The Berkeley Endoskeletal Below Knee Modular System

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INTRODUCTION

Endoskeletal systems for lower limb amputees are increasingly used as a means of efficiently fabricating, aligning and finishing prostheses. Early work with pylon systems was done by Wheeler (1947) in an experimental prosthesis for Northrup Aircraft (1). Hammontree et al (1965) described a temporary pylon used as an early fit system for geriatric below knee amputees (2). Foort and Hobson (1965) revolutionized many of the concepts of below knee pylon systems by their development of a prefabricated receptacle system with alignment features built into the pylon at the socket and ankle levels (3). Goldner et al (1966) from Duke University used temporary plaster and plastic pylons as a preparation for fitting permanent above knee and below knee prostheses (4). Staros and Gardner (1969) presented the concept of direct forming of below knee sockets using thermoplastic materials. Adapting that technique, they utilized the United States Manufacturing Company's Adjustable Pylon System (5). Wilson (1969) detailed the existing pylon systems in a comprehensive overview of below knee prosthetics (6).

DESCRIPTION OF COMPONENTS

The Berkeley Endoskeletal Below Knee Modular System* (Fig. 1), or Berkeley pylon

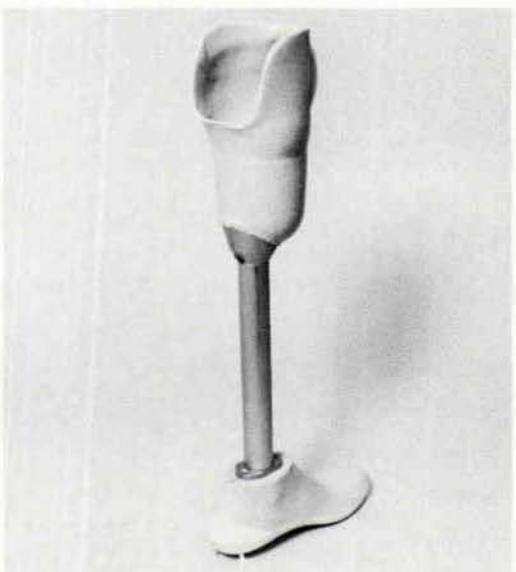

Fig. 1 – A below knee socket which has to be aligned on the Berkeley pylon and then finished with a reinforcing lamination.

is a vertical pylon alignment coupling and endoskeletal foundation for the below knee prosthesis. The Berkeley pylon offers a light weight, easy to fabricate and simple design pylon for use as a temporary or intermediate pylon. The Berkeley pylon was developed at the University of California at Berkeley, Biomechanics Laboratory under contract with the Veterans Administration. The Berkeley pylon may be used as a definitive prosthesis only if the system is duplicated from an aligned socket on an adjustable leg using standard prosthetic fabrication methods. The Berkeley pylon system can also be adapted to commercially available ankle rotators.

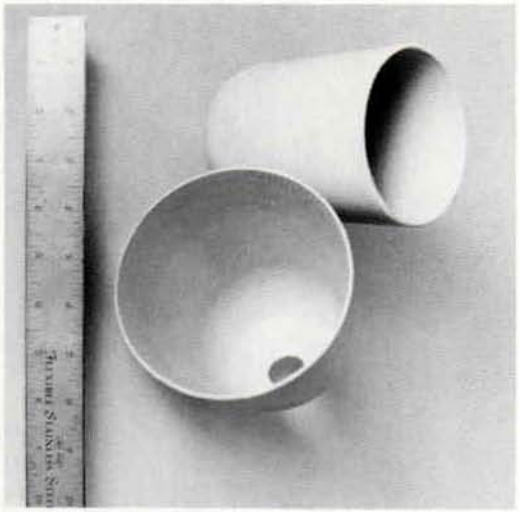

Fig. 2A – The flexible socket attachment cups are fabricated from polyester resin and come in two sizes.

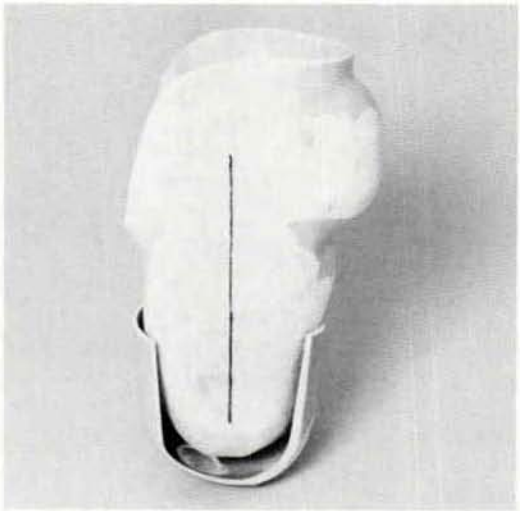

Fig. 2B – The socket attachment cup is heated, molded and trimmed to provide contact and then epoxied to the socket.

The Berkeley pylon weighs 18 ounces, and consists of five component parts:

- Socket cup
- Spherical alignment coupling
- Internal proximal clamping component
- Pylon tube - 1⅜" O.D.
- Internal foot clamping component

The socket cup is a receptacle for the below knee socket (Fig. 2A). The socket cup is heated to allow the below knee socket to be press fitted into the cup. The socket cup is available in two sizes, regular (4" diameter) and large (5" diameter). The semi-flexible cup is presently fabricated with nylon and fiberglass polyester laminate. When heated, the cup may be trimmed to adequately receive the below knee socket. A clearance space of ½" minimum (Fig. 2A) is necessary between the distal end of the socket and the cup when the pylon is used as a temporary or intermediate prosthesis. For a definitive prosthesis, the socket can be pressed into the bottom of the cup during essentially standard duplication procedures.

The spherical alignment (Fig. 3A and 3B) coupling attaches the below knee socket and socket cup to the pylon system via a coupling retainer and $^{5}/_{16}$" hex bolt, which passes through the posterior aspect of the coupling housing. The lower end of the spherical alignment coupling is called the Internal Proximal Clamping Component (Fig. 4A). The pylon tube slides over this assembly and is secured by tightening the hex bolt on the distal end of the clamping component using an extension socket wrench (Fig. 4B). The internal expanding tube clamp utilizes the full strength of the pylon to assure rigid connection. *Care must be taken not to over tighten the internal tube clamp. Optimal wrench torque is 15ft./lbs.*

The Internal Foot Clamping Component

Fig. 3A – The spherical alignment coupling allows angular adjustment by loosening the hexagonal bolt on the posterior aspect.

can be used with any wooden keel SACH foot (Fig. 5). The foot should be attached to the clamping component with a ⅜" -16 hex bolt and two wood screws to secure the assembly to the top of the foot. The foot is attached to the pylon by tightening the foot bolt (Fig. 5). *The Berkeley pylon system is designed for and requires a minimum of 5-½" between the bottom of the socket and the top surface of the SACH foot.*

INITIAL ASSEMBLY AND ALIGNMENT

Select the proper size socket attachment cup in which to fit the below knee socket. The upper edge of the socket attachment cup must fit snugly against the below knee socket. It is usually necessary to heat and trim the socket attachment cup to achieve this intimate fit. Scribe or draw an alignment center line on the posterior aspect of the

Fig. 3B – The serrated edges in the spherical alignment coupling that lock alignment adjustments in place.

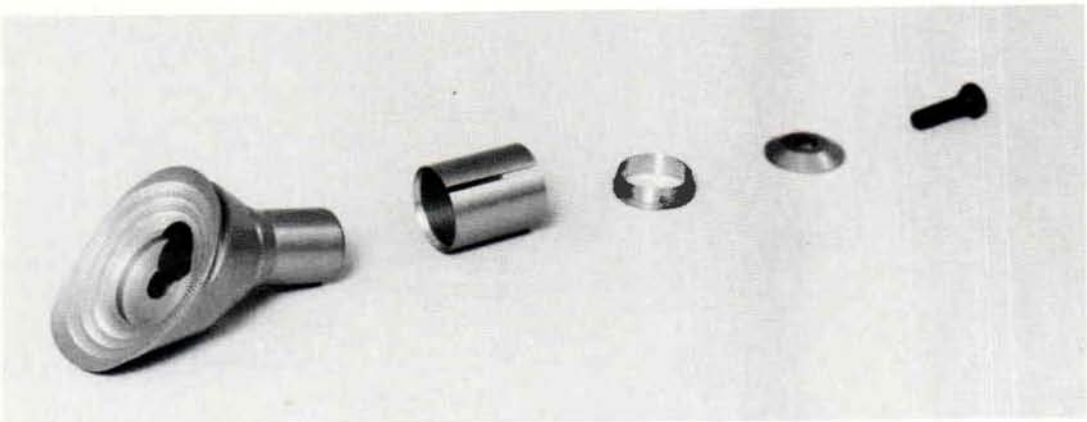

Fig. 4A – The internal clamping component. The pylon slips over this component and is held in place by the expansion of the component when the bolt is tightened.

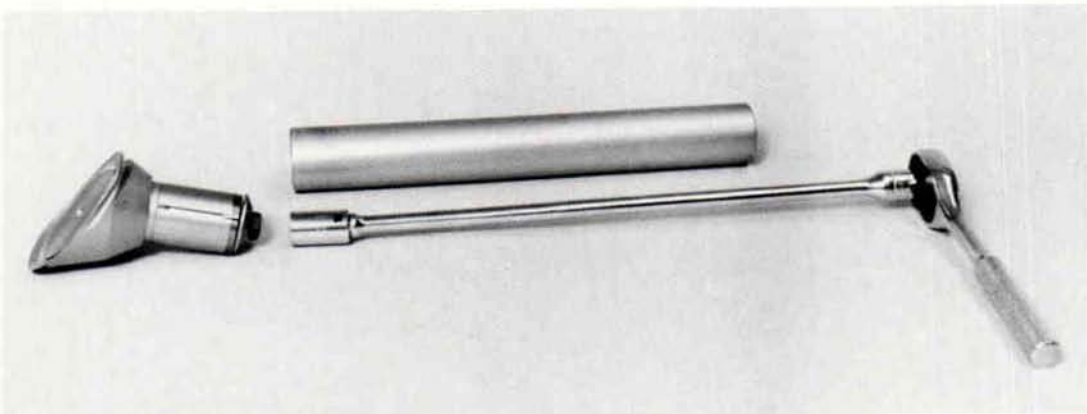

Fig. 4B – An extension socket wrench is required to reach in the pylon and tighten the bolt.

socket. This will allow the socket to be removed from the socket attachment cup and accurately replaced. Bond the socket to the attachment cup using epoxy or a similar adhesive.

Static alignment of the Berkeley pylon requires accuracy in negative impression casting and positive mold modification techniques for the best results. It is suggested that the negative impression casting techniques and prealignment lines described by Hampton (1965) in the "Northwestern Suspension Casting Technique" (7) be considered to aid in establishing angular and linear references prior to static alignment. Generally, if reasonable care is taken to establish good flexion and adduction angles, socket foot positioning with the Berkeley pylon is adequate for temporary and intermediate prosthesis designs. Basic dynamic alignment for temporary or intermediate prostheses is performed by loosening the alignment coupling retainer bolt and tilting the socket cup and socket to the new position. Changes in flexion or extension, adduction or abduction in tilt angles of $\pm$ 10° and unlimited rotation are possible. Exaggerated socket flexion/extension adjustments will affect the toe and heel levers. Similarly, adduction or abduction maneuvers will affect foot inset or outset. Changes in

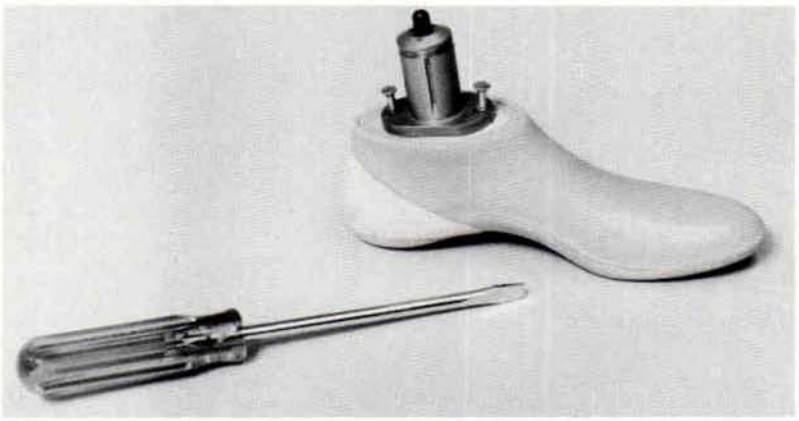

Fig. 5 – The internal foot clamping component functions in the same manner as the component on the spherical alignment coupling. There must be a minimum of 5½" between the distal socket and the top of the foot to use this system.

these angles are enhanced by the socket attachment cup's 30° angle attachment to the alignment coupling. If radical angle changes are performed and unwanted lever arm conditions are encountered, the socket can be loosened from the socket cup and repositioned to accommodate the situation. When precise alignment of the prosthesis is required, it is suggested that the prosthesis be aligned on the V.A.P.C. adjustable pylon and the Berkeley pylon be duplicated into position during finishing. All adjustments are made prior to the final lamination as a lamination tie off groove will permanently fix the socket attitude when the final lamination is performed.

The following guidelines should be followed when adjusting the pylon:

1) Mark initial position of the alignment coupling by a pencil ring mark on single piece alignment coupling to adjust the Berkeley pylon.
2) Loosen the alignment bolt if angular adjustments are required after walking trials. Make the alignment change and tighten the bolt.
3) Adjustments should be made as viewed from the rear. A space of ⅛" represents an angular change of three degrees (Fig. 6).

FINAL ASSEMBLY AND FINISHING

The finishing technique for the Berkeley pylon involves procedures that are generally used in other pylon systems. Certain steps are necessary to insure proper results:

- Scribe an alignment line on the posterior aspect of the socket. This will allow the socket to be removed from the cup and replaced accurately (Fig. 7A).

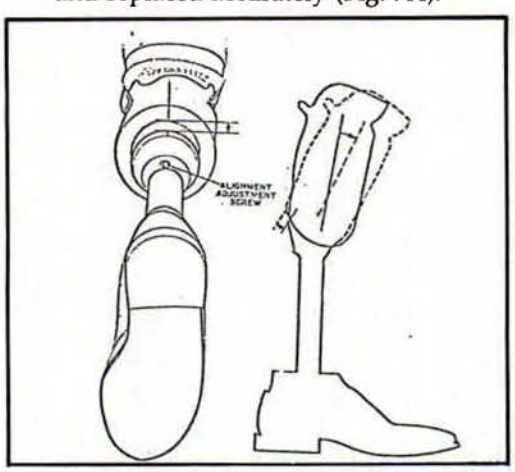

Fig. 6 – Angular adjustment of the socket is made by loosening the alignment adjustment skrew. Ten degrees of rotation are available in the sagittal and frontal planes. Unlimited rotation is available. The 30° set angle to the pylon enhances the effect of the angular adjustments.

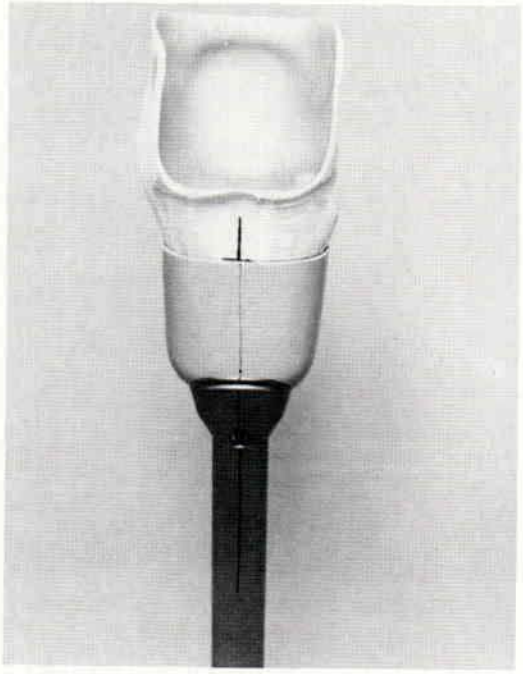

Fig. 7A – Permanent fastening of the socket to the attachment cup. Mark the alignment and remove it from the socket by breaking the temporary bond used for alignment.

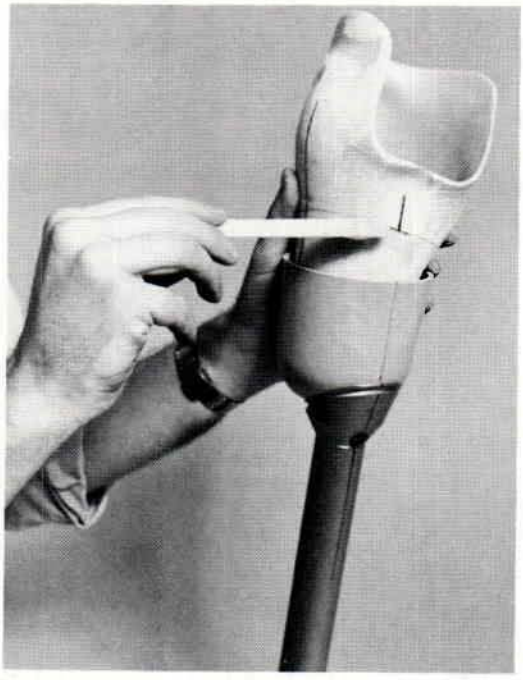

Fig. 7B – Rough up the socket and the attachment cup and epoxy all surfaces. Replace the socket.

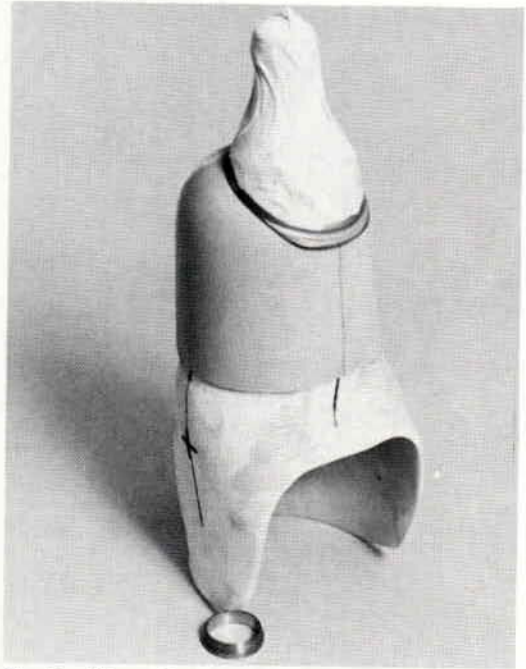

Fig. 8 – All machined surfaces are protected from the laminating resin.

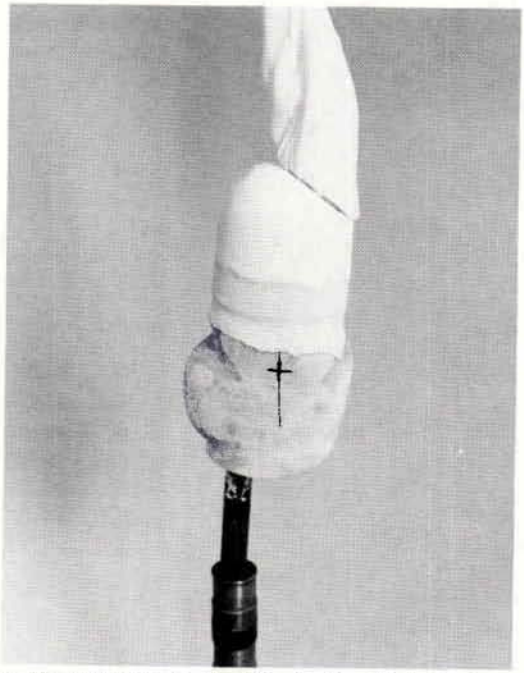

Fig. 9 – Layup for the final lamination. Nylon is staggered on the socket and pulled into the tieoff groove with wire.

- Sand the inside proximal edge of the cup and the socket for good bonding. Apply epoxy bond (Epibond) or suitable adhesive resin to the spherical alignment coupling retainer inside the cup and bond the socket to the cup. Replace to alignment lines previously described (Fig. 7B).
- Mark the toe-out position before removing the pylon system from the socket-coupling assembly. The base of the foot coupling should be permanently attached to the foot with two wood screws, as well as the ⅜" bolt provided with the foot.
- All loose parts are removed from the socket-coupling system for final lamination. All machined surfaces are masked off (Fig. 8). *Do not remove the alignment coupling retainer bolt for final lamination.*
- Pull one layer nylon stockinette over the socket-coupling until the leading edge is ½" above the cup socket joint. Pull the second nylon stockinette layer over the first layer until the leading edge is ½" below the cup-socket joint (Fig. 9).
- Important: Secure the two layers of stockinette into the tie off groove with three or four wraps of lockwire (type 302 temper soft stainless steel, 0.20" diameter).
- Reflect the second nylon back and trim at 1" below the cup socket joint, then reflect the first layer back over the brim of the socket and laminate as usual.

PROSTHETIC FOAM COVER

For a definitive prosthesis a soft foam cover will be applied to the pylon and the socket. For a smooth transition between the foot and the foam cover, the following steps provide a simple method to achieve this result:

- Measure the approximate length of the foam cover from the top of the foot to the upper boundary on the socket.
- Wrap the upper boundary of the socket with lead wire to determine the shape of the entry to carve inside the foam cover.
- Insert the socket-pylon system into the foam cover. Check the socket attachment for tightness and attach the foot as per previous instruction.
- Fit the foam cover to the socket and to the foot (Fig. 10). Sculpture the foam cover as desired beveling it into the foot and the socket leaving minimal transition lines.
- Apply cosmetic hose or suitable cosmetic cover over the sculptured prosthe-

Fig. 10 – Foam cover shaped over the Berkeley pylon.

sis. In some finishing techniques, resin is used to bond the socket brim and cosmetic hose together at the ½" brim line. The location of suspension cup studs are coated with resin to prevent stockings from running.

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4. Research Director for the United States Manufacturing Company

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*Available from the United States Manufacturing Company.