Prosthetics and Orthotics International, 1979, 3, 147–149

Economics of modular prostheses*

A. STAROS

Veterans Administration Prosthetics Center, New York

Introduction

Some clarification is needed about the meaning of "modular" in prosthetics. To describe the endoskeletal modular prosthesis as simply "modular" is not fully correct. The crustacean (wood) *exoskeletal* array used for many years in above-knee limb construction was modular, at least in the assembly process. For this, a fitter or his technician took a knee-shank set-up, a foot-ankle set-up, and a socket and assembled these in a modular fashion. Each of the major elements was in fact a module. Nevertheless, the value of modularity was lost whenever replacement of individual components was required; it was quite difficult to replace a major component such as the knee-shank set-up in this system without re-making the whole prosthesis. The nature of the design, in wood finished with plastic laminates, prevented easy replacement.

Thus a particular significance to the modularity of current *endoskeletal* designs is associated with the quickness with which individual components might be replaced. This "plug-out, plug-in" capability simplifies servicing and maintenance of prostheses requiring either changes in function or replacement due to wear or failure.

Fitting with endoskeletal prostheses

The use of modular hardware in the endoskeletal above-knee prosthesis does not produce savings in prosthetist time; he or she is still required to cast the patient, design and conduct the fitting of the socket, and perform dynamic alignment at complexity levels no different from that used for exoskeletal systems. However, the technician, who in most facilities supports the prosthetist, will save time, especially if the modular system includes alignment devices incorporated within the prosthesis. Alignment transfers, shaping, and finishing are not necessary; assembly is quicker with no glued joints consuming waiting time. But any saving in technician time is approximately equal in value to the increment in initial cost of the modular hardware over the cost of similar wood exoskeletal components.

In the non-labour-intensive developed countries of the world, the choice between endoskeletal and exoskeletal designs offers no economic differentials, at least in the fitting and assembly processes. But, in the developing world, the procurement of the higher cost of "modular" metal hardware would be financially (and socially) unsound since use of labour-intensive methods is indicated for prosthesis production.

Repair and maintenance

Servicing the modern automobile would be an economic impossibility were it not for modularity. Local (neighbourhood) automobile servicing depends on persons who are not experts in rewinding generators or rebuilding transmissions but who can provide, through the modular approach, replacement of the defective part at that site; more specialized facilities may be involved in complex rebuilding tasks.

Thus it is primarily in the repair and maintenance that modularity may produce some economic advantages. The time of the people providing such service is saved, as is the very valuable time of the automobile user or the prosthesis wearer whose economic welfare is most likely very dependent on the quick availability of a functioning appliance.

All correspondence to be addressed to Mr. A. Staros, Director, Veterans Administration Prosthetics Center, 252 Seventh Avenue, New York, N.Y. 1001, U.S.A.

*Based on a paper presented at the ISPO International Course on Above-knee Prosthetics, Rungsted, November, 1978.

More complicated prosthetic systems may be expected in the future. In these there will be an increased need for special "fitting" considerations, particularly in the selection of the proper components for the prosthesis. An economic value from modularity during the initial fitting and assembly processes may then be realized but, with fitting practices today, the economic advantage in the use of modular systems comes solely in repair and maintenance.

Advantages of interchangeability

A very significant advantage can nevertheless be experienced in the prescription process today with one particular endoskeletal design; the multiplex system designed by the U.S. Manufacturing Company in response to a U.S. Veterans Administration standard. This unit permits an interchange, in the same metal shank, among different kinds of fluid knee controls as well as a special mechanical friction system. The dimensions (and angles) of the triangle in the antero-posterior plane formed by the knee axis, the top of the piston rod and the lower attachment of the cylinder have been standardized (Fig. 1). Manufacturers of the various units co-operated with the Veterans Administration in making their knee controls conform with this standard geometry.

This design permits quick interchange among these systems as prescription is contemplated. Since there are variations in the functions among the fluid controlled units, a trial with actual performance analysis can be quickly organized.

This system also typifies the advantage which will be evidenced when a fluid control malfunctions; replacement is very easy. The "plug-out, plug-in" possibilities when selecting rotators for prostheses should also not be overlooked; future designs will consider this.

On a subject not directly related to the main thrust of these comments, we have successfully experimented with the use of graphite fibre-epoxy composites to achieve weight reductions in certain prosthetic components. For example, the present aluminium multiplex frame weighs approximately 700 g. A graphite-epoxy frame weighs about 450 g. (Fig. 2). Models of these units are now being tried on patients.

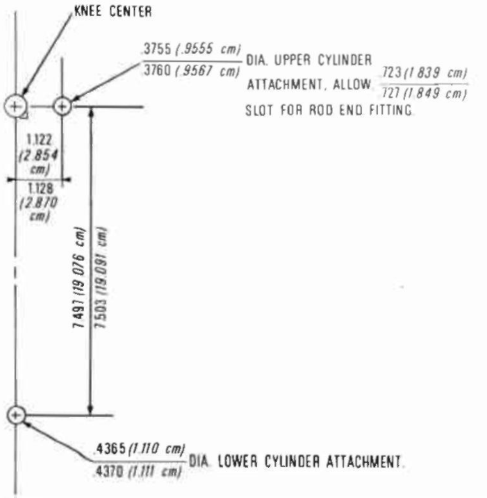

Fig. 1. Dimensions for fluid knee controls.

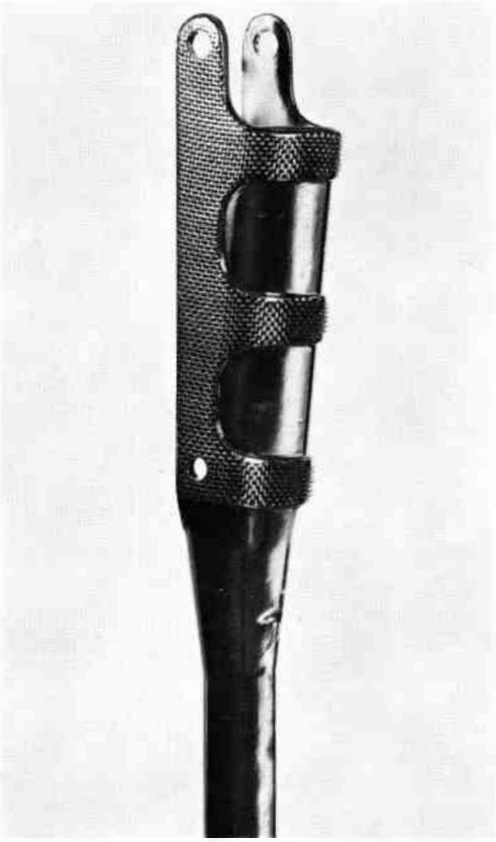

Fig. 2. Graphite composite multiplex pylon.

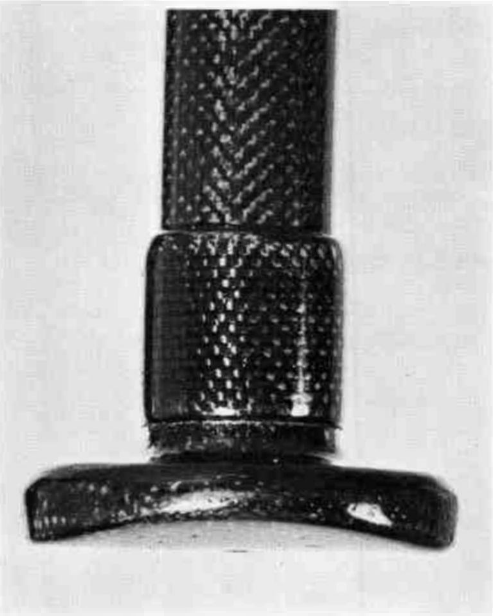

Fig. 3. Graphite composite rotator.

Graphite-epoxy is also being used in rotators (Fig. 3) and in the SACH foot keel; by this latter application the total foot weight can be reduced by about 20%, a significant functional gain at the end of the long lever that is the lower-limb prosthesis.