

The prosthetic treatment of upper limb deficiency

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Abstract

The provision of prostheses for children with upper limb deficiency starts at an early age. The roles of the occupational therapist and prosthetist in this programme are described. Casting and fitting techniques applicable to transverse forearm loss and aspects of myoelectric hand prostheses are included. An outline of training methods as related to both parent and child is explained. Higher levels of limb deficiency are covered briefly and the use of alternative methods of electric hand control is included. Finally, a brief summary of distal deficiency is discussed.

Introduction

The treatment of children with congenital limb deficiencies is carried out at this centre by a team comprising doctors, prosthetists and an occupational therapist. A social worker is also available for counselling when necessary. Early referral is encouraged so that the parents can be helped as soon as possible.

Transverse forearm deficiency

A first prosthesis can be fitted as early as two months of age. It consists of a plastic socket to accommodate the stump, bonded into a foam-filled cosmetic glove (Fig. 1a). The provision of such a prosthesis:

1. meets the need of parents for cosmetic replacement;
2. provides the child with an early experience of wearing a prosthesis;
3. lengthens the deficient limb and provides passive assistance to the sound hand;
4. assists the child's balance.

The socket of the first prosthesis can do little more than contain the volume of the stump. It

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should be thin-walled so that it may be stretched to accommodate growth whilst a new prosthesis is being manufactured. Progress is reviewed at two to three month intervals, or more frequently if the parents' wish. The child will continue to wear a passive prosthesis until aged fourteen to eighteen months, when consideration is given to providing a more functional type consisting of a self-suspending socket, with activation of a terminal device by a cord and single shoulder loop. Two alternative devices are available — a small lightweight split hook and the CAPP terminal device (Figs. 1b and 1c). For the past nine years the CAPP device has been preferred because:

1. it is inherently safer than the split hook, and therefore can be fitted sooner, enabling the child to develop early awareness of its functional benefits;
2. it has a more efficient gripping surface than the split hook;
3. the opening span is wide, enabling a small child to grasp things easily even though co-ordination is not well developed;

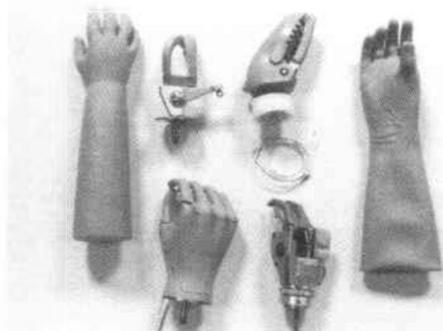


Fig. 1. Terminal devices. Top row (left to right): (a) Cosmetic foam filled glove. (b) Lightweight split hook with plastic covered jaws. (c) CAPP terminal device. (d) Cosmetic cover for hands. Bottom row (left to right): (e) Child's mechanical hand (cable operated). (f) 2 inch myoelectric hand.

4. the appearance has been found to be more acceptable to parents;
5. it has been found that less formal training is required (as skills seem to develop more naturally and automatically).

If the CAPP device is rejected the child and parents are encouraged to continue with the cosmetic prosthesis, which may be provided in addition to the functional arm for social reasons.

Transverse upper arm deficiency

The first prosthesis is provided at six to nine months of age for this level of deficiency and is similar to that provided for forearm loss, i.e. a laminated socket bonded in a flexed position to a foam-filled forearm and hand. Suspension is via a web harness which later provides attachment for control cords. As the child develops, an elbow joint is required and flexion provided via bi-scapular excursion. Once this is achieved with conviction, an elbow lock can be added, thereby allowing the flexion cord to be utilised for operation of the terminal device. As with the forearm levels, the CAPP device is preferred and is fitted once the child has gained control of elbow flexion and locking.

The occupational therapist's (OT) role initially is to advise on wearing the prosthesis, to reassure the parents about the child's development and to give information about help available from other professionals and voluntary bodies.

When a functional prosthesis is provided the OT spends more time with parent and child to familiarise them with the arm, albeit in an unstructured manner. It is imperative that parents are aware of their child's development, both physically and mentally, so that their expectations of achievements with the prosthesis are realistic. If the child does not appear to be making progress with the CAPP device 2-3 months after delivery, structured training sessions are arranged. In these, activities are chosen to encourage awareness of the use of the prosthesis, with passive assistance by the OT initially when necessary.

The spring which controls the grip force of the CAPP device is available in two strengths, the weaker one being used until the child is competent. Further sessions may take place if prosthetic use does not increase in line with normal development. At all times the parents

are advised how to help the child develop skills with the prosthesis.

The provision of an electrically powered hand is usually considered between the ages of three and four years before starting primary school (Fig. 1f).

This type of hand provides good prehension with the minimum of physical effort, combined with good cosmetic appearance. It is necessary to give parents accurate information because they may have unrealistic expectations acquired from the publicity given to these hands, and it is important to determine the optimum age for fitting. Consideration is given to the child's ability to accept a new type of prosthesis, his attitude to his existing prosthesis, his level of co-operation and also the attitudes of his parents. Physical factors, such as the length and shape of the stump, the ability to produce good myoelectric signals and the stature of the child, play a part in the decision. Myoelectric control is the preferred option for transverse forearm cases.

An alternative method of hand control is a "servo" system, in which an electronic circuit causes the hand to move in synchrony with an external transducer thus providing positional feedback. This has several advantages over myoelectric systems for those who are prepared to accept minimal harnessing and an external lead, and is especially appropriate when it is difficult to locate controllable myoelectric signals, or when there is a problem in providing the required accuracy of socket fitting. Another advantage is that the suspension and control

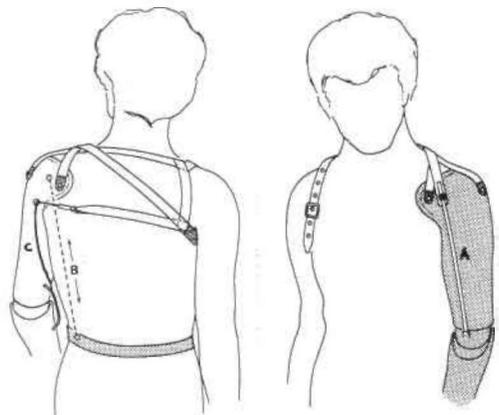


Fig. 2. Typical arrangement of control cords for above-elbow prosthesis. (a) Elbow locking. (b) Hand operation (servo). (c) Elbow flexion.

techniques used in body-powered prostheses are quite adequate to control the servo hand. The only major differences are that the forces and excursions required for control are small and that operation of the hand is possible with less discomfort, exertion or gross body movement.

In some cases the child may change from servo to myoelectric control if, through growth and maturity, better signals are eventually achieved. For transverse forearm deficiencies a minimum amount of harness is required to control the servo hand, i.e. a shoulder loop, but for upper arm cases a full harness and suspension are needed for elbow flexion and locking, as well as hand control (Fig. 2).

Prosthetic techniques

Below-elbow myoelectric prostheses may be retained by any suspension technique as long as the electrodes remain in continuous contact without slippage under normal loading conditions and at all angles of elbow flexion. One of the major benefits of below-elbow myoelectric systems is that the prosthesis can be made to be self-suspending because body activation of terminal devices is no longer necessary. Although self-suspending sockets have been available for some time, earlier prosthetic methods limited flexion quite severely and were therefore not as well accepted as they might have been. These sockets relied on a reduced antero-posterior measurement to provide suspension over the olecranon. The newer techniques such as those developed in the UK and elsewhere rely on a decreased mediolateral measurement above the condyles of the humerus, thus freeing the anteroposterior dimension to give the maximum range of flexion and extension.

Two casting techniques are used and are typical of modern prosthetic practice. The first relies on moulding the plaster bandage over the condylar areas whilst the cast is still wet, thus forming suspension areas. The second involves no primary moulding. Instead, a suspension "brim" is formed by rectification of the positive plaster model. The only criterion as to the choice of technique is that the prosthetist should feel confident enough with it to provide a comfortable and reliable socket. In order to ensure good contact it is desirable that the electrodes are held firmly against the skin

during all normal loading conditions. They should produce distinct marks on the stump which show all the features of the electrode face. However, they should not indent the skin so deeply that discomfort is caused. Care should be taken to avoid sites over bony areas or scar tissue. If distinct marks are not found, the depth of the electrode position should be increased or the electrode resited to improve contact. Electrode positions which give high signal response on the myo-tester may be identified on the posterior aspects of the medial and lateral stump surfaces. It is not advisable to site the electrodes towards the posterior aspect of the stump as it is likely that contact will be lost during part of the flexion range. A trial fitting prior to completion of the prosthesis is an essential feature, and enables the prosthetist to assess the accuracy with which the definitive prosthesis will match the original intentions at the plaster cast stage. An inner socket is manufactured from the cast and contains all the features necessary for suspension and electrode placement. At this stage a set of equipment — the hand, cables, battery, electrodes etc, as well as a temporary outer socket must be available. The latter can be made from a laminated cylinder with an internal diameter which accepts a friction wrist housing at one end (Fig. 3). The use of a transparent thermoform socket has been found to be extremely useful when refining technique. Not only can the prosthetist identify areas of the socket which are inappropriately loaded, but he can also locally modify these areas with the careful use of a heat gun. The initial stage of fitting is concerned with socket comfort and retention. After removal from the cast the socket is trimmed to remove surplus material and sharp edges are smoothed with sandpaper. The temporary outer socket is aligned on the check socket and

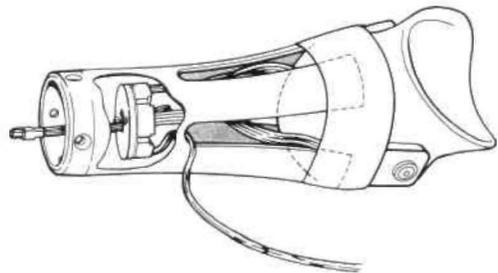


Fig. 3. Temporary prosthesis for myoelectric fitting.

held in position with adhesive tape. Length is not a major consideration at this point, although clearly some approximation to the required length is desirable. The temporary prosthesis, complete with hand is then fitted to the child. Comfort, alignment and suspension are now rechecked and adjustments made where necessary.

The fitting procedure now moves on to the next stage which tests the electrode placement and the operation of the hand. It is essential that the child acquires a basic understanding of the control of the hand before the prosthesis is completed.

It is believed that the fitting stage is the time to carry out any rectification of the socket and alignment, thus ensuring as far as possible a trouble-free acceptance by the child when the prosthesis is delivered and training commences.

Occupational therapy

It has been found that immediate training in the control of a myoelectric hand is an essential part of provision, especially with young children. If this is not available a few *may* learn to control it by trial and error, but many will be unable to establish adequate control quickly and consistently enough to prevent frustration and disillusionment. During this early training it is vital to spend time establishing a balance between the settings of the opening and closing electrodes, in order to ensure that success is quickly achieved. The child is seen by the OT at the casting and the fitting stages. This enables her to make observations of the child's ability prior to the prosthesis being completed.

Following delivery the child attends the OT department for two days basic training, during which emphasis is placed on using the prosthesis in bilateral functional activities. A prosthetist is available for any adjustments to be made during this time. Further training may be given 1-2 weeks later if required. Liaison with schoolteachers and others regularly involved in the child's care ensures that the prescribed regime is followed. This is particularly important in order to prevent undue pressure being put on the child which may contribute to rejection. The amount of training given often depends on the level of use of the previous prosthesis. A review takes place after 2-3 months but once well established, intervals between appointments may lengthen.

Responsibility is then with the parents to notify the centre when problems occur. With the servo hand very little training is needed from the point of view of hand control, but the parents should be instructed in the care of the equipment and may still need to adjust their expectations of the prosthesis. In higher levels of loss such as upper arm and total shoulder deficiency, time will be spent on achieving control of a functional elbow unit when this is fitted.

Bilateral limb deficiency

The treatment of children with bilateral deficiencies requires even closer co-operation between the professionals involved. As these deficiencies are rare it is considered that the children should attend specialist centres where the staff have built up considerable experience over a number of years. Although no two children are exactly alike the problems presented have a common core and experience gained with one child can be of considerable assistance in dealing with another. Psychological and practical support is essential for parents from the earliest possible time to help them to adjust and create the right environment in which to rear the child. The aim is to enable the child to see himself as having the least handicap. This can be achieved by a balanced combination of prosthetic provision and continuous assessment of ability by an occupational therapist.

It has been found, especially in the more proximal deficiencies, that children often achieve greater independence without prostheses. This does not mean that they should not be fitted because it is important that the child and parents see the provision of prostheses as a part of a total programme of treatment. Early experience of prostheses will enable the child to make a more effective choice at some future date.

Although a programme of prosthetic treatment may be mapped out for the first few years, invariably this is changed because it is impossible to forecast progress accurately, both in the development of the child and that of available components. For total shoulder and upper arm deficiencies, both sides are fitted with prostheses from about the age of 6-12 months. These prostheses consist of sockets with friction elbow units and foam-filled

forearms and hands made in one piece. The children are not expected to wear the prostheses for long periods but they fulfil certain requirements for the developing child and parents. These are as follows:

1. preparing the child for probable future prostheses;
2. creating early involvement of parents in the programme;
3. providing simple functional ability.

The main purpose of occupational therapy is to enable the child to reach the highest level of independence both with and without prostheses. Maximum use of residual limbs, however small, should be encouraged and much time will be spent developing use of the feet.

Feeding will be the first functional daily activity to be developed, followed by dressing, writing skills, toileting etc, as appropriate to normal child development. Aids will need to be provided but these should be kept to a minimum and as simple as possible. They



Fig. 4. Prosthesis for bilateral total upper arm deficiency. Note — voluntary elbow flexion, bite operated elbow lock and electric hand.

should also be easily portable to ensure independence in any location.

Prosthetic training is given in short sessions as and when necessary and with close cooperation with community-based paediatric OTs. Activities to develop skills with the various different mechanisms should be purposeful and appropriate to the age of the child and advice is given to the parents about encouraging the child to develop spontaneous use. Meeting other children can be helpful in learning by example.

From the first simple prostheses the child will progress on to more complex elbow mechanisms with the ability to lock the elbow in varying degrees of active flexion, and a terminal device fitted from the range already described. "Bite tabs" are used for elbow locking when the child is unable to operate a standard mechanism. Consideration is given to electrically powered prostheses along the lines already described for unilateral deficiencies (Fig. 4).

Distal deficiency

Distal longitudinal and transverse deficiencies pose a different problem in the sense that replacement of function takes priority over that of cosmesis in the early years, although the reverse may happen later. If a carpo-metacarpal joint is present, the rudimentary palm can oppose to a shaped plate mounted on a forearm gauntlet proximal to the wrist. Such a device may be made of plastic, leather or wire. The development of a simple plastic-coated wire device for holding a knife, fork or spoon has proved extremely successful for children (Fig. 5). By the very nature of

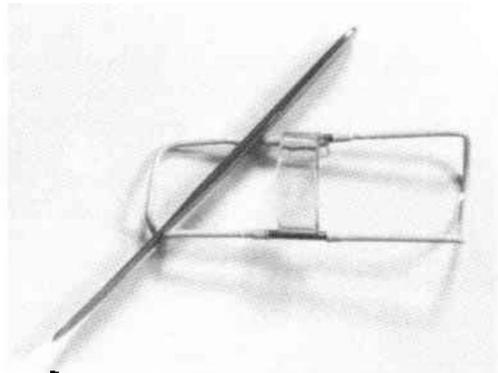
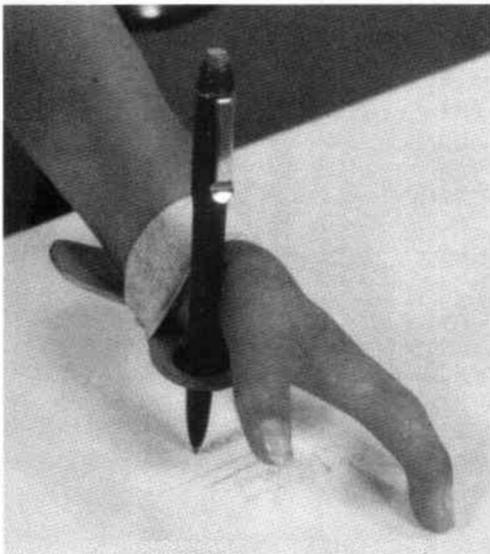


Fig. 5. Wire opposition device to hold knife or fork for hand deficiency.



(a)



(b)

Fig. 6. Opposition devices. (a) To hold cricket bat.
(b) To hold pencil.

distal deficiencies opposition plates have to be designed individually according to the function required and that already available. Much ingenuity is required to design simple yet

effective devices which can be provided for a variety of everyday activities — educational, social and recreational (Fig. 6). Cycling, holding a skipping rope, writing and holding musical instruments are examples. In some cases the OT may solve the problems by the provision of external aids and a wide range of these is available, such as adapted scissors, non-slip mats, special cutlery, and writing aids. Every encouragement should be given to enable the child to use the deficient hand in a normal manner.

Children's needs are changing constantly throughout childhood, and correspondingly their prosthetic requirements also change. Sometimes children choose not to wear a prosthesis for a period of time, but this can change very suddenly, so they should be reviewed in the centre periodically even when in "a non-wearing phase". Parents should always have access to the professionals when required.

Because the replacement of a hand is so complex, there is frequently a need to have two different types of prostheses at the same time to suit the varying activities in which children are engaged. No direct charge is made to the client for any limb prostheses provided by the National Health Service in the UK even though there is a higher cost in providing electrically powered prostheses. Thus no pressure is brought to bear on any member of the clinic team when selecting the most appropriate prosthesis for the child. It is essential for doctors, prosthetists and therapists to keep abreast of new developments both in hardware and techniques, in order to provide the best possible service to these children.

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