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Research and development of functional aids

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Abstract

Four aids, developed by the Department for Research and Development from existing ideas and being used in Revalidatiecentrum "De Hoogstraat" by patients with a spinal cord injury, are described. These aids are: a dynamic elbow extension orthosis; a modified flexor hinge splint; a rolling writing aid, and a urinary device for females.

Introduction

Disabled people are confronted with many problems resulting from the loss of various functions. Solutions are sought for the problems they meet in everyday life and these may be found in surgery, physiotherapy or in the use of technical aids.

When developing aids, it is important to keep the user's abilities and needs in mind. To obtain a simple but functional aid, the basic requirements should first be outlined and then the aid designed to fulfill these requirements. This approach results in useful aids and with more experience may also be applied to the development of more complex aids.

Methods:

Criteria

The aim of development is to tackle the heart of the problem. In making an aid, one strives for the following goals:

lightweight
as small as possible
preferably without external power supply
silent
acceptable form
easy fitting
anti-allergy material
aesthetic value.

Some practicalities are:

use of standardized parts;
possibility of adjustment;
simplified assembly.

Fitting

User acceptance of an aid depends on a good fit, therefore attention should be paid to the following:

The distribution of pressure (force) on the body. The force must be perpendicular to the skin; the pressure on the skin must be lower than the systolic blood pressure in the capillaries ($< 0{\cdot}5\ N/cm^2$).

The positioning of the parts on the body: the axes of movement of the aid must correspond with those of the joints of the body.

Comfortable fit: i.e. snug fit, allowance for ventilation, easy to clean/hygienic, cosmetic.

The aim is to make a device/aid with adjustable and easily fitted parts.

Material

The material used for the devices described is thin-walled stainless steel tubing. This material has several advantages: sufficient strength, lightweight (and slender of structure), easily assembled and disassembled by brazing. Therefore, fitting adjustments and maintenance are easy to carry out.

Results

In general, the problems have been approached from a basic mechanical point of view as well as considering the importance of cosmetic aspects. Advanced techniques have not been used.

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Elbow extension orthosis

Patients with a C5 or C6 spinal cord injury have only active elbow flexion and no elbow extension. It is therefore rather difficult to prevent flexion contractures of the elbows, especially shortly after the spinal cord injury (Bedbrook 1981). Various methods are used to prevent these contractures e.g. maintaining full passive range of movement and (the use of) splinting. A year ago fitting of the elbow extension orthosis began. This is derived from an elbow flexion orthosis, designed for patients with a brachial plexus lesion, which was developed at the University of Technology in Delft (Cool, 1976). In the extension orthosis a spring provides the necessary extension force. The orthosis is easy to apply and may be fitted in the acute phase soon after the spinal cord injury to prevent flexion contractures.

The physiotherapist tries to teach the patient to consciously relax the flexors, thus reducing the flexion force. This allows the spring to pull the elbow into extension.

Therefore, by consciously contracting or relaxing his biceps, the patient is able to flex or extend his elbow which increases his abilities in activities of daily living.

Description

The orthosis (Fig. 1) is made so that with increasing flexion of the elbow, the pull in extension also increases. It is also possible, technically, to keep the extending force constant or to decrease it with increasing flexion.

With this method of achieving extension, there is some chance of causing an increase in spasm. However, by using the maximum force of the rubber band, possible in extension, the elbow can be kept in extension for better advantage. In this position spasm does not occur so readily.

It is not certain whether the orthosis causes an increase in muscle strength in biceps, thus not achieving the required result (Abrahams et al, 1979).

To achieve extension one can use a single hinge joint. If active pronation is also required, it may be necessary to use a hinge on both sides of the arm for additional strength. The fitted parts of the system were developed at the University of Technology in Delft. It consists of adjustable, hinged plastic fittings which provide an adequate distribution of pressure on the skin surface.

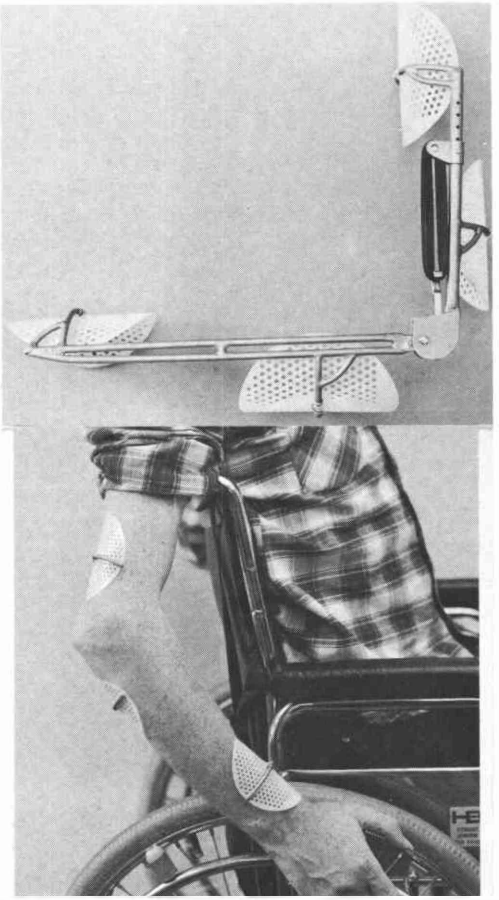

Fig. 1. Elbow extension orthosis. Weight 120 g; material, stainless steel and polyethylene; construction time 5–10 hours. Number issued 7, cervical lesions 5, others 2.

The plastic fittings are perforated to allow for ventilation. Normally they do not require padding and being plastic, they are hygienic.

As the orthosis is maintained in its correct position by spring tension, no straps are required. The tension of the rubber band is adjustable. The usual value of the torque of the spring is 1 Nm in 90° flexion. The maximum value is limited however by the acceptable pressure on the skin surface and the possibility of oedema.

This orthosis has only been used in seven cases. From this limited experience it has been learned that the orthosis should not be used for patients with a spastic paralysis as it causes increased spasticity in the elbow flexors.

On the other hand it seems a good solution for cases with flaccid paralysis, especially in the early phase.

Flexor hinge splint

Various types of flexor hinge splints are available. The many publications concerning this subject and the amount of research done in this field indicates the importance of prehension of the hand. The flexor hinge splint is used to obtain a pinch-grip between the thumb, in opposition, and the second and third finger. By extending the wrist, both fingers are passively flexed towards the thumb by means of a dynamic splint mechanism. In this way the patient is able to grip and release objects (Malick and Meyer 1978; Nichols et al. 1978).

A new splint of simple design and construction is described.

Description

If prehension occurs between thumb and fingers and the initiating movement takes place from the forearm, it must be sufficient to support the fingers, thumb and forearm only.

With the splint (Fig. 2) made as described, it is evident that with dorsiflexion of the wrist the fingers are passively flexed towards the thumb—immobilized by the splint. In this way a useful pinch grip is achieved by the use of minimum force. Yet, with strong dorsiflexion of the wrist, the fingers may slip out of the fittings. As the C6 lesions usually do not have a strong wrist dorsiflexion this will not happen. Thus this results in a flexor hinge mechanism which leaves the metacarpals free.

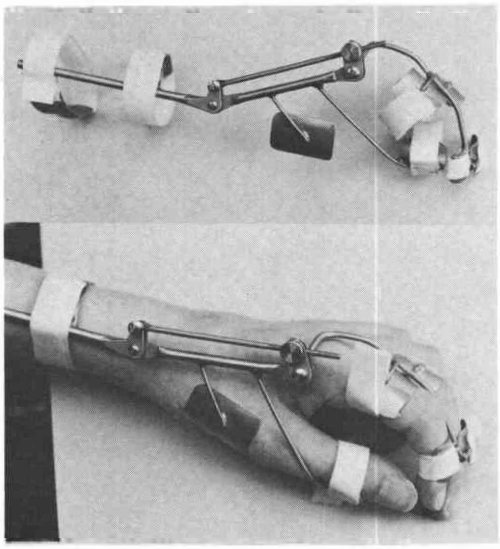

Fig. 2. Flexor hinge splint. Weight 90 g; material stainless steel; construction time 4–8 hours. Number issued 5.

An accurate fit is obtained because the small fittings on the fingers and thumb are separately adjustable. A future consideration may be the introduction of self-adjustable fittings. Velcro straps keep the fingers in the required position. As the straps are not very aesthetic, a better solution e.g. "clip on" fittings is being sought.

As the surface area of the fittings of the fingers and thumb are small, the corresponding areas of support on the forearm must also be small. As this splint fits snugly, there is no need to pad it, which improves its cosmetic appearance and is more hygienic.

During fitting the arm is placed on a special armrest which allows easy access to the required areas of the forearm and hand. Thus the construction time is about four hours. It is possible to use a spring assist consisting of one or more elastic bands, if the dorsiflexion of the wrist is too weak.

The new flexor hinge splint has been issued in 5 cases. The most important advantage of the orthosis is that it is easily fitted and therefore can be assembled soon after referral.

It is a well-known fact that the earlier splints are supplied, the better they are used. Another advantage is that this flexor hinge splint is more aesthetic than the old type and therefore more readily accepted.

Rolling writing aid

Writing is a tiring activity for patients who lack sufficient muscle power to lift the hand, due to the friction of the hand shifting over the paper. The rolling writing aid (Fig. 3) has been developed in order to decrease this resistance. Due to the wheeled support of the hand, the person is able to write legibly using shoulder and upper arm movements. The hand is placed on the support, which rolls by means of two ball-bearing fittings attached to the support. The ballpoint-pen provides the third support, thus forming a stable base. The ball-bearing fittings are placed in such a position that the hand can be tilted in order to lift the ballpoint-pen off the paper. The advantage of this aid is that the patient can rest his hand on the splint and therefore need not support his whole arm and hand with his own muscle power while writing. This aid has been supplied in 12 cases. No pressure sores have been observed.

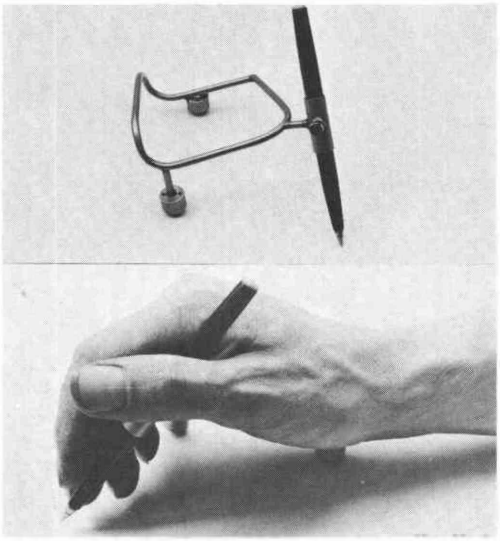

Fig. 3. Rolling writing aid. Weight (with pen) 45 g; material stainless steel. Number supplied 12.

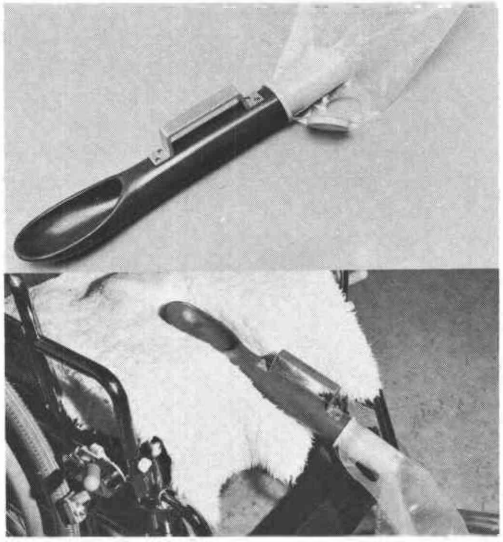

Fig. 4. Urinary device. Weight 400 g; material PVC tubing 50 × 450 mm. Number issued 30.

Urinary device for females

With this urinary device, females are able to void while seated in the wheelchair. Without this aid, the person would have to transfer to the toilet or use a catheter with its attendant increased risk of infection.

If the patient uses the lavatory, it should always be accessible for a wheelchair-bound person, which is not always the case. Due to the effort made when transferring to the lavatory, the person may void spontaneously.

If the urinary device is used, the patient avoids all the above mentioned problems.

Description

The urinary device (Fig. 4) has the advantage that it is relatively small and easy to handle. The one that is being used at present is being developed and is still undergoing modification.

The urinary device consists of a plastic tube with an oval opening at one end, and a plastic urinary bag attached to the other end. The urinary bag can be closed after use.

When using this urinary device, the person has to slip forward in the wheelchair so that she is half-lying. In order to keep the urinary device sloping downwards, a removable centre piece is made in the wheelchair cushion.

Instead of having to take off the trousers, the patient uses an extra long zip. Usually the underpants have enough stretch to allow use of the urinary device, but if not, the underpants may be adapted with zips or Velcro. The urinary device is then placed under the body and pressed downwards with one hand, while the other hand is used to stimulate the bladder (by tapping or constant pressure) to void.

This device has been used in about 30 cases. It is very useful because it means that female patients need not be dependent on a catheter with its risks, in addition they are also not dependent on a wheelchair-adapted toilet.

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