Artificial Limbs, Vol 1 4, No 1. pp 57-64. Spring 1970

Direct Forming of Below-Knee PTB Sockets with a Thermoplastic Material[1]

ANTHONY STAROS AND HENRY F. GARDNER

Prior to forming the socket, a careful evaluation of the stump must be made. The usual prosthetics data must be noted, especially any stump characteristics which would require special considerations for socket comfort.

With the patient seated, a lightweight cast sock is applied snugly (Fig. 1) to maintain tension. The top of the sock is clamped to a strap encircling the patient's hips. The strap is made of two halves of mating Velcro for easy adjustment behind the patient's back, and the two free ends are equipped with Yates clamps, which are placed medially and laterally at the top of the sock.

A strip of 1/4-in. felt, cut to form a tibial-crest relief, is positioned from the superior border of the tibial tubercle to *and over the end of the stump* (Fig. 2). The portion of the pad over the tubercle is made approximately 1 1/4 in. wide, tapering to a 5/8-in. width for the entire length of the tibial crest relief. All edges are carefully skived. If adhesive-backed felt is not available, medical adhesive may be used to attach the pad.

A second lightweight cast sock is pulled snugly over the tibial relief and fastened in the same manner as the first sock (Fig. 3).

Using the VAPC knee caliper, the anterior-to-posterior knee measurement at the level of the patellar tendon is taken (Fig. 4). The medial-to-lateral dimensions of the epicondyles of the femur are measured in the same manner. These dimensions are useful in determining the accuracy of the socket. The maximum depth of the patellar ledge is determined by the A-P measurement.

SOCKET FORMING

A section of Polysar[2] X-414 synthetic rubber tubing with a Vi-in. wall is se-

Fig. 1. Application of a lightweight cast sock.

[1] Although this article describes direct forming of a "hard socket" patellar-tendon-bearing prosthesis, the technique is applicable to the formation of other variations of PTB sockets. The procedure was first described by the staff of the Veterans Administration Prosthetics Center, New York, N. Y., in the March 1969 issue of *Prosthetics and Orthotics,* the journal of the American Orthotic and Prosthetic Association. Since that date, the technique has been simplified, particularly by the elimination of the pressure apparatus. The authors wish to acknowledge the contributions of the entire VAPC staff in the development of this procedure.

[2] Registered trademark of the Polymer Corporation Limited.

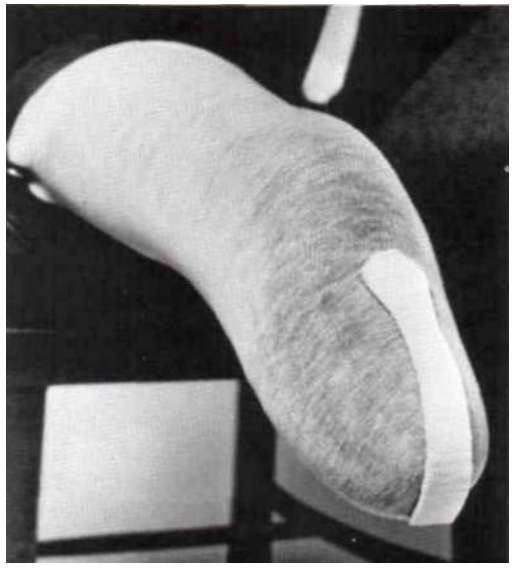

Fig. 2. Placement of the relief for the tibial crest.

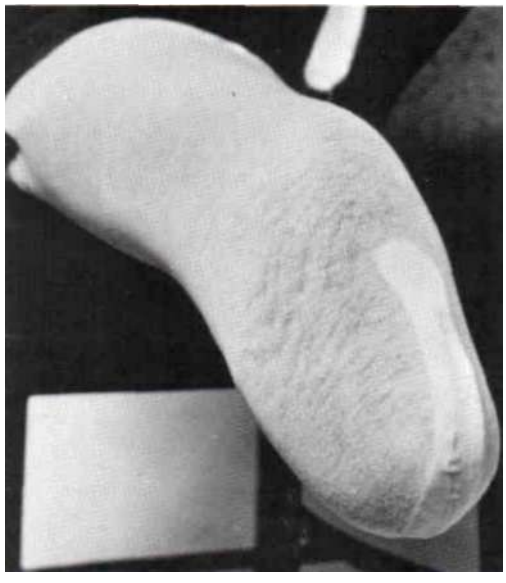

Fig. 3. Stump with second cast sock applied.

lected. The diameter of the tubing should be one-third of the mid-stump circumference. The tube length should be approximately one and one-half times the distance measured *from the top of the knee to the end of the stump* (Fig. 5).

A section of Helenca stockinet 36 in. long is used to pull the heated tube over the stump. One end of the stockinet is pulled up on the stump as shown in Figure 6. The other end is passed through the heated tube.

The inside surface of the tube is thoroughly cleaned to remove all plastic dust. (When heated, the dust would cohere to

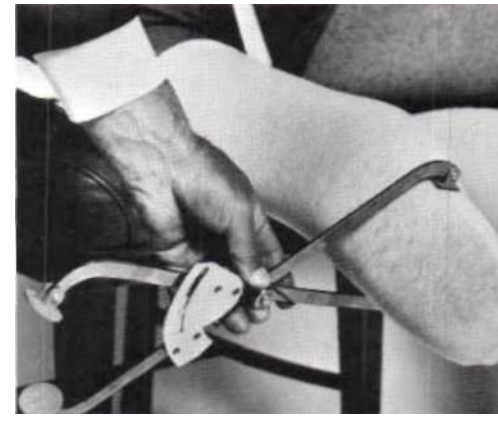

Fig. 4. Measuring stump dimensions with the VAPC caliper.

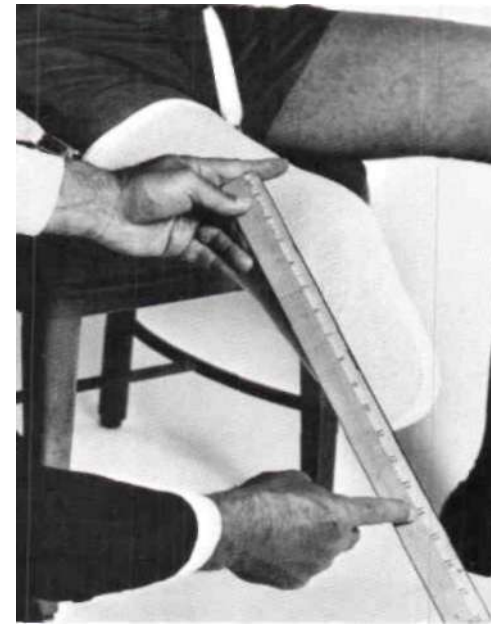

Fig. 5. Determining the proper length of tubing.

the inner walls, causing undesirable irregularities.)

The dust-free tube is softened by immersing it in water heated to 180 deg F, or just under the boiling point, for four to six minutes. Because the inner walls of the tube would cohere instantly if permitted to touch when heated, *the tube is placed on its end in the water container.*

Fig. 6. The stockinet in position over the stump for pulling on heated plastic tubing.

Fig. 7. Pulling the heated tube over the stump.

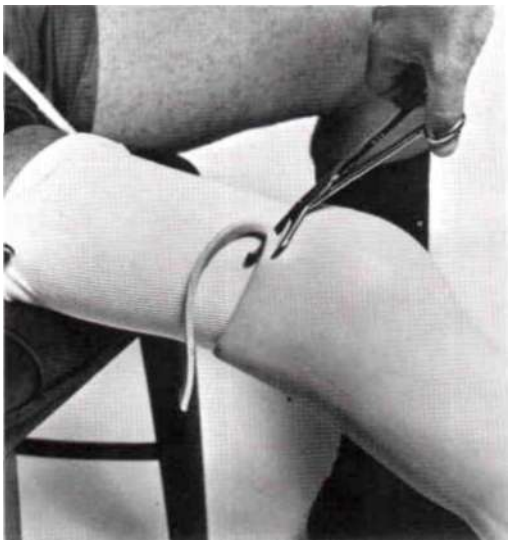

Fig. 8. Trimming the upper socket borders before molding.

To facilitate slipping the tube over the knee, the upper half is enlarged by spreading (hands together, palms out). The end of the stockinet hanging from the stump is pulled through the heated tube. The tube is pushed on the end of the stump and carried up over the stump by a continuous pull on the stockinet (Fig. 7).

Twists or folds in the stockinet should be avoided while drawing the stockinet and plastic tube over the stump. The forming pressures which compress the soft thermoplastic produce a slight imprint of the stockinet material on the inner surface of the socket, and any folds or twists in the stockinet will cause undesirable irregularities in the inner socket wall. The top of the stockinet is then clamped in the same manner as the cast socks.

The upper socket borders are trimmed with bandage scissors, leaving the posterior borders approximately 1/2 in. higher than the required measurement, for later rolling out of the material to form a relief for the hamstrings (Fig. 8). The remainder of the socket border is cut transversely above the superior edge of the patella.

Fig. 9. Application of pressure using an elastic pressure-sensitive-tape wrap.

Fig. 10. Hand molding to define the medial tibial flare and tibial crest.

The lower tube end and the stockinet are trimmed to provide an extension of 3 in. beyond the stump.

The stump is held relaxed in 5 to 10 degrees of flexion. Starting approximately 1/2 in. above the stump end, a snug wrap of 1-in. elastic pressure-sensitive tape is applied over the tube in a continuous anterior-to-medial spiral, with increasing tension approaching the level of the medial tibial flare and continuing over the knee (Fig. 9). The tension is controlled best if one steadies the socket while the

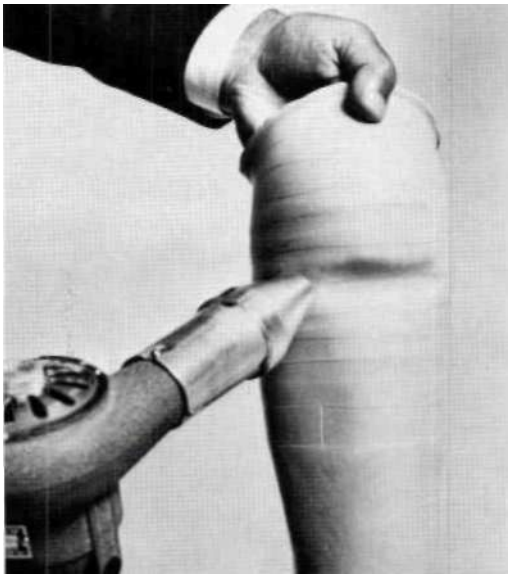

Fig. 11. Heat gun with modified cone for control of heated area.

Fig. 12. Rolling out the softened posterior socket wall

other wraps half of the circumference. The hands then change functions to wrap the other half of the circumference.

The section of soft tubing extending below the stump will tend to sag. This must be prevented by supporting this section until it cools while molding the material. Approximately 10 minutes are required for the material to harden. During this time, the socket is molded to provide freedom over the anterior end of the tibia by massaging the taped surface of the socket to define the tibial crest and medial flares of the tibia (Fig. 10). During the molding process, all surface irregularities may be pressed out of the socket. The socket should not be removed from the stump until the thermoplastic is no longer deformable by hand. The tape is removed, and with the knee flexed to at least 90 degrees, the socket is forced from the stump. Later, pressure-sensitive fiberglass or nylon tape may be put on the socket as a circumferential (barrel hoop) reinforcement, usually required only around the proximal brim.

The resulting open-end socket will permit easy attachment of the shank. Once the socket extension has been secured to the shank, the end of the socket chamber is filled with foam, or another type of resilient end pad is provided.

SOCKET MODIFICATIONS

To modify the socket, heat is focused with a heat gun fitted with a cone (Fig. 11). With one hand placed inside the socket against the surface to be modified, heat is directed to the *immediate area from close range* until the heat is sensed by the fingers through the socket wall. *Large areas should not be heated, nor should heat be directed against the socket for a prolonged period of time, because excessive temperature will cause the plastic to boil and discolor.* When molding for a pressure point, one finger should press from inside the socket, and the surrounding areas should be supported on the outside of the socket with the fingers of the other hand. After the molded area has cooled sufficiently to retain its shape, the socket should be chilled with cold water or refrigerated for a short interval to reset the plastic. *Caution must be exercised to avoid heating the entire socket. The heat should be concentrated on the one spot until the pressure applied with the fingers inside the socket causes the material to yield.*

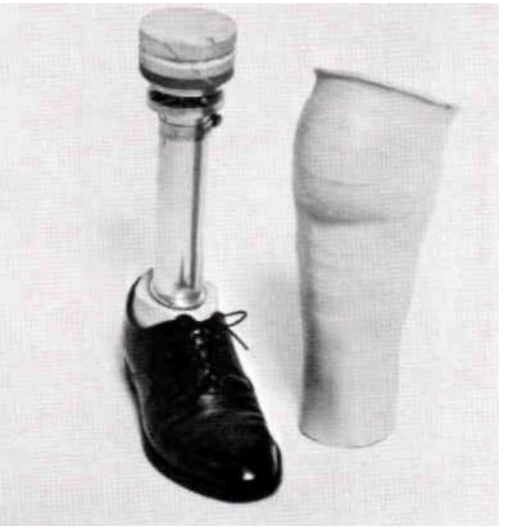

Fig. 13. The pylon and socket ready for assembly.

A similar procedure is followed to shape the patellar-tendon ledge. For patients who have previously worn prostheses, the A-P measurements obtained by caliper are used to determine the depth of the ledge. For recent amputees, the patellar-tendon ledge is not molded to the maximum depth in one adjustment. Instead, three or more adjustments should be made at intervals of one month until the required A-P dimension is reached.

The proximal posterior socket border is heated and rolled out to form a smooth radius for comfortable knee flexion (Fig. 12), the border being maintained at approximately the patellar-ledge level.

An adjustable pylon is prepared with a wood socket-attachment block 1 V2 in. thick and 3 in. in diameter, with a Vi-in. deep circumferential groove at the midpoint of the block. The block is tapered to a

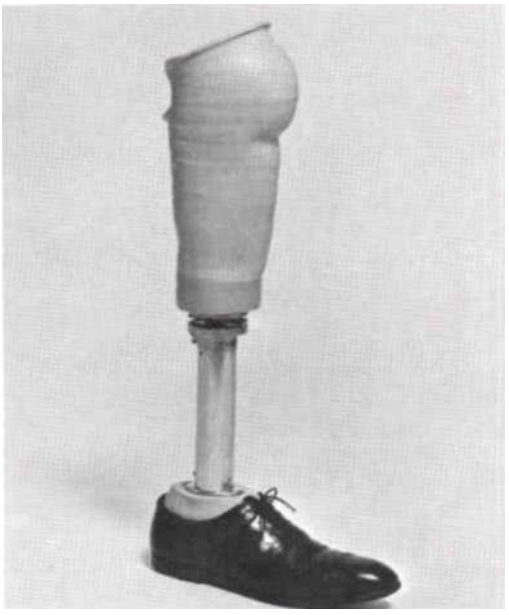

Fig. 14. The heated socket bottom is joined to the pylon with elastic-tape wrap.

slightly smaller diameter around the bottom, then fastened permanently to the pylon with bolts and cement (Fig. 13).

The tube end extending distally from the socket is heated, then fitted over the wood pylon-attachment block, with the groove helping to make a good bond. *A 1-in. space between the stump end and the attachment block must be maintained.* The tube is taped tightly to the wood block and permitted to cool (Fig. 14). Any excess tubing extending below the wood can be trimmed while the plastic is still soft. When hardened, the tube is fastened permanently to the wood block with four screws set at 90-degree angles to one another.

SUSPENSION

To provide for suspension, the socket can be trimmed at the regular PTB level and a separate cuff used above the knee. Of the several kinds of PTB suspension that can be provided with this socket, suprapatellar-supracondylar suspension is described.

The patient is seated in a chair with his knee flexed at approximately 45 degrees, and the stump is covered with two cast socks. The upper socket walls above the level of the upper border of the patella are softened by holding the socket (bottom up) in hot water. When the socket top is heated, the stump is pushed into the socket. The plastic is molded against the thigh over the condyles by wrapping tightly with pressure-sensitive tape and hand molding.

After the patient has been fitted and the prosthesis aligned, the bottom of the socket chamber should be foamed to obtain a total-contact fitting. To avoid difficulty in quickly inserting the stump into the socket, the stump is covered with a lightweight sock and a powdered PVA bag. Three 1/8-in. holes are drilled through the lower socket wall at the level at which the stump begins to taper inwardly, away from the socket wall. A foam mixture is prepared

Fig. 15. Pouring the foam mixture to form the total-contact socket bottom.

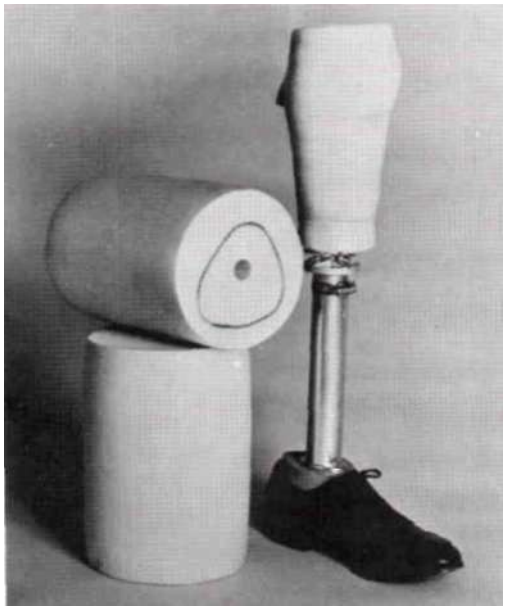

Fig. 16. Foam blocks prepared for fitting over the pylon and socket.

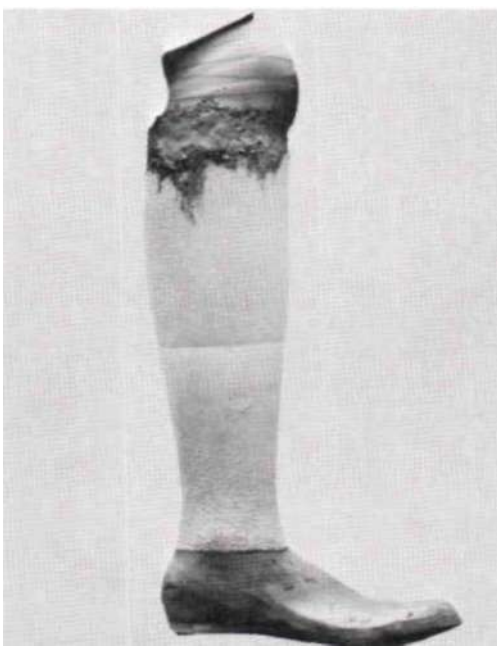

Fig 17. Foam blocks fitted over the socket and pylon and rough-shaped

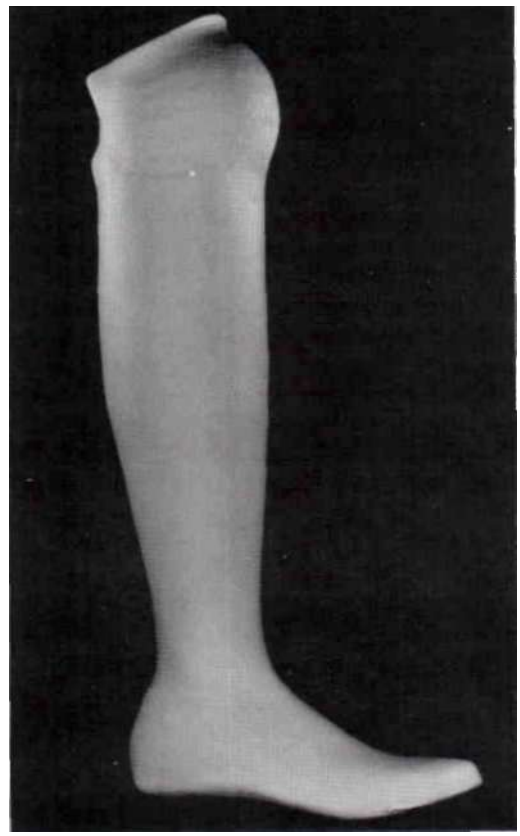

Fig. 18. The prosthesis with a flexible plastic coating over stocking-covered foam,

and poured into the socket (Fig. 15). The patient's stump is inserted into the socket and the patient stands still until the foam has set. The. foam mixture may vary, depending upon the type of stump and condition of the distal tissues. Usually a combination of foam and RTV rubber is used.

SHAPING AND FINISHING

A leg shape can be made from prefabricated sections of semirigid foam, Koroseal Spongex.[3] Beginning at the level of the patella, a paper pattern is cut to fit around the socket at this level. The pattern is

[3] B. F. Goodrich Co.

traced upon one foam section (Fig. 16). The foam is carefully sanded to form a hollow for the socket. It is necessary to obtain a tight, gap-free fitting of the foam to the socket; best results are obtained from a slight stretch fit. For this, the foam is heated in an oven at 180 deg F before placement over the socket.

To cover the remaining part of the pylon, a foam block is cut to correspond to the measurement between the bottom of the foam surrounding the socket and the top of the foot plus 1/4 in. A hole is made through the length of the block large enough to receive the pylon tube. Since the foam is semirigid, the areas for the alignment coupling and ankle plug of the pylon are cut slightly undersize to permit a snug fit about the pylon (Fig. 17).

A 1/2-in. hole is bored transversely through the foam block to permit entry of a screwdriver to fasten the tube clamp. The two foam sections are *not* glued together, in order to facilitate removal for alignment adjustments. Compression of the foam block between the socket base and the foot will prevent any movement of the block.

The blocks are shaped with a band saw or knife and sanded with a drum or cone sander. For cosmesis, either a flexible polyurethane coating over the foam or a stocking cover is recommended (Fig. 18).