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A system of extension prostheses

H. J. B. DAY and J. WRIGHT

Artificial Limb and Appliance Centre, Manchester

Congenital lower-limb deficiencies, which have not been converted by amputation, usually present with shortening as well as deformity and joint defects.

It is normal practice to equalize the length by the use of a bootee, prepared from a cast, which is attached to a platform mounted above appropriate prosthetic components. In writing the prescription for the prosthesis (Fig. 1), consideration must be given to the ability of the limb to bear weight, and the range of movement, power, and stability of the joints. Partial relief is provided by a thigh corset whilst full weight relief will require ischial support. The provision of either type of corset will suffice to control lateral instability of the knee. Some restriction of knee movement may require alteration in the normal alignment of the prosthetic joints and/or the provision of locks, whilst gross restriction of movement or ankylosis of the knee in a limb which cannot bear full weight calls for solid side bars joining the shank to the thigh corset. The bootee, especially if made of soft leather, provides comfort but is not particularly efficient at transferring force to the prosthesis, and does not give a good cosmetic result.

This project was intended to investigate whether the bootee, together with any outside container or supports, could be replaced by a laminated plastic socket which might improve both the efficiency and the appearance.

The major problem is that the shape and size of the foot deny access to a rigid total-contact socket. The simplest way of overcoming this difficulty is to use an "access trap" as in the Canadian Syme's prosthesis (Foort, 1956). This can be used only when the foot is narrow as in absence of the fibula. (Longitudinal Deficiency: Fi—complete; Ta—partial; MT complete 4, 5; Ph complete 4, 5 (Kay, 1974)).

All correspondence to be addressed to: Dr. H. J. B. Day, Artificial Limb and Appliance Centre, Withington Hospital, Cavendish Road, Manchester M20 8LB.

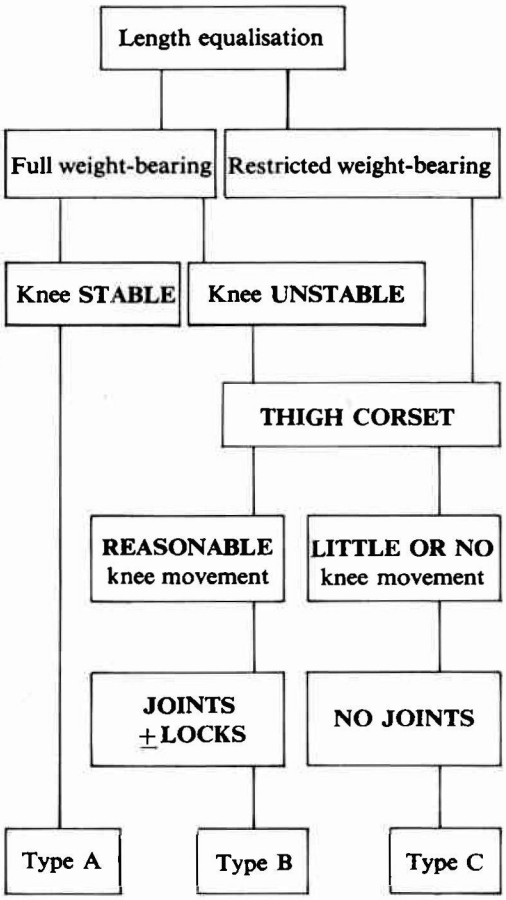

Fig. 1. Prescription scheme.

This is a Type A case and, whilst conversion by amputation is usually desirable, many parents refuse or wish to defer operation until the child is older. A socket is made with a posterior aperture which allows the heel to protrude while the toes and forefoot are gaining access to the front of the socket (Fig. 2). The aperture is closed with a rigid cover held in place by

Fig. 2. Access trap socket.

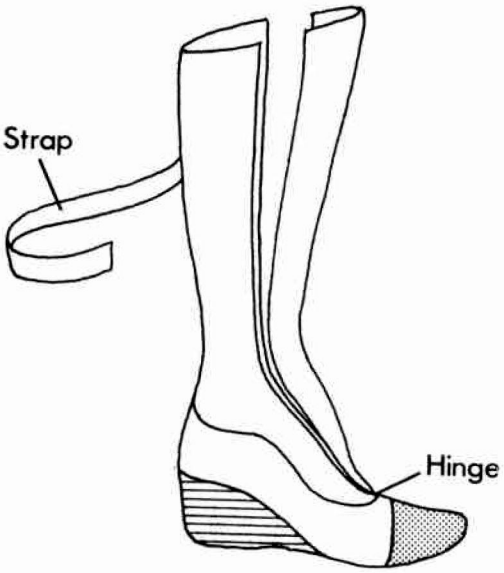

Fig. 3. Hinged split socket.

elastic straps. The socket is mounted at an appropriate height on a wooden foot incorporating a wedge-shaped heel cushion and felt toe piece. This type of prosthesis has been fitted to five children, all of whom have been wearing it for more than three years. A similar approach has been used in three cases of proximal femoral focal deficiency, but in these the sockets are longer, giving ischial support, as required in Type C cases.

The "Access Trap" method is not suitable when the foot is of normal size and will not enter a rigid socket unless the brim can be opened. This can be achieved in two ways. In the first, almost the entire front of the socket is made detachable. The second and, in our view, the more desirable method is to split the socket down the sides and hinge the two halves together at the toe. The posterior half which includes the plantar surface of the socket is mounted on the foot. The socket is opened to allow the foot to gain access and a strap or elastic is used to hold the socket closed round the leg (Fig. 3). This technique was also used for a girl of 12 years who had an amputation of the forefoot and shortening of the leg due to multiple tibial fractures. When wearing a surgical boot, her function was excellent but the appearance ungainly. The circumference of the hind foot was considerably larger than that of the leg below the knee. A socket was made incorporating a hinge distally and cut down the sides.

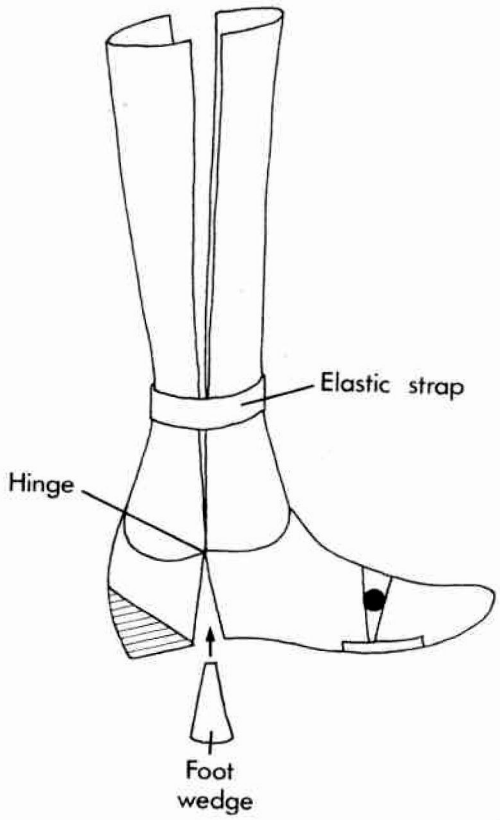

Fig. 4. Hinged split socket with wedged foot.

This was mounted at the correct height on a foot from which an inferior wedge was removed (Fig. 4). The socket opened for insertion of the leg and the wedge was then replaced under the foot and a normal shoe was worn. An elastic strap round the socket completed the prosthesis. Because her leg, even in the socket, was smaller than the sound leg, a more recent version has been built up with Plastazote to improve the appearance. This patient has been wearing this type of prosthesis for six years with complete success.

A similar technique has been used in a Type C case of a boy with a congenital absence of the forefoot, ten inches (250 mm) of shortening, and the knee ankylosed in 40 degrees of flexion. He had worn an extension prosthesis consisting of a platform-mounted leather socket attached to a thigh corset by rigid side steels. Access to a total-contact rigid socket is prevented more by the flexed knee than by the size of the hind foot. A split socket, hinged distally, has provided him with a prosthesis which is lighter, easier to don, and cosmetically more attractive. In this case the anterior half was attached to the limb structure.

The Type B case, using a socket attached to a thigh corset by jointed side steels, presents another problem. If the foot is narrow the posterior "Access Trap" method can be used, but the hinged type of socket, which would appear to be indicated for a normal-sized foot, cannot be used because a complete rigid brim is needed to provide a strong attachment for the jointed side steels. Instead, the proximal part of the socket is enlarged sufficiently to allow passage of the foot in conjunction with a posterior access trap lower down (Fig. 5). A separate inner liner is inserted into the top of the socket after donning the prosthesis in the manner of the KBM or Fillauer wedge (Kuhn, 1966 and Fillauer, 1968). So far experience of this type is limited to one case, but will be extended in the near future.

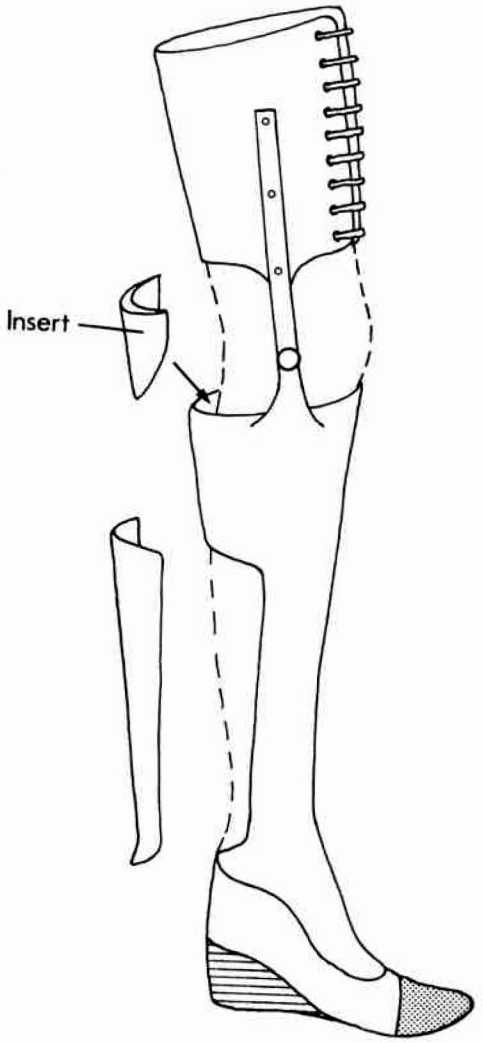

Fig. 5. Access trap socket with thigh corset, joints, and insert.

Selection of Type of Prosthesis

The first step is to decide, by examination of the patient, which of the three basic prescriptions A, B, or C is required. This information, together with an assessment of the foot size, allows the most suitable type of prosthesis to be chosen from the table shown in Figure 6.

Measurement

Measurement and cast-taking follow standard practice. The cast is taken over a tailored stockinette cast sock and a positive model is poured. This is modified as necessary to provide relief for any bony prominence and rectified for patellar-tendon-bearing if considered necessary. A wool sock is applied to the positive cast and a plaster check socket is made from this. The patient is given a trial fitting using the check socket in order that:

(a) it may be established, in cases where doubt exists, whether an access aperture or a hinged socket is appropriate;

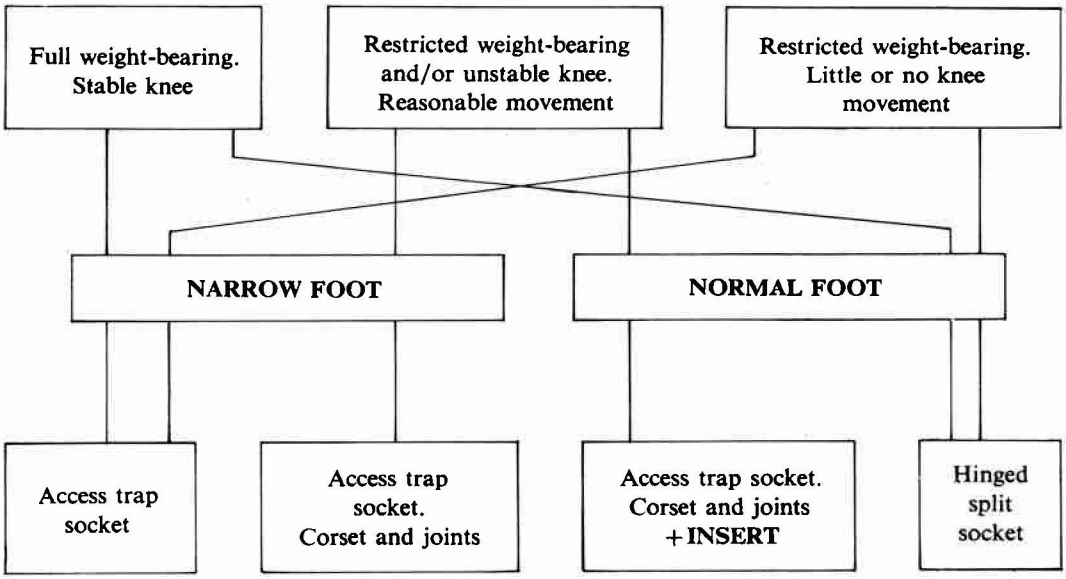

Fig. 6. Table for selection of correct prosthesis.

(b) the size and position of the access aperture may be found and reinforcement of the socket planned;

(c) a static alignment may be obtained;

(d) fitting alterations may be made, if necessary.

A positive model is made from the check socket. At this stage a further negative cast may be taken for record purposes, as the positive model will have to be broken out of the plastic socket.

Fabrication Technique

Access trap sockets. In general, the fabrication is similar to that of the Syme's prosthesis. In certain cases of proximal femoral focal deficiency, an anterior position of the trap may be preferred, and in all cases the trap covers are retained by elastic and Velcro fastening.

Hinged socket. The fabrication of this type of socket is unusual owing to incorporation of a hinge. The method is to lay-up on the positive cast:

Wool sock
PVA sleeve
2 nylon stockinette sleeves
3 layers of tubular glass cloth
1 or 2 polypropylene strips as a hinge
3 layers of tubular glass cloth
2 nylon stockinette sleeves.

A mixture of flexible resin and white pigment is stippled into the hinge area. Spread of the mix beyond this part is prevented by masking. The lay-up must be thoroughly impregnated and the resin allowed to gel. The masking is removed and a full-length PVA sleeve applied. A mixture of 80 per cent rigid and 20 per cent flexible resins with pink pigment is poured and allowed to cure. Surplus resin at the distal end is cut or sanded away until the white flexible resin is visible. The socket is then cut down the medial and lateral aspects as far as the hinged area.

Prosthesis with thigh corset. The heel-instep diameter of the cast is taken, and the posterior aspect at mid-patellar-tendon level is built up to the same measurement.

Extra reinforcement is required in the lay-up medially and laterally at the site of the knee-joint attachments. An insert is shaped to fill the space between the leg and socket posteriorly, and this incorporates the clip which holds in position the posterior access cover.

Results

Sixteen children and two adults have been fitted with these prostheses. Follow-up ranges from six months to seven years and all but two patients prefer the new type. Because of growth the children have required replacements and

altogether 103 prostheses have been made. Of the fourteen patients who had worn conventional appliances previously, six no longer need a thigh corset because of the improved stability provided by the rigid socket.

Summary

It is suggested that three basic types of extension prostheses are required as shown in Figure 1. Four methods of achieving these prescriptions using rigid, total-contact, polyester laminate sockets have been described, and the table (Fig. 6) indicates the correct method to be used for each type. These prostheses have proved very durable and repairs have been limited to replacing the straps and foot coverings.

Advantages claimed are improved comfort, efficiency, and appearance, in addition to speed of fabrication and lightness when compared with conventional prostheses.

Acknowledgements

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