

Scotchcast® P.V.C. Interim Prosthesis for Below-Knee Amputees

YEONGCHI WU, M.D.^{ab}
 MICHAEL D. BRNCICK, C.P.O.^b
 HAROLD J. KRICK, C.C.T.^a
 TIMOTHY D. PUTNAM, M.D.^a
 JOSEPH S. STRATIGOS, M.D.^a

^aVeterans Administration
 Lakeside Medical Center,
 Chicago, Illinois 60611

^bRehabilitation Institute of Chicago
 Chicago, Illinois, 60611

Adoption of newly available materials and knowledge, through trial and error experiment, sometimes can result in an increase of productivity as well as improvement of quality. This is often true in industry in general, and can also be true in the prosthetic field. This paper describes a fabrication system combining many widely used techniques (2,4,5,6) and accepted principles (3) and a few new time-saving approaches in making a below-knee interim prosthesis. Using this approach, a skillful prosthetist can fabricate an interim prosthesis in less than 2 hours.* The goals are to improve service to new amputees by speeding provision of interim prostheses and reducing visits to prosthetics facilities. These techniques can also increase the productivity of prosthetists.

Details of the Procedure

A. Making the PTB Socket

1. When the residual limb is healed and no longer edematous, (though further shrinkage will be expected from weight-bearing exercise) usually two to three weeks after surgery, a tube sock (with the elastic band removed) is worn over the residual limb. A tube sock is similar to an athletic sock but without a shaped heel, and is commercially available at low cost at many department stores. Patches of cotton padding, three layers thick and tapered at the edges, are applied over the bony prominences of the tibial tubercle, the tibial crest and the fibular head. Eight to ten layers of tapered cotton padding are also used over the distal end of the tibia (Fig. 1-A). The cotton padding, differing from the felt used in the immediate postsurgical fitting (IPSF) (1), is used as a "spacer." It will be removed after the PTB socket is made to provide graded pressure relief over the bony

*The "less than 2 hours" refers to direct fabrication time only, and does not include travel to and from the hospital, patient evaluation, subsequent adjustments, or overhead activities such as billing and bookkeeping.

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Please address reprint requests to Yeongchi Wu, Research Department, Rehabilitation Institute of Chicago, 345 East Superior St., Chicago, Illinois 60611. A videotape which supplements the text is also available. Tape may be obtained directly from Dr. Wu at the above address, or by writing to the Editor, Bulletin of Prosthetics Research, VA Office of Technology Transfer (153D), 252 Seventh Ave., New York, N.Y. 10001.

prominences, as was used in the removable rigid dressing technique (5,6).

2. Cover the tube sock and the cotton paddings with a 5-ply wool stump sock to a level above the knee. Mark on the wool sock the patella and the trim line of the socket to be made.

3. Apply a strip of 10-cm-wide Scotchcast tape (by 3M Co.) or similar casting tape, longitudinally around the stump starting from the patella, down over the tibial tubercle and the tibial crest, and turned under the distal end and upward to the popliteal trim line. This strip provides a smooth inner surface of the socket over the bony prominences. After this longitudinal layer, apply the rest of the Scotchcast tape evenly over the entire stump following the routine bandaging technique. Exert moderate manual tension to the Scotchcast tape to ensure firm adhesion between the layers. Cut along the postero-medial and postero-lateral corners, so that a flared posterior edge can be formed by asking the patient to flex the knee.

4. While waiting for the Scotchcast tape to set, manually apply extra pressure between the posterior wall and the patellar tendon area to form a PTB bar and control A-P diameter for weightbearing. After the tape is set, in about 10 minutes, remove the socket, cut along the trim line, and fold the wool sock outward for a smooth edge (Fig. 1-B).

B. Determining the "Axis" and "Height" of the Socket (Fig. 2)

The patient is then asked to wear his usual sock and shoe on the remaining foot, and two to three tube socks and the socket (with cotton padding removed) on the residual limb. He then stands in the parallel bars with the bottom of the slightly flexed socket resting on a padded adjustable automobile jack. The jack is adjusted until the anterior superior iliac spines are even. The patellae and the patient's subjective feeling are checked. While bearing full weight, the patient adjusts the socket axis to the most comfortable position. Then, the end of a small spirit level is attached with putty to the lateral surface of the socket, and adjusted so that the air bubble is maintained in the center (Fig. 2,3). In addition, another spirit level is attached to the anterior wall, leveled, and is adjusted so that its long axis is parallel to the line of progression. A mark, arbitrarily 18 inches from the ground for adult males, is made on the wall for control of the height of the socket. The shoe on the remaining foot is traced on cardboard or heavy paper.

C. Assembling the Pylon-Foot-Shoe Unit

For the pylon unit, 1½ inch inside diameter, thermoplastic polyvinyl chloride (PVC) pipe is used. The pipe is softened on one end with a heavy-duty hot air blower (heat gun), then snugly fitted to the metal plug attached to the top of the SACH foot. The junction of pipe over plug is further reinforced with a hose clamp. The proximal end of the PVC pipe is then sliced longitudinally (preferably to small holes as crack-stoppers) into four sections, softened, and bent outward into X-shaped bars. The height of the pylon-foot-shoe unit is now slightly lower than that of the adjusted jack (Fig. 3).

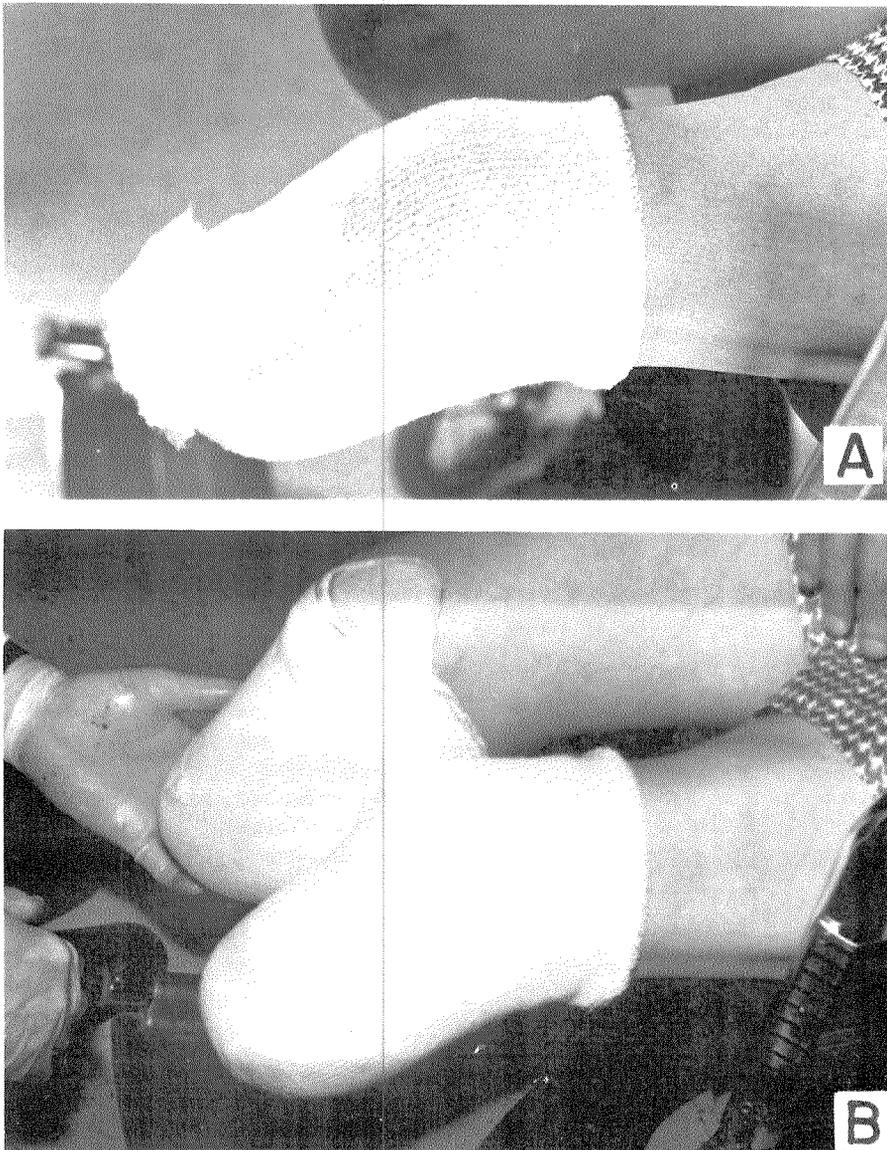


FIGURE 1.
Application of cotton padding (A)
for casting the Scotchcast PTB
socket (B).

D. Alignment of the Socket and the Pylon-Foot-Unit (Fig. 4)

1. Sketch a prosthetic shoe print symmetrical about the axis of progression to the tracing of the shoe on the remaining foot (Fig. 2). Identify the "alignment reference center" at the junction of posterior and middle thirds on the longitudinal axis of the prosthetic shoe print. Place the print on the work table of a vertical alignment fixture, so that the "alignment reference center" is under the plumb line (on the alignment axis) (Fig. 5A.) Place a thumbtack to fix the "reference center" to the work table top. This permits turning the cardboard (Fig. 5B) if needed for adjustment of degree of toe-out without displacing the alignment reference center.

2. The following steps are then taken to position the wool-sock-lined socket in the clamp of the alignment fixture:
 - a) adjust the mediolateral tilt until the bubble of the lateral spirit level is centered;

- b) adjust the socket flexion according to the anterior spirit level;

- c) adjust the height so that the mark on the socket wall is 18 inches from the table top (Fig. 2,5C);

- d) determine the "center" of the socket at the midpoint of the AP axis from the center of the PTB bar (Fig. 4);

- e) adjust the clamp and socket so that the vertical plumb line (alignment axis) points at the "center" of the socket (Fig. 4,5B); and finally,

- f) if necessary, rotate the cardboard about its vertical axis through the alignment reference center (thumbtack) to provide the desired amount of toe-out in relation to the line of progression guided by the long axis of the anterior spirit level on the socket wall (Fig. 5B).

3. The next step is to bring the pylon-foot-shoe unit into position (Fig. 5D) and to connect the PVC pylon to the socket by softening and molding the four x-shaped bars on the outer surface of the socket (Fig. 5E). This step is facilitated by using double-sided mounting tape between the PVC bars and the socket wall. Then, remove the levels and apply another roll or two of Scotchcast tape to reinforce the

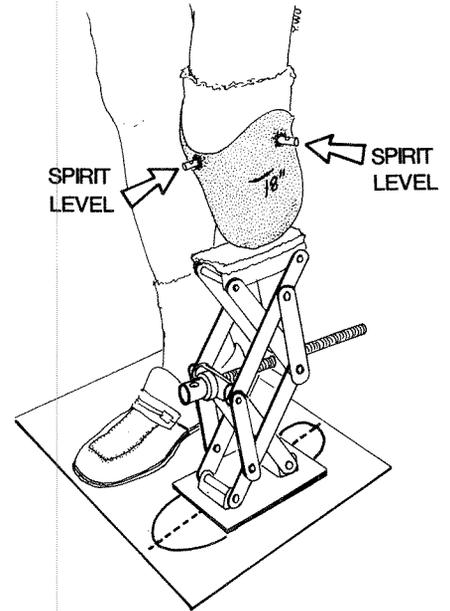
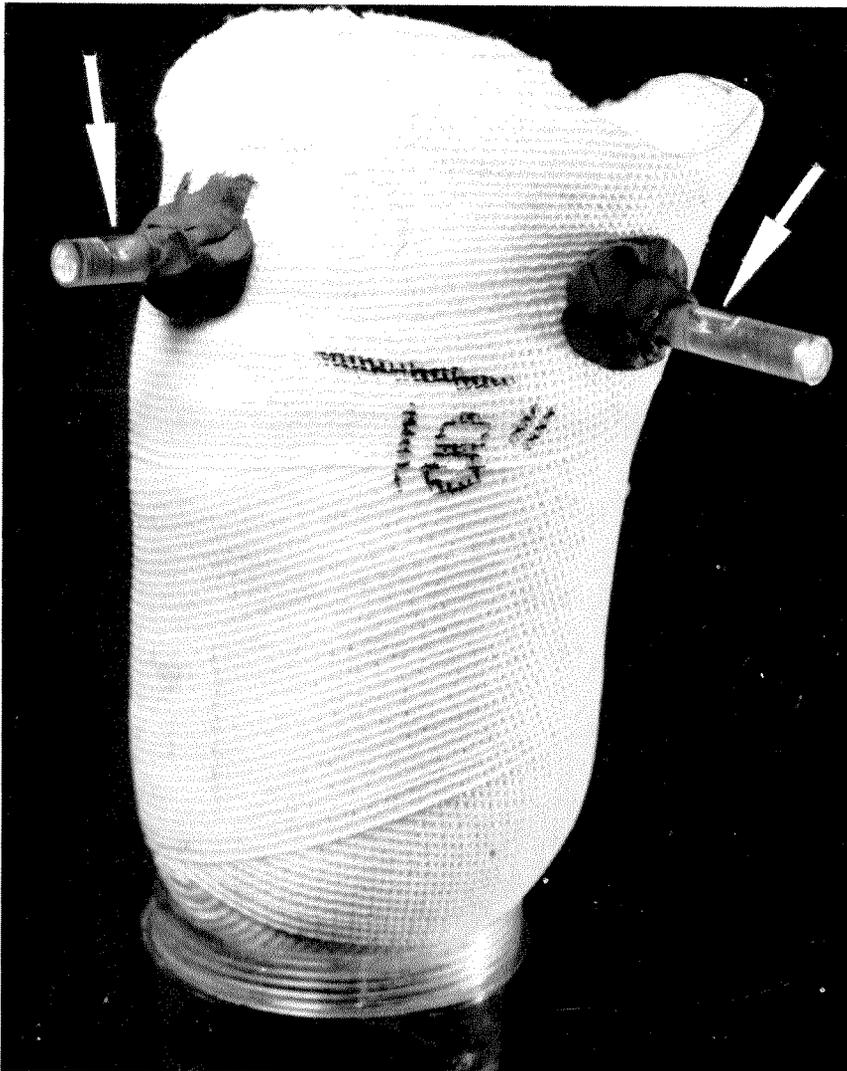


FIGURE 3. Determine the position (axis and height) of PTB socket by the patient during full weight bearing. Use the anterior and lateral spirit levels to maintain and monitor the medio-lateral tilt, flexion of the socket. The height of the socket is monitored by a mark at a specific height, from the ground, 18 inches for a typical male adult.

FIGURE 2. The lateral spirit level is used to control medio-lateral tilt while the anterior level is used to control flexion of socket and degree of toe out.

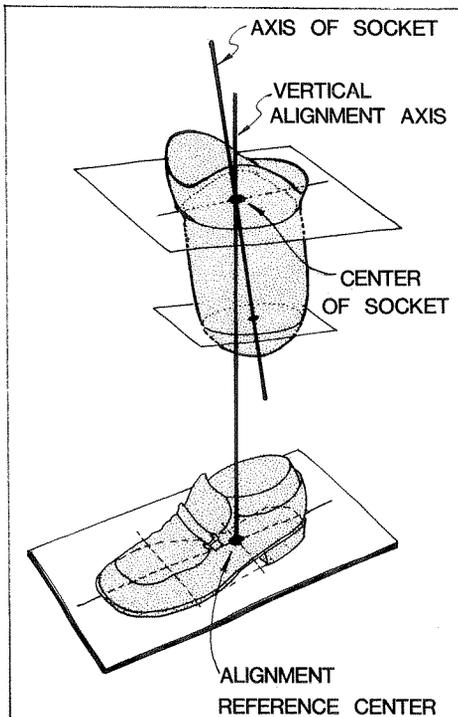


FIGURE 4. Relationship between the PTB socket and pylon-foot-shoe unit.

attachment of the PVC pipe on the socket. Place Scotchcast in the V-shaped gaps between bars in an effort to reduce stress concentration. Finally, attach the supracondylar strap (and sometimes a waist belt as in Fig. 6) for suspension. Although re-alignment of the prosthesis can be done by softening the PVC pipe with a heat gun (2), it has rarely been necessary.

Sometimes, the interim prosthesis can be foamed and laminated to form a definitive one.

Discussion

For preparatory prosthesis, the use of Lightcast for PTB socket (4) and the use of PVC pipe as part of the pylon unit (2) were reported earlier. Yet, the combination of the two approaches was not described in those articles. The purpose of our approach, initially, was to try a simple preparatory prosthesis, for gait training while the patients were waiting (often many weeks) for the standard VA temporary

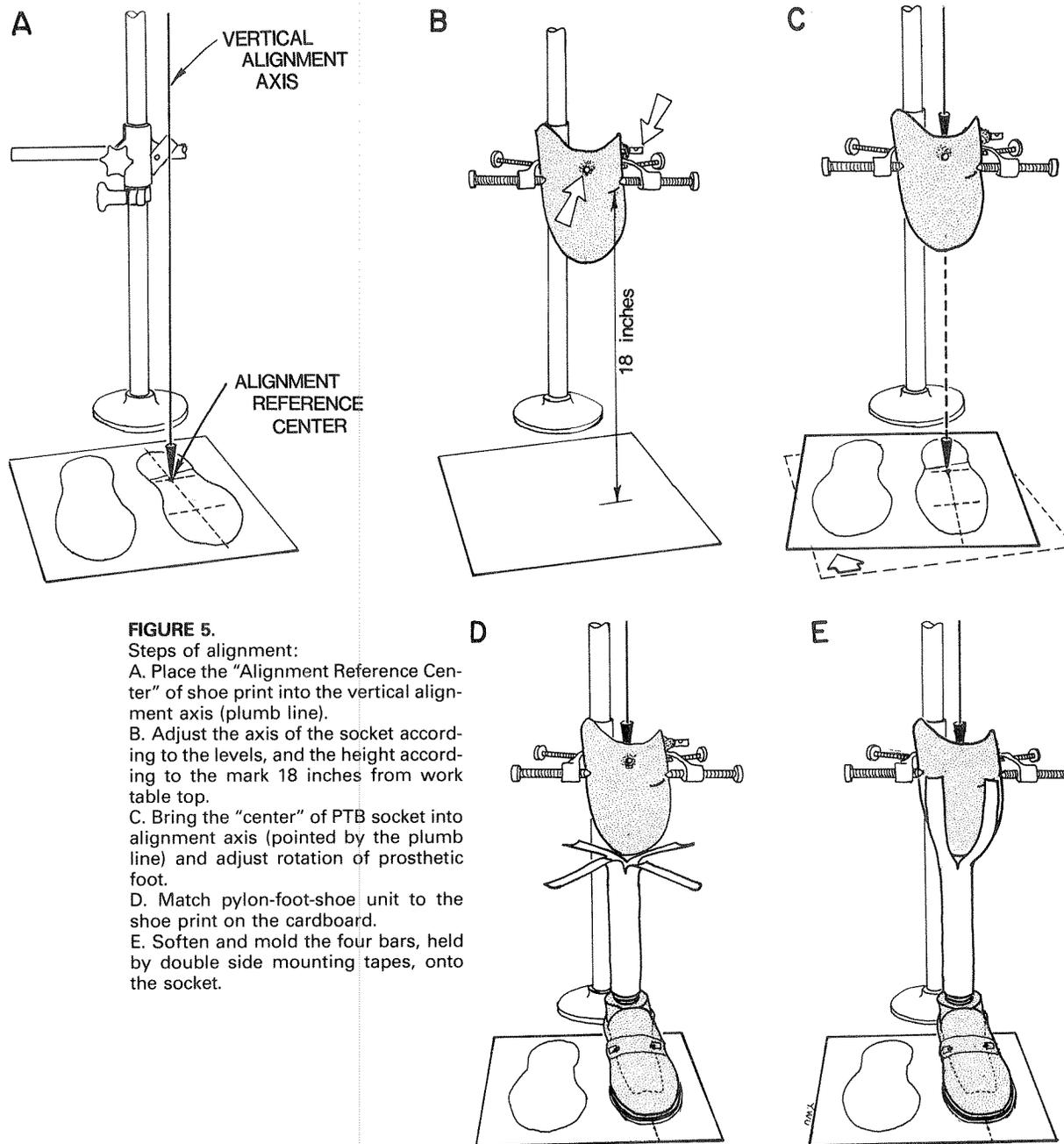


FIGURE 5.

Steps of alignment:

A. Place the "Alignment Reference Center" of shoe print into the vertical alignment axis (plumb line).

B. Adjust the axis of the socket according to the levels, and the height according to the mark 18 inches from work table top.

C. Bring the "center" of PTB socket into alignment axis (pointed by the plumb line) and adjust rotation of prosthetic foot.

D. Match pylon-foot-shoe unit to the shoe print on the cardboard.

E. Soften and mold the four bars, held by double side mounting tapes, onto the socket.

prosthesis from the regional laboratory at another medical center.

Since 1979, we have used this system on 25 patients including two bilateral BK amputees. Mechanical failure of the system has never happened. The longest period of use was 90 days until the patient received his VA training prosthesis. On a patient with 330 pounds body weight, a total of 5 rolls of Scotchcast tape were used—with excellent results.

An advantage of this technique, besides light weight, comfortable fitting, and only rare need for realignment, is the reduction of fabricating time, often to less than 2 hours. This is achieved by the following: (i) direct formation of the socket on the residual limb using the new casting material and simple pressure relief technique, (ii) use of wool sock lining as the soft insert, and (iii) precise static alignment of the socket to prosthetic foot to replace the conventional dynamic alignment procedure.

Direct formation of the socket on the residual limb, using the cotton padding (spacer) method (5,6) provides a graded pressure relief over the bony prominences, and in some cases sensitive areas, while uniform pressure is distributed over the rest of the stump and a desirable higher unit pressure exerted over the patellar tendon for weightbearing (3). The use of a thick wool sock as the liner for a smooth inner surface, and the wearing of tube socks, replace the need for a soft insert in our system. Both direct casting on the residual limb and elimination of the soft insert are effective time-saving approaches in making the PTB socket.

Alignment techniques used are also markedly simplified, although they do follow common principles (3). To connect the socket (upper section) and the prosthetic foot (lower section), three independent factors are involved: (i) the position of the prosthetic foot; (ii) the position of the socket; and (iii) the relationship between the socket and the prosthetic foot. Since the prosthetic foot is the foundation

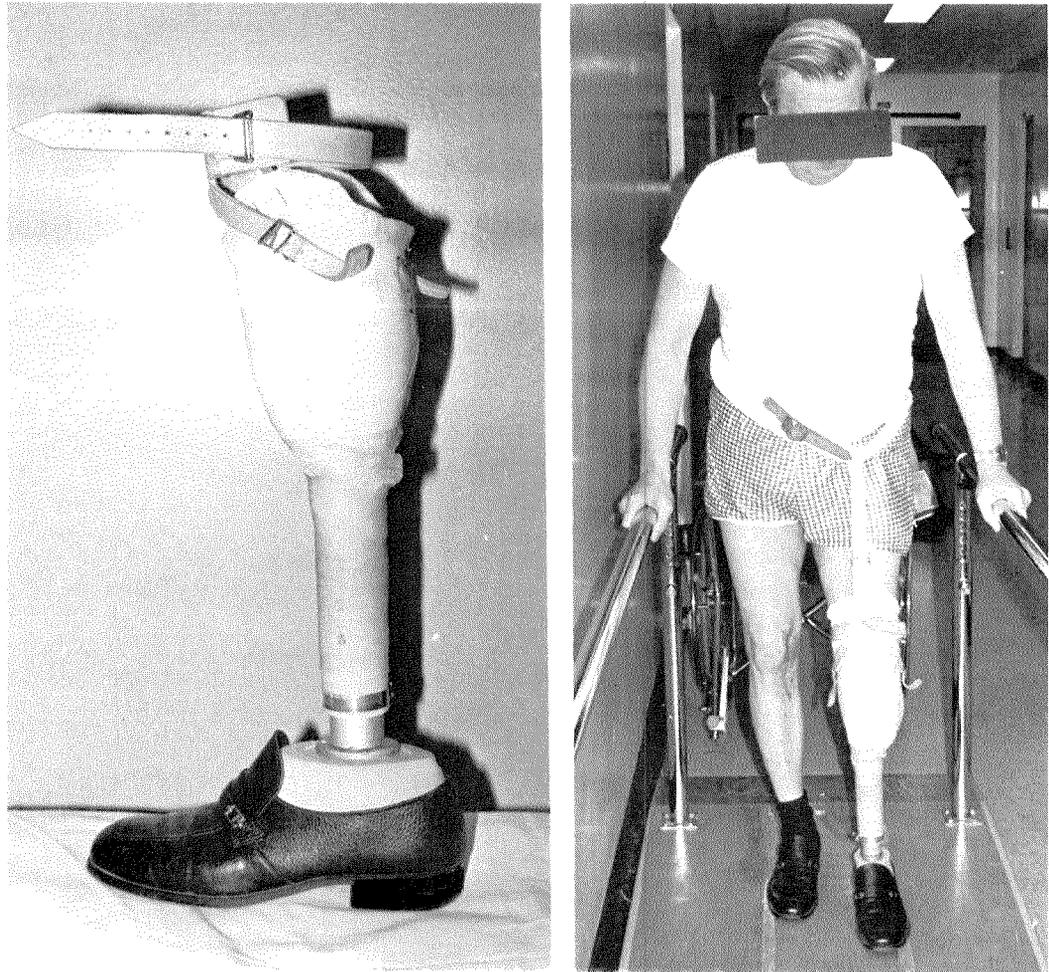


FIGURE 6.
Gait training using
Scotchcast-PVC
prosthesis.

for the alignment, all that is required is the stability of the pylon-foot-shoe unit on the floor (or work bench). The position for the socket, however, involves the "height" as well as the "axis" (a result of mediolateral tilt and flexion) of the socket. This position can be readily and accurately determined by the patient while standing with the socket on. While bearing full weight, the patient adjusts the socket to the most comfortable position. Once this is achieved, with no excessive pressure to any certain area of the residual limb experienced by the patient, the exact "axis" (i.e., the mediolateral tilt and flexion) of the socket is maintained by temporarily attaching two spirit levels. The exact "height" is defined by a mark on the socket wall. During the transfer from the residual limb to the alignment fixture, the degree of mediolateral tilt, flexion and rotation of the socket is monitored accurately by the spirit levels.

While the patient determines the position of the PTB socket, it is possible to make certain that the socket fits comfortably as in the check socket procedure, thus avoiding later time-wasting in correcting a poorly cast, improperly modified, or otherwise faulty socket normally discovered only after attachment to the pylon unit.

The relationship between the socket and the pylon-foot-shoe unit in the conventional approach is determined by dynamic alignment. Since the "center" of the socket at PTB bar level was found to fall vertically at or very close to the

"alignment reference center" in our 20 definitive or temporary below-knee prostheses aligned by conventional dynamic technique, we believe that simply bringing the "center" of the PTB socket onto the same vertical axis with the "alignment reference center" would approximate the same goal as the dynamic alignment process. This has been proved by the fact that realignment in our system was rarely necessary in 25 consecutive cases. Two cases aligned by eye (to test the need for the spirit levels) were inadequate: they were then refitted with the recommended techniques, leading to perfect results.

The "center" and the "axis" of the socket are two independent factors, and must be considered separately. The "center" of the socket must be in the alignment axis (Fig. 4) and the "axis" of the socket should be flexed to match the most comfortable position of the residual limb determined by the patient during full weightbearing. From a practical viewpoint, establishment of the most comfortable position (axis) of the socket by the patient while standing on the jack is a modified form of dynamic alignment, while alignment of the "center" of the socket to the prosthetic foot is a precise and simple method of static alignment.

From our experience, using Scotchcast casting tape and PVC tubing along with a simplified alignment technique by a nearby certified prosthetist-orthotist (M.D.B.) has resulted in improved patient care at this VA Medical Center where no

prosthetic workshop is available and where delay in obtaining a standard training prosthesis has been a problem. To this date, we have had no major complications associated with its use except for two earlier patients who developed very mild superficial skin breakdown over the tibial end. Those incidents led to the application of thicker distal cotton padding and the wool sock lining in making the PTB socket.

This interim prosthesis is very practical and effective. It has been well received by the patients and the staff ■

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