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Technical note

An alternative design of extension prosthesis

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Abstract
Some patients with a congenitally shortened lower limb can be fitted with a total contact socket of one piece construction, dispensing with the need for removable panels or split socket construction. This gives advantages in weight, strength and cosmesis. The technique is described and compared with those conventionally used.

Introduction

The provision of a prosthesis for a patient with a congenitally shortened lower limb frequently presents more problems than that for the more commonly encountered amputee. The presence of a reasonably normal foot, although capable of load bearing, may give special difficulties. Often the proximal joints are inherently unstable and will require the support of a total contact socket, yet the relatively large foot produces problems of access to such a socket.

Socket design criteria

a) If the foot can take weight on the heel pad and also on the heads of the metatarsals, then suitable areas in the socket should be provided to preferentially stress them. The unstable proximal joints will require the general support of a total contact socket to maintain alignment.
b) The foot will usually be held in an equinus position within the socket. A system of forces must be provided to hold the heel pad on its seat.
c) Provision must be made to allow the foot to gain entrance to the socket yet retain the support of total contact.
d) Since ankle movement will be lost within the socket an attempt must be made to provide this function prosthetically.
e) The appearance of the finished limb must be acceptable cosmetically especially when fitted to the young and socially active.
f) The limb must be durable without being excessively heavy.

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Conventional extension prostheses

The patten ended orthosis

This device consists of a metal "rocker" attached to the shoe by two or more struts. The foot is held plantar grade by the shoe, a Knee Ankle Foot Orthosis may be used to provide support for the proximal joint (Fig. 1, left).

While function is acceptable, cosmesis and weight are not.

Internal shoe extension

A leather boot is used to secure a raised heel under the patient's foot. This boot then fits securely into his own shoe. The foot is held in equinus, bearing weight on the heel and metatarsal heads.

Access is achieved through a laced front section which, when secure, will maintain the foot in position supporting the proximal joints.

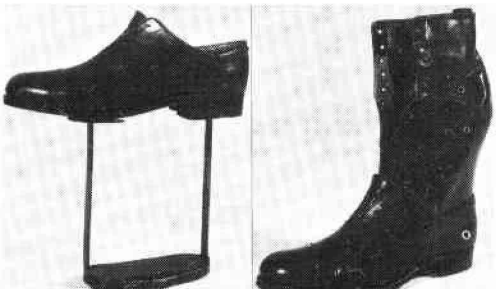

Fig. 1. Left, patten ended orthosis. Right, internal shoe extension.

Cosmetically the device is reasonable, but since the material of construction will deform, it is lacking in function and strength (Fig. 1, right).

The panelled socket

This is a total contact device manufactured in glass fibre reinforced plastic. It contains the shortened limb up to the level of the knee with careful moulding around the tibial crest to control rotation.

The rigid material and close fitting construction does not allow easy access. To permit this, an aperture is cut in the side of the socket allowing the foot to pass the narrow region and then locate in the distal portion. The cut out panel is then secured in position by a strap, so producing total contact and positive suspension.

Normal load-bearing areas of the foot are used, with the foot held in the maximum possible degree of plantar-flexion. This facilitates good cosmesis since the profile of the foot can be fitted inside a shank of normal dimensions. Ankle movement is simulated by a prosthetic foot of S.A.C.H. design. Cosmesis is good and function is excellent (Fig. 2, left).

Strength and durability are compromised by removal of the panel as loss of material weakens the structure. Higher stresses are experienced at the edges of the aperture, which can lead eventually to failure. Extra material may be used to increase the strength, with a consequent weight penalty.

The split socket design

Functionally this device behaves exactly like the panelled limb. The load-bearing areas in the socket and the positioning of the foot are the same, as is the material of construction.

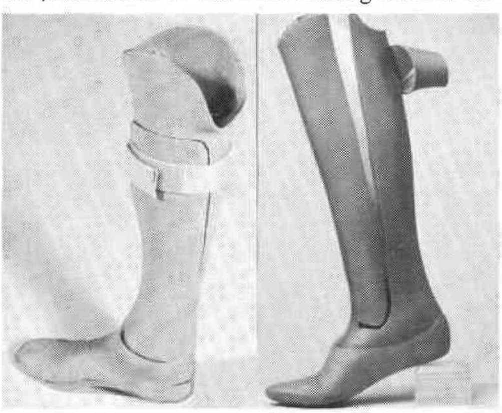

Fig. 2. Left, panelled socket extension prosthesis. Right, split socket design.

Access is gained by splitting the socket from the proximal brim down the medial and lateral aspect to a hinge at the distal end. When donning, the anterior shell is pulled away from the posterior shell and the foot inserted. The two halves are secured by a strap (Fig 2, right).

Strength is compromised by cutting the socket, and weight increase may be necessary to maintain strength.

An alternative design—the flexi-liner socket

Design

By continuing the use of glass reinforced plastic, but in the form of a conical one piece socket, the strength of the structure, can be greatly increased thus decreasing the weight.

Total contact fit is attained by using a soft flexible liner. The internal profile matches that of the limb remnant while the external profile matches the socket (Fig. 3).

When donning the device the patient first pulls the liner on to the limb and then pushes the liner and contained limb into the rigid socket. Entry to the soft liner is eased by two or more vertical cuts corresponding to the narrowest part of the limb. Once fitted these splits close regaining total contact.

Load-bearing areas in the socket remain as previously described, prosthetic foot construction is also unchanged.

Manufacturing technique

The liner is manufactured directly to a modified plaster cast of the affected limb and is moulded from P.E. Lite. Successive thicknesses are built up until the outer profile appears conical, the smallest circumference being distal.

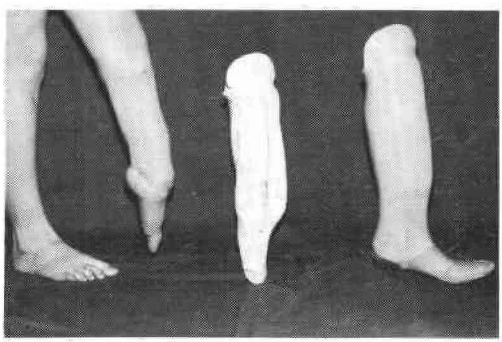

Fig. 3. The flexi-liner socket.

The cross-sectional profile should not be circular so as to provide positive resistance to rotation within the prosthesis or outer rigid socket. The outer rigid socket is manufactured in glass fibre over the outside of the finished liner using conventional techniques. The socket is then attached to the S.A.C.H. foot ready for dynamic alignment. The final exterior limb profile can now be shaped using filler material and completed by a second lamination integral with the foot.

Conclusions

Since changing to this method of construction the author has recorded a reduction in mechanical failures in extension prostheses. Weight has also been significantly reduced. Patient comments on cosmesis are encouraging. They also report an increase in overall comfort. The results to date would appear to indicate the usefulness of this technique.

FURTHER READING

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