

## A PATELLAR-TENDON-BEARING ORTHOSIS

Bert R. Titus, C.P.O.<sup>1</sup>

"Short leg braces" with molded leather cuffs or ischial weight-bearing "long leg braces" have been used for years to unweight the leg below the knee.

In certain pathological conditions of the lower limb, the stress of weight-bearing cannot be tolerated because of pain or the possibility of tissue damage. Pathologies encountered in such situations fall into three broad categories: 1) those affecting bone, such as delayed unions or nonunions of fractures; 2) those involving the ankle or foot joints, such as traumatic arthritis or similar conditions; and 3) those involving the soft tissue, such as ulcers and traumatic loss of the heel pad or other soft tissues.

The Veterans Administration Prosthetics Center designed an orthosis in 1958 using principles of the patellar-tendon-bearing prosthesis to load the distal shin, ankle, and heel (1) (2).

Using the Veterans Administration Prosthetic Manual, "PTB Sockets for Below Knee Weight Bearing Braces," dated January 3, 1961 (1), we measured, fabricated, and fitted several braces as described therein. After experience with patients wearing the patellar-tendon-bearing socket for some time, changes in the anterior-posterior measurement of the leg seemed to be indicated. No provisions for adjustment of the hinge on the medial side of the socket had been made, but adjustment could be made on the lateral side by tightening the strap. However, the patients felt that the socket was not fitting the leg properly, as though the socket was twisted about the leg. Additional strips of Kemblo were glued to the socket, but this increased the bulk.

In an attempt to overcome these problems several two-part sockets were made. The anterior section was attached to the uprights and the posterior section was made so that it lapped over the outside of the anterior section. Straps to adjust the anterior-posterior pressure were provided. This design represented progress but the poster-

ior section tended to move up and down on the anterior section, and it was still quite bulky.

With improved techniques for plastic lamination and casting, a new design was developed, and is being used today.

### FABRICATION

#### CASTING

A wet cast sock is pulled over the patient's foot and leg, and held up by an elastic strap around his pelvis and two Yates clamps.

In the posterior area a piece of lead or webbing or elastic strap is laid underneath the cast sock along the midline where the cast will be cut for removal.

The position of the knee joint is located and marked on the medial and lateral sides at the level of the center of the patellar tendon. A line in the horizontal plane connecting these two points through the center of the patellar tendon is drawn.

The distal, proximal, medial, and lateral aspects of the patella are outlined and connected.

A horizontal line is drawn through the center of the outline of the patella.

The lateral condyle of the tibia and the head of the fibula are located and marked.

The crest of the tibia is outlined and a line is drawn down the crest to a point approaching the ankle.

The posterior tibial flare is marked on the medial side.

Two layers of plaster-of-Paris splints are laid over the crest of the tibia. The cast is made somewhat longer than necessary, and when possible, the distal part of the splints are folded over to reinforce that part of the cast. Two more layers of splints are laid just slightly medial to the original two layers, and then two additional layers are laid over the lateral aspect. The plaster in these splints is worked with the hand so that it is well molded over the crest of the tibia and around all the bony areas of the stump. The thumbs are imprinted in the patellar-tendon area, and indentations are made the same as when a cast is

<sup>1</sup>Associate Professor of Prosthetics and Orthotics, Director of Department of Prosthetics and Orthotics, Duke University Medical Center, P. O. Box 3885, Durham, North Carolina 27710.

taken for a patellar-tendon-bearing socket. After these have partly dried, the balance of the shin is wrapped with a roll of plaster bandage.

When the cast has set, it is removed by cutting it with a cast saw down the posterior aspect along the midline of the webbing that was inserted under the cast sock. After the cast has been removed from the patient it is wrapped with an additional bandage to hold it together, and the distal end is covered so that a positive model can be poured.

### THE POSITIVE MODEL

The cast is coated on the inside with sodium silicate, commonly called waterglass, or any other separating agent.

The cast is then put into a box, and supported with sand. A pipe is inserted as nearly as possible in the center of the cast between the patellar tendon and the popliteal area in the AP plane, and between the medial and lateral walls in the ML plane to make alignment easier later. The cast is then filled with plaster of Paris which is allowed to cure until it is hard.

The female cast is removed and the male mold is ready for modification.

With a round Surform file, plaster in the area of the patellar tendon is removed to the point where the indentations in the plaster cast were formed by the thumbs.

With a scarpa knife, the plaster along the lateral aspect of the tibia is removed and a Surform file is used to remove a small amount of plaster along the shank of the fibula. However, the marks at the head of the fibula and the distal end of the fibula are not removed.

An additional small amount of plaster is removed from the posterior aspect of the cast coming around to the medial side and a slight amount is removed under the medial tibial plateau.

Usually the amount of plaster removed from the male mold is so slight that the marks made by the wet stump sock are still visible.

Circumference measurements should then be made of the cast. They should be the same as those taken of the stump with the exception of the one taken through the patellar-tendon area which should be  $\frac{1}{4}$ -in. smaller than the measurement taken on the patient.

If any additional plaster needs to be removed, it should be removed in the posterior aspects of the cast.

The cast is then smoothed with a sand screen.

The ML dimension should be the same as that measured on the patient's leg.

The AP dimension should be the same as that measured on the patient's leg. If the AP dimension is not the same, plaster should be removed from the popliteal area.

The cast (Fig. 1) is now ready for the buildup in the posterior area so as to provide a "roll" of the socket in that area.



Fig. 1. Modified positive model for PTB orthosis.

A line is drawn on the posterior aspect of the cast in the same horizontal plane with the midline of the patella tendon.

With a "T-type" instrument and using the pipe as a reference, a horizontal line is drawn on the posterior aspect of the cast, perpendicular to the pipe.

A piece of lead about  $\frac{1}{16}$ -in. thick,  $\frac{1}{2}$ -in. wide, and 12-in. long is sprayed with Silicone and then shaped to conform to the back of the cast making it the width of the posterior aspect of the cast (Fig. 2). It is placed on the line just previously drawn as shown in Figure 2.

The area within the lead piece is filled with plaster of Paris. The head of the fibula is built up with plaster slightly about  $\frac{3}{16}$  in. at the apex and feathered to nothing around the edge of the marks

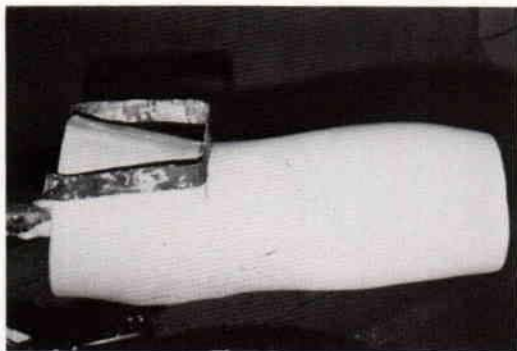


Fig. 2 Lead form in place for formation of roll in proximal posterior section of socket.

that have been on the cast outlining the head of the fibula.

The lateral tibial condyle area is built up in the same manner.

The tibia tubercle is also built up in the same manner but is extended down the entire length of the tibia while the distal third of the tibia is built up at least 3/16 in. and the sides are feathered into the cast.

The lead is then removed, and plaster is used to fill in the cracks around the edge of the buildup which is smoothed to where it is even with the rest of the cast. A little additional buildup is made on both the medial and lateral sides of the popliteal area to allow for motion of the hamstrings when the knee is flexed.

#### LAMINATION

After the cast is has been modified and smoothed, it is covered with a coat of Vaseline or talcum powder in order to allow the PVA bag to slide over the cast easily when the lamination is to be made over a wet cast.

A PVA bag is pulled over the entire cast, and tied off at the proximal end. Any extra material is cut off of the distal end, a small sheet of PVA is pulled over the distal end, and the excess material trimmed off so that the entire cast is covered with PVA.

A piece of nylon stockinet, cut twice the length of the cast plus an extra allowance, is sewed in the center and the first section is pulled over the cast followed by the second section.

A piece of plastic sheeting (Mylar) about 1/32-in. thick and a width approaching, but not exceeding, the buildup on the posterior aspect of

the cast in the popliteal area is sewn to a piece of stockinet about as long as the model (Figs. 3 and 4).



Fig. 3. Stockinet with Mylar sewn in distal end in place on positive model.

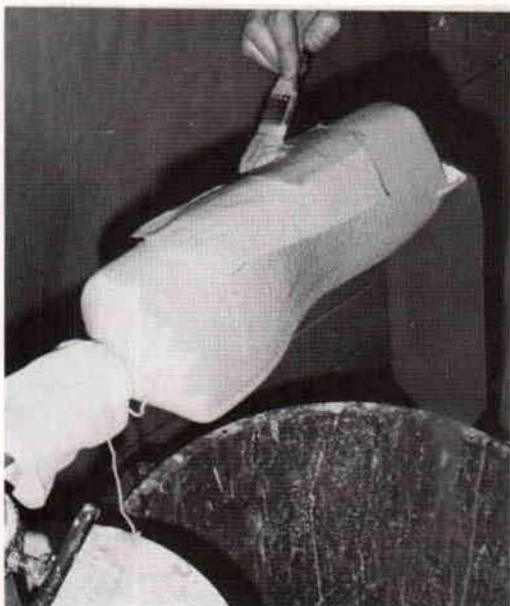


Fig. 4. The addition of Dynel for reinforcement. Note the Mylar strip that is to be used as a separator.

The stockinet is then stretched over the cast. It should be large enough so that when it is pulled over the cast bridging will not occur. The distal end of the stockinet is tied to the cast.

Then a mixture of 85 to 90 percent rigid and 10 to 15 percent flexible polyester resin is mixed together along with the catalyst, color, and promoter, and painted on the anterior area and along both sides to approximately 1 in. of the posterior line of the cast. Only a few drops of promoter are used so that the resin will cure very slowly, to give more time for carrying out the rest of the laminating procedure. Dacron felt is not used because with the opening and closing of the posterior aspect of this socket, Dacron felt seems to break down while nylon stockinet continues to hold up over several years of service. The rigid plastic should be far enough posterior on both medial and lateral walls so that the metal uprights can be attached to the rigid section.

Dynel is added to the lateral wall for reinforcement. It goes posteriorly over the head of the fibula and additional layers are added so that the Dynel gives extra support over the entire anterior, medial, and lateral aspects of the rigid part of the socket (Fig. 4).

A mixture of 85 to 90 percent flexible and 10 to 15 percent rigid polyester resin is then mixed and painted on the posterior aspect of the cast.

The Mylar strip is then pulled down over the posterior aspect of the cast, and tied at the distal end (Fig. 5).

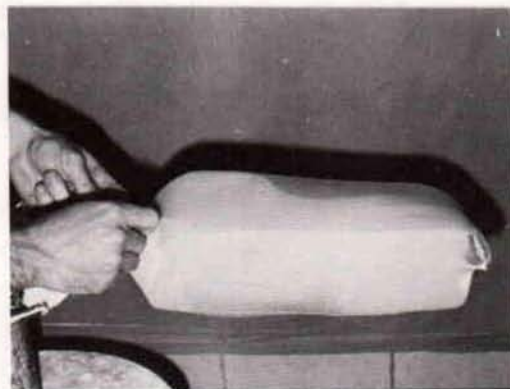


Fig. 5. The Mylar strip in place over the posterior aspect of the positive model.

Two additional layers of nylon stockinet are then applied over the entire model (Fig. 6) and the rigid mixture is painted over the same area to the point where the rigid plastic was applied previously. Two more layers of stockinet are then



Fig. 6. Application of two layers of stockinet over the positive model after the Mylar strip has been put in place.

pulled over the entire cast and tied off around the pipe. Additional rigid resin can be painted on these last two layers if desired.

A PVA bag that has been previously wrapped in a wetted towel for dampening is pulled over the entire cast at this time and the 85 to 90 percent flexible and 10 to 15 percent rigid mixture of polyester resin is poured into the bag and worked into the material over the entire model (Fig. 7).

The PVA bag is then stretched tight, and tied off by means of Yates clamps at the top.

Plastic tape is used to wrap the model in the patellar-tendon-bearing and the popliteal buildup areas. A piece of sponge rubber is placed in the popliteal area and wrapped with the plastic tape to form an even roll in the hamstring-popliteal area.

The entire model is then wrapped with an Ace bandage and allowed to cure.

After the laminate has set, the entire assembly is cured at 250°F for a minimum of 30 minutes.

#### TRIMMING THE SOCKET

The ends are cut off after the laminate has been cured in the oven, and while it is still hot.

The posterior wall over the area that is built up is cut away.



Fig. 7. The outer PVA bag is in place and the resin is being poured.



Fig. 8. The laminate is cut to the Mylar strip.

Marks are made on the posterior aspect of the cast for the centerline and the width of the Mylar that was inserted under the lamination.

The posterior aspect of the plastic is cut to, but not into, the Mylar (Fig. 8).

The inner area should be on the lateral side when it is cut so that the tongue goes from the medial to the lateral side and therefore there will be no pressure on the medial posterior condyle area (Fig. 9).

Other trimlines can be determined at this time, and the plastic can be cut while it is still warm (Fig. 10).

When all of these areas have been cut, the socket should be taped back together and allowed to cool completely on the cast.

#### FITTING AND ASSEMBLY

After the socket is cool, it is removed and tried on the patient, at which time additional adjust-



Fig. 9. The inner socket is cut on the lateral side.

ments can be made to the "socket."

The outline of the leg that was taken at the time of measurements is laid out in accordance with standard orthotic principles, and uprights are bent to the outline.



Fig. 10. Posterior view of the socket.

The footpiece is attached to the shoe, the socket is applied to the patient and taped together, the shoe is put on the patient, and the alignment of the uprights is checked, making sure that the socket is in the proper place and that patellar-tendon-bearing is achieved. The location of the uprights is then marked on the socket.

The socket and uprights are removed, holes are drilled in the uprights and the socket, temporary screws are inserted, and the orthosis reapplied to the patient for additional checks of alignment and weight-bearing characteristics.

Adjustments are made as required, and the socket and uprights are riveted together.

Velcro straps should be attached to the posterior aspect of the socket to keep it closed and the patellar-tendon-bearing surface is placed in the proper relationship to the lower limb.

After the patient wears the orthosis for a short time, he should remove the socket and check the pressure points. Usually he will find a red spot over the patellar-tendon area. Occasionally on people who have very thin skin, it is necessary to put a piece of stockinet under the socket when they are first using this weight-bearing orthosis.

With this orthosis, the amount of the patellar-tendon bearing can be adjusted as required.

Experience has shown that this orthosis is most effective when used with limited motion joints at the ankle. The range of motion may be increased as the patient progresses.

#### ACKNOWLEDGMENTS

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#### LITERATURE CITED

1. McIlmurray, William J., and Werner Greenbaum, *Patella Tendon Bearing Socket for Below Knee Weight Bearing Braces*. Veterans Administration Prosthetics Center, New York, January 3, 1961.
2. Kay, Hector W., Clinical applications of Veterans Administration Prosthetics Center patellar-tendon-bearing brace. *Artif. Limbs* 15:1:46-67, Spring 1971.