly-developed intellectual abilities can do well without any arm prosthesis, if only one arm is healthy. Therefore economical reasons have never been important for fitting. Of course there are some professions, which need two-handed working. If the amputee wants to continue it, for example, because special vocational training had been necessary, an arm prosthesis with movable joints is indicated. If the amputee has to perform rough and dirty work, we fit him with a body powered prosthesis. We have to do so especially because of failure of externally powered hooks.

Myoelectrically controlled hand prostheses are not suited for heavy work. We apply them to patients who do white-collar work, because functional aspects correspond best to cosmetic appearance.

Electric arm prostheses are functionally more intact than pneumatic ones. Storage and carriage of pneumatic energy are difficult and inconveniant. We prefer use of nickel-cadmium cells in a belt carried about the trunk.

The best way of controlling prostheses is by myoelectric signals. In connection with this we relate to one model of VIENNATONE and two others from the Soviet Union, all with on-off control.

In special cases a simple control by switches is possible. Such mechanical control requests less of motors and is obtained without considerable technical expense. These prostheses are relatively cheap and sturdy. Figure 1 shows an example. This patient had had a cineplastic operation 30 years ago. Muscle power and contraction were so small that it was impossible to move the original Sauerbruch hand prosthesis. The remaining muscle function was sufficient to activate the electric motor for prehension by pull-switches. For years our patients with very long forearm stumps have been fitted with a parted socket. The electric hand prosthesis is connected to the short distal socket. The proximal cuff contains the surface electrodes, and natural rotation of the forearm is obtained. We abandoned this method because the weight of the electric hand in all cases causes pain. Forearm amputees do not need hand rotation, since this movement is easily compensated for by the shoulder joint.

In general the weight of a hand prosthesis is very important. Therefore parts of the elctronic amplifier are not incor-

Fig. 1. Sauerbruch - cineplastic controlling an electric hand prosthesis

porated in the hand. Besides such hand prostheses need more space, and this is often needed with long forearm stumps.

Fitting with two myoelectric prostheses is not always the best method for the double forearm amputee. By combining a myoelectric and a body powered prosthesis many possibilities result. If it is possible, the dominate arm should be fitted with the externally powered hand prosthesis and the other side with a body powered one. Figures 2 and 3 demonstrate such a fitting. This patient is very interested in working in his large garden. For this he mainly employs the conventional body powered prosthesis with hook. For other activities he uses the myoelectric prosthesis. He always wears both prostheses.

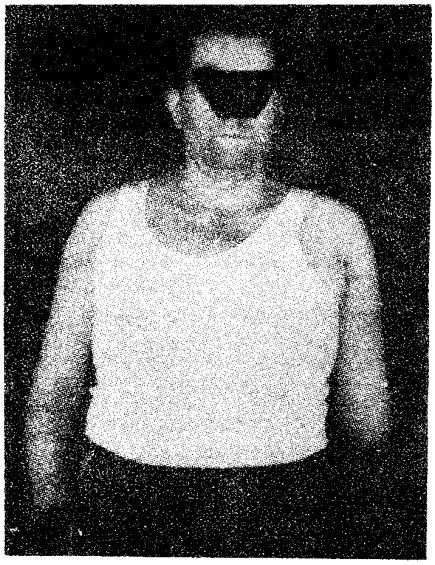

Fig. 2. Bilateral arm amputee

Fig. 3. Bilateral arm amputee fitted with a myoelectric hand prosthesis on the left and with a body powered prosthesis on the right side

Useful possibilities for electrical elbow-flexion are not available but we rarely need functional prostheses for patients with amputations above the elbow. Only 5 of 21 one-sided amputees are using such an artificial limb. One of the five is fitted with a hybrid prosthesis: electric hand, which is myoelectrically controlled by musculus biceps and triceps brachii; elboe-flexion and locking are bodv powered by straps in traditional manner.

Special problems are to be seen with bilateral above-elbow amputees or still more radically operated patients. Without any functional arm prostheses they are completely dependent on assistance by others. Prehension, hand-rotation, and elbow-flexion and extension are needed.

Each method of fitting amputees with two functional prostheses stresses the patient psychically. Such fitting is seldom successful for this reason. There is no alteration by myoelectric control. The physical strain of using external power is unimportant. Therefore temptation is given to use all objective possibilities, but not to notice the subjective stress involved.

Figures 4 - 6 show a patient with a shoulder-disarticulation procedure on the right and an above-elbow amputation on the left. Moreover there are a pactoralis cineplastic tunnel on the right and a biceps cineplastic on the other side. Both show sufficient function. This patient uses a Sauerbruch-prosthesis on the left without achieving independence.

We tried to improve it by fitting a hybrid prosthesis for the right side: electric prehension and hand rotation controlled

Fig. 4. Patient with shoulder disarticulation and hybrid prosthesis on the right and above-elbow amputation on the left side

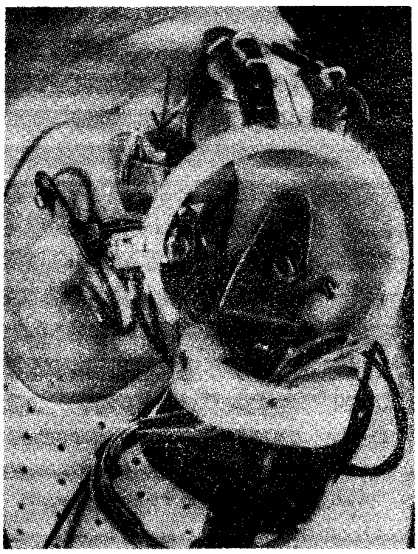

Fig. 5. Shoulder part of the hybrid prosthesis; ⟶ switches for electric prehension and hand rotation

by four switches (Fig. 5), which are activated by motion of the shoulder stump; pneumatic elbow-flexion controlled by the cineplastic tunnel of the musculus trapecius. Smooth movement of the forearm is obtained by a hydraulic damping cylinder. The expected success did not occur.

Experiences with Quadriplegic Patients

All these patients need an electric wheelchair, the control of which must be adapted to the individual possibilities. It is possible to use switches, which are activated by a lever. It can

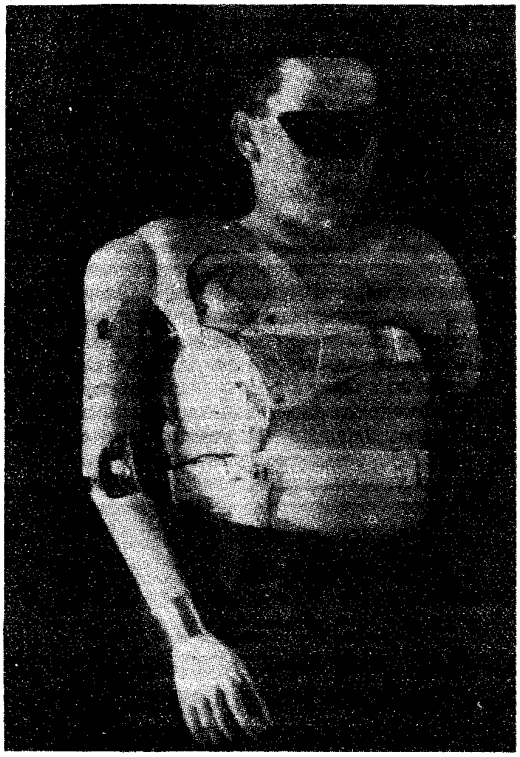

Fig. 6. Complete hybrid prosthesis for shoulder-disarticulation

be moved by residual functions of the arm or by the chin. It is also possible to control wheelchair motion myoelectrically. We have designed such a system, but we did not need it till today, because all our patients were able to move switch-lever. In our clinical rehabilitation programme there is the physiotherapy. We succeed nearly always in expanding residual muscle function and in exercising compensating movements. In three cases this therapy has been supported for some weeks by flexor tenodesis splint. Used in an early stage of rehabilitation, prehension can be sponsored and development of contractures avoided. Two patients of 27 have been fitted with externally powered splints. For technical reasons pneumatic power has been employed. The whole system consists of a modified pullvalve, which is activated by trunk motions, a small cylinder as an actuator and other usual parts of a pneumatic prosthesis systems.

In Figures 7 and 8 a patient with a splint cord lesion at the C5/6 level is shown with such a device. The suppositions in this case are very favourable, because the patient's husband is a technican. For him gas storage and filling are no problems. Some people are unable to do it. This woman needed the hand splint about one year. Now she has a relatively good prehension without any technical aids.

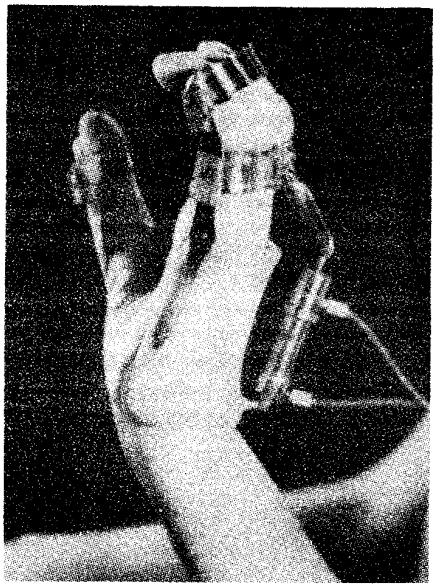

Fig. 7. Pneumatic hand orthosis

Fig. 8. Modified pull-valve (←—) and bottle for gas storage at the wheelchair

By assistance of externally powered prostheses and orthoese for upper extremities rehabilitation can be improved. In spite of this it is useful to remember also the conventional possibilities. It must be exactly decided what a function is to be replaced and how it is done in the best manner.

Equal anatomic findings seldom need equal prosthetic or orthotic fitting. It should be replaced as little as possible but as much as needed for this special patient. This decision is a medical task. But successful rehabilitation, especially in application of external power, is the result of teamwork.