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Modular assembly above-knee prostheses*

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Introduction

The main aim of a modular system of assembly is to provide functional prostheses to the patient faster and more easily than has been possible up till now.

The waiting time in the past could extend to periods of months for completion of a prosthesis, when there was a heavy demand on the service.

The ideal modular lower limb assembly prosthesis, as has been agreed at the many conferences on the subject (Cosmesis and Modular Limb Prostheses, 1971; Lower Limb Modular Prostheses, 1973; Standards for Lower Limb Prostheses, 1978), would also have the following advantages:

(1) Possibility of alignment adjustments throughout the effective life of the prosthesis.
(2) Simple change of components to give flexibility in prescription.
(3) Easy disassembly of components permitting rapid replacement of worn or damaged parts.

The first requirement, that of alignment, has not been accepted by all manufacturers; two systems which come to mind—those designed by Hosmer and United States Manufacturing Company—require the alignment device to be removed after completion of dynamic alignment. Other systems such as Blatchford and Otto Bock have the alignment facility as part of the final structure. When looking at the other two advantages of the supposed ideal modular prostheses, it would seem that the systems which are designed with built-in alignment devices are at a distinct advantage.

Most of the following comments will be directed to four systems which I have been involved with over the last six years—two of which have built-in alignment systems and two which transfer-out the device.

The systems are the Blatchford or British system; Otto Bock, West Germany; Hosmer and United States Manufacturing, both designed and manufactured in the United States of America.

These systems have been the subject of an evaluation programme (Solomonidis, 1979) and, for the last three years, Blatchford and Otto Bock prostheses have been regularly supplied to patients in our clinic.

Prostheses for the above-knee amputee have always tended to be rather heavy and it was confidently expected that modularization would ease this but any gain has been minimal.

An interesting feature emerged when the weights of the completed systems were recorded; it has been argued long and often that a weight penalty would be incurred by leaving the alignment device in the finished structure, in fact the two systems which had the alignment devices as part of the structure, proved to be considerably lighter.

Blatchford	2.90 kg. to 3.65 kg.
Otto Bock	3.30 kg. to 3.50 kg.
Hosmer	3.65 kg. to 4.45 kg.
U.S. Manufacturing	3.70 kg. to 4.73 kg.

The conventional prosthesis worn by the patient taking part in the series—which included all-metal limbs—ranged from 2.5 kg. to 4.04 kg.

It would seem then, that in the present state of design, to have the alignment facility as part of the structure gives two advantages; less weight and a reduction in the manufacturing process.

Before the introduction, in the 1950's of the adjustable leg which was designed at the University of California, Berkeley, the fitting

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and alignment of conventional limbs could only be achieved with considerable difficulty. The adjustable leg constituted a significant improvement on conventional fitting methods, in that it allowed the prosthetist to make easy changes in alignment, while observing the patient's gait. On completion of alignment, the adjustable portion was transferred out and replaced by a conventional knee and shank.

The introduction of modular assembly prostheses has assured alignment capability as a standard feature, whether the alignment unit is a permanent part of the structure or not, this in itself is a tremendous step forward.

While the time spent by the prosthetist on alignment has not necessarily reduced with these aids, there is no doubt that greater alignment accuracy has been made possible. Some of the alignment systems are somewhat awkward to handle, although one can adapt to them in time.

The Otto Bock arrangement which has alignment capability at two levels, below and above the knee, is particularly useful from the prosthetist's point of view—and when used in conjunction with the static alignment apparatus, makes this a very satisfactory combination. The use of the static alignment apparatus makes bench alignment so accurate that only a minimum of adjustment is required during the dynamic stage. This is perhaps something that other designers may consider with a view to reducing the size and weight of alignment couplings.

Socket shape and manufacture has not changed a great deal as a result of modularization, but the method of attachment to the knee units vary to some extent.

The Blatchford system was originally designed with metal sockets in mind hence the duralumin struts (Fig. 1), perhaps if plastic sockets had been standard, as surely they will be in the near future, this may have influenced their design. Blatchford have also designed an attachment to accommodate plastic and wood sockets but in many cases this arrangement does not allow close enough access to the knee centre. This is not necessarily wholly the fault of the prosthesis, as many above-knee stumps are fashioned without knowledge of prosthetic design and are as a result too long. Given a better shaped stump many of the so-called design faults would disappear, with benefit all round.

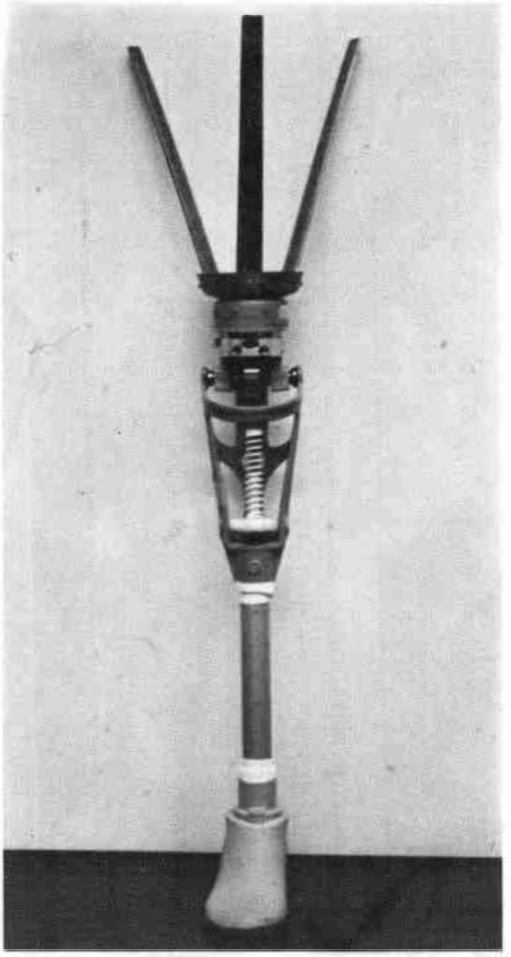

Fig. 1. Blatchford modular assembly prosthesis showing duralumin struts for socket attachment.

The other feature which makes modular assembly prostheses so acceptable is the availability of different knee mechanisms. Some systems are far more complete than others in this respect and have units which can cater for almost any eventuality. As far as the prosthetist is concerned, the easier the exchange of knee mechanisms during the alignment procedure, the more acceptable is the system.

The ease of change of components makes it possible to try different prescription combinations and also to effect repairs very quickly, and as even a new socket can be made and instantly attached, it lessens the need for a second or spare prosthesis in many cases. This could lead to an overall reduction in delivery times to patients, one of the original aims of modularization.

Cosmetic restoration is one area which is presenting a lot of problems to designers—whether it should be one piece or two piece, soft or firm, etc. The cosmesis should not be too difficult to work with. If it is to be modular it should not take up too much technician's time to fashion it, and the final shape should approximate to the remaining leg (Fig. 2). It has been my experience that no matter the material, shape is the most important feature, although in a percentage of amputees softness is an added bonus.

Fig. 2. Otto Bock above-knee modular prosthesis with built-in alignment unit and one piece soft cosmetic cover.

Use of a one piece cosmesis is desirable but not at the expense of knee function; this, of course, is no problem with a large percentage of the elderly above-knee amputees who would use a fixed knee and a one piece cosmesis suits their needs. However, in the present state of development the one piece soft cosmesis is not totally adequate for the young active amputee, as regards to both function and to a greater extent, durability. There is no doubt, however, that these problems will be overcome in time.

The complete system should be able to cope with all levels of amputation, not all can do this at the moment. The adult hip disarticulation patient is adequately satisfied by some systems but children, who form a fair percentage of amputees at this level, cannot be easily fitted as there are no small sizes of socket attachment.

In conclusion, during the last two years our clinic and workshop have used modular construction for all above-knee prostheses; production can be satisfied with a small number of technicians and storage of components is not a problem as sources of supply are good. In general it can be said that modular assembly makes production possible in smaller, self-contained units so long as component supplies can be readily obtained. In this connection it makes for easier handling to have a system of ordering and pricing such as is available with the British and West German modular systems.

If one could get the ideal modular system, that is one which could satisfy the needs of all patients, production and storage would be easier still and smaller production units attached to clinics would be able to function quite satisfactorily.

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