

# Premodified Casting for the Patellar-Tendon-Bearing Prosthesis

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Methods for producing a functional, comfortable, and well-fitting patellar-tendon-bearing prosthesis have been the subject of considerable discussion, and in fact some controversy, since the prosthesis was first introduced several years ago. Prosthetists use a variety of techniques to cast below-knee stumps, and there is an extensive literature on the subject, not excluding the technicians' differing viewpoints. There is agreement, however, that the effectiveness of the prosthesis depends to a great extent upon how well the wrap-cast (negative) was taken and, subsequently, how precisely the male plaster mold (positive) was modified.

The positive mold is modified in order to relieve pressure-sensitive areas by the addition of build-ups, and to increase the pressure to the pressure-tolerant (or natural weight-bearing) areas of the stump by the judicious removal of small amounts of plaster. These alterations prevent vertical displacement during stance and provide for comfortable accommodation of the stump during full weight-bearing. The precise amount of plaster removed varies with the individual patient, depending upon the muscle tone and the amount and resilience of the subcutaneous tissue. The procedure is by no means a difficult one, but timing is a complicating factor.

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Authorities on the subject encourage immediate rather than later modification of the positive cast in order to prevent improper interpretation of the individual stump characteristics. Consequently, the well-qualified prosthetist who finds himself with a large number of plaster positives to be modified, or the less experienced prosthetist who is just developing a keen sense of technical judgment, is at a disadvantage because, even with the best memory and with detailed prosthetic information, he is limited by techniques which involve nothing more than intelligent guesswork and which are conducive to at least an occasional error, regardless of the individual's experience and skill.

This difficulty can be overcome by modifying the cast on the patient's stump when the negative-cast impression for the permanent prosthesis is taken. This paper describes such a procedure, essentially initial socket fitting during casting, which provides a plaster negative-positive that requires only a final smoothing to be ready for socket lamination. The method includes the application of felt pads to strategic areas of the stump. Elastic plaster bandage is used for the negative plaster wrap because it effectively conforms to the irregular stump surfaces, controls tissue compression and displacement, and yields a precise stump impression. The resulting positive plaster mold resembles the stump contours accurately, thus providing the basis for a comfortable, well-fitting, and functionally acceptable PTB prosthesis.

Provision of a total-contact, hard PTB socket, without a soft end or the customary insert, is the standard procedure at the

Prosthetics Research Study, and the premodified-casting procedure results in a precise reproduction of the stump socket, so essential in hard-socket prostheses. This method has been used routinely at this facility since 1964, during which time several hundred PTB prostheses have been effectively fitted.

The premodified-casting procedure can be used, with but relatively minor modifications, for the patellar-tendon supracondylar or the patellar-tendon supracondylar-suprapatellar (PTS) prosthesis, with wedge suspension. We have also used this technique, with promising results, for the production of interim prosthetic sockets using both synthetic rubber, Polysar X-414 (TM), and Lightcast (TM). Both these materials will produce an effective interim prosthetic socket for immediate and early fitting.

#### PROCEDURE

##### NEGATIVE PLASTER WRAP

##### *Prosthetic Information*

Examine the stump to obtain all pertinent prosthetic information. Measurements of the normal leg can also be recorded at this time on page B of the prosthetic information form, but measurement of the stump is postponed until all felt relief pads have been applied to the stump.

##### *Materials and Equipment*

Materials required for the premodified plaster cast for a PTB prosthesis are:

- One lightweight cast sock
- One heavyweight cast sock
- Dow Corning Medical Adhesive Spray Type B
- Two rolls of 4- or 5-in. elastic plaster bandage
- One roll of 4-in. conventional plaster bandage
- Four plaster splints, 4 in. x 15 in., extra-fast-setting

Soft felt, approximately 5 in. x 10 in. x 1/8 in. thick

Medium felt, approximately 5 in. x 10 in. x 3/8 in. thick (or a right or left set of prefabricated felt relief pads, as used in immediate postsurgical prosthetic fitting)

Equipment required for this procedure is:

- Two 48-in. lengths of 1-in. elastic webbing
- Four Yates clamps
- One pair medium-size scissors



Fig. 1

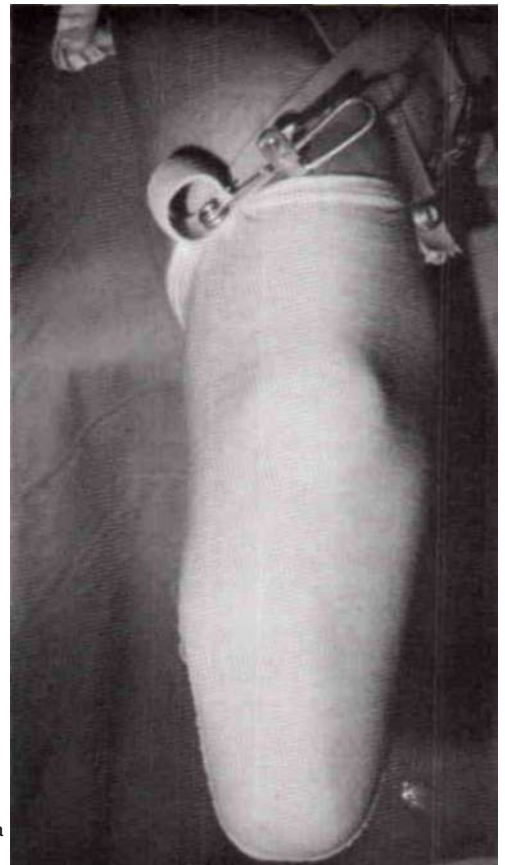


Fig. 2

Skiving knife  
 Inside calipers  
 Measuring tape  
 Combination square  
 VAPC knee-measuring caliper  
 Preshaped piano-felt, hamstring-tendon relief pads  
 Below-knee casting fixture  
 Bucket or basin of clear water, approximately 70° F

#### *Preparation of Patient*

Have the amputee sit on a table approximately 30 inches high, with the knee of the amputated leg extending six to eight inches beyond the table edge (fig. 1).

Roll the heavy cast sock onto the stump and attach the proximal portion of the cast sock with two Yates clamps to the 1-in. elastic-webbing strap which encircles the amputee's hips and crosses the amputated leg approximately four inches proximal to the patella (fig. 2). The strap should exert considerable tension on the cast sock in order to support all soft tissues of the stump, particularly those located distally.

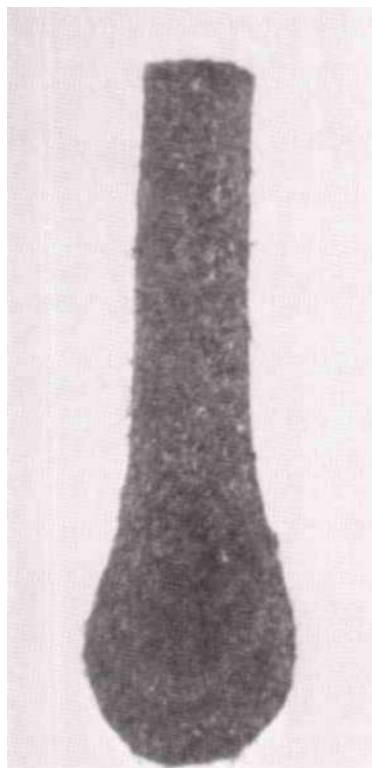


Fig. 3

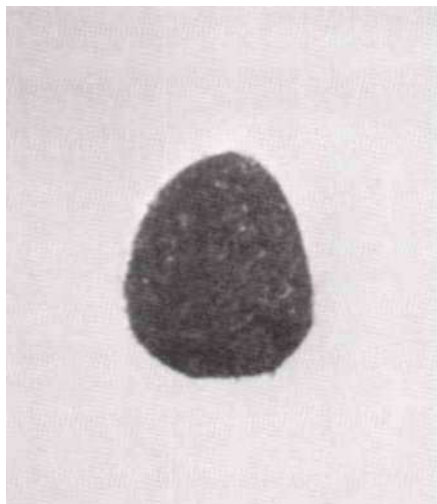


Fig. 4

*This is most important* because improper tissue support would result in too large a cast, necessitating modifications of the positive model or prosthetic socket to achieve proper fit.

Direct the amputee to flex his knee approximately 35° and to maintain this flexion in a relaxed attitude throughout the entire casting procedure.

#### *Preparation of Pressure-Relief Pads*

By palpation, locate the surface areas of the stump which require pressure relief.

For the *tibial crest*:

1. Measure the entire length of the crest of the tibia from the proximal border of the anterior tibial tubercle to 1/2 in. beyond the posterior edge of the transected tibia.

2. Measure the width of the anterior tibial tubercle and the cut end of the tibia.

3. Cut a piece of *soft* felt, 1/8-in. thick, to the length dimension taken in step 1 and width dimension taken in step 2. This results in a felt relief pad (fig. 3) which has a long rectangular form and widens in its distal aspect into a well-rounded teardrop shape, approximating the contours of the cut end of the tibia.

4. Neatly skive the periphery of the tibial relief pad to assure a smooth transition between the stump sock and pad.

5. Usually, additional relief of the distal anterior tibial area is indicated. The additional relief pad should represent the contours of the cut end of the tibia, resulting in the general shape of a large metatarsal pad. The periphery of the pad is smoothly skived to blend in with the tibial relief pad (fig. 4).

For the *head of the fibula*:

1. Measure the proximal-distal and anterior-posterior dimensions of the head of the fibula.

2. Fashion a piece of *soft felt*, 1/8-in. thick, to those dimensions, rounding off all corners and neatly skiving the periphery. The fibular relief pad should have a shape similar to a large metatarsal pad.

VARIATION : If the cut end of the fibula is prominent, sensitive, or close to the surface, provide another felt relief pad according to its dimensions and skive all edges.

For the *anterolateral condylar ridge of the tibial plateau*:

1. Measure the length and width of this area.

2. Fashion a piece of *soft felt*, 1/8-in. thick, to the dimensions obtained in step 1 (fig. 5).

3. Round off all corners and neatly skive the entire periphery. This results in an oval-shaped condylar-ridge relief pad.



Fig. 5



Figs. 6 and 7

#### *Application of Pressure-Relief Pads*

1. Spray all felt relief pads with Dow Corning Medical Adhesive Type B on the reverse, or unskived, side and allow the adhesive to dry for five seconds.

2. Spray the appropriate areas on the cast sock where the relief pads will be

located and allow the adhesive to dry for five seconds.

3. Apply the felt relief pads in their pre-established locations and recheck to be sure they adequately cover the bony prominences on the stump (figs. 6 and 7).

#### *Stump Measurements*

1. Remind the patient to maintain his stump in an attitude of 35° of flexion, with the stump musculature relaxed.

2. Place the appropriate portion of the VAPC knee-measuring caliper on the femoral condyles. Measure the mediolateral stump diameter and record on the prosthetic-information form (fig. 8).

3. Place the appropriate portion of the VAPC knee-measuring caliper on the patellar tendon and the popliteal tissues. With the stump relaxed, measure the anteroposterior diameter and record on the prosthetic-information form (fig. 9).

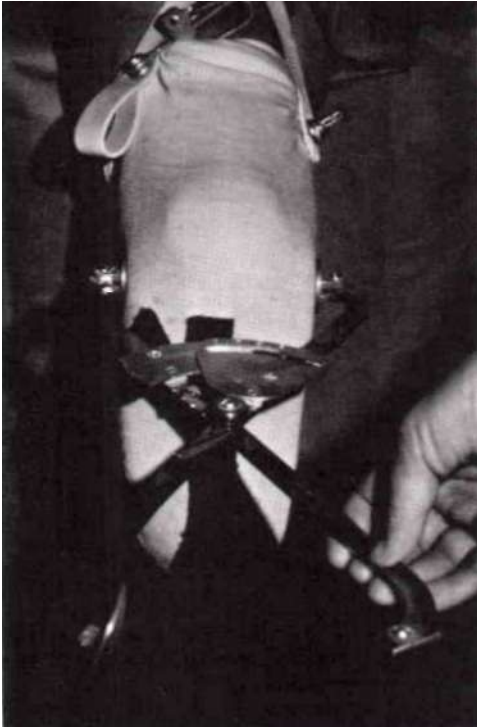
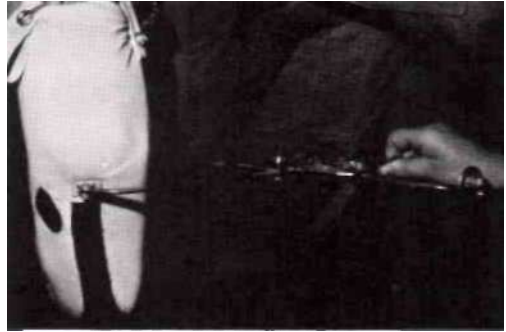


Fig. 8



Kg. 9

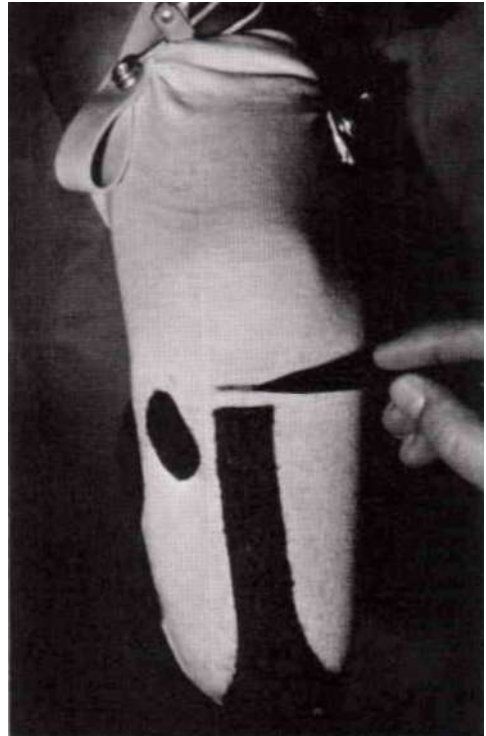


Fig. 10

4. Mark the apex of the patellar tendon with an indelible pencil (fig. 10). Place one end of the combination square rule on the patellar tendon and rest the blade of the rule against the long axis of the tibial-crest felt relief pad. Square the distal stump end and record the resulting stump-length measurement in the appropriate box on the prosthetic-information form.



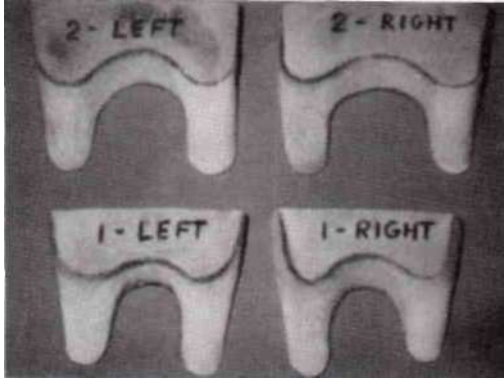


Fig. 11

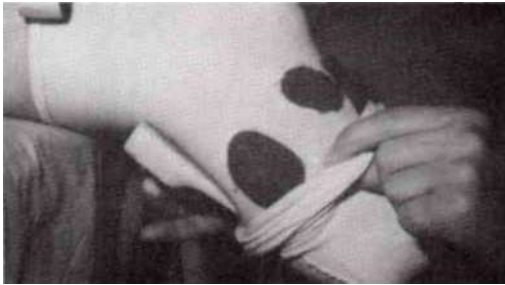


Fig. 12

#### *Second Cast Sock and Hamstring-Tendon Relief*

1. The second cast sock, lightweight, is applied very wet. Carefully roll the sock onto the stump without displacing the previously applied felt relief pads.

2. The posterior socket brim line should have a well-rounded flare for comfort during prolonged sitting. Appropriate relief for the hamstring tendons provides additional comfort when the knee is maintained in an attitude of  $90^\circ$  of flexion. For this purpose, two standard sets of relief pads in sizes large and average are fashioned from one-inch-thick piano felt. Each set consists of a right and left relief pad. They must resemble the finished rounded contours of the posterior socket brim and include skived distal projections for medial and lateral hamstring-tendon relief. Pad selection is based on matching the distal projections against the hamstring tendons.

Select a right or left piano-felt hamstring-tendon relief pad of the proper size (fig. 11) and place it at the approximate level of the posterior socket brim behind the knee, between the first and second cast socks (fig. 12). The projections on either side of the relief pad should be located directly over the hamstring tendons behind the knee. Maintain the knee in  $35^\circ$  of flexion.

3. With the hamstrings relief pad in place, the second, or lightweight, cast sock is pulled up tight and attached with Yates clamps to a second 1-in. elastic-webbing strap which encircles the amputee's hips and crosses the amputated leg approximately 4 in. above the patella (fig. 13). This elastic-webbing strap must also



Fig. 13

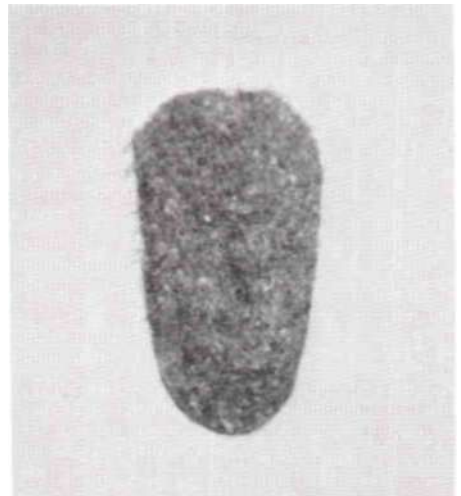
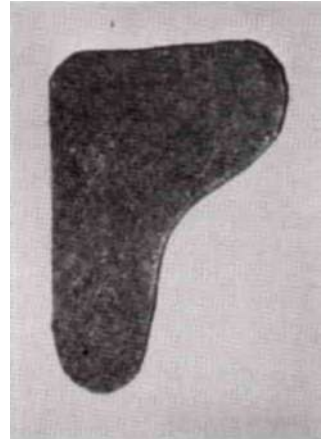
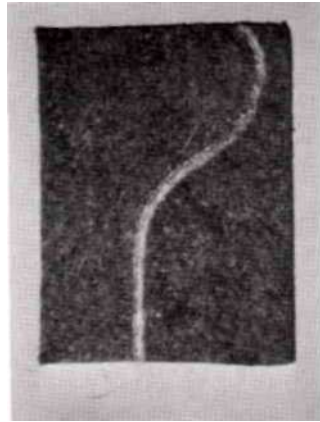
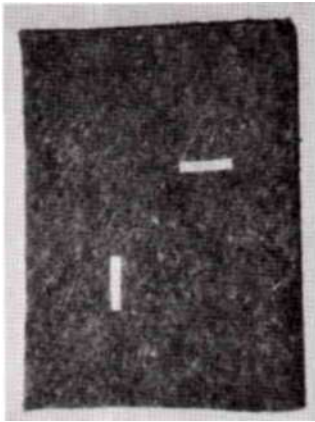


Fig. 14



Figs. 15, 16, and 17

exert considerable tension on the second cast sock, without creating wrinkles.

4. Recheck all felt relief pads for retention of their proper locations and adjust if indicated.

#### *Preparation of Compression Pads*

By palpation, locate the surfaces of the stump which are pressure tolerant.

For the *pretibial area lateral to the tibial crest*:

1. Measure the length of the crest of the tibia from the inferior border of the anterior tibial tubercle to within 1/2 in. of the anterior cut end of the tibia.

2. Measure the distance between the lateral edge of the previously applied tibial-relief pad to the anterior border of the fibular head.

3. Cut a piece of 3/8-in. *medium* felt to the dimensions recorded in steps 1 and 2.

4. Round off all corners of the pad. The entire periphery is now provided with a 1/2-in. skived border, with a uniform gradual taper, finishing in a feathered edge (fig. 14).

For the *pretibial area medial to the tibial crest*, including the medial tibial condylar flare:

1. Measure the length of the crest of the tibia from the inferior border of the tibial tubercle to within 1/2 in. of the anterior cut end of the tibia.

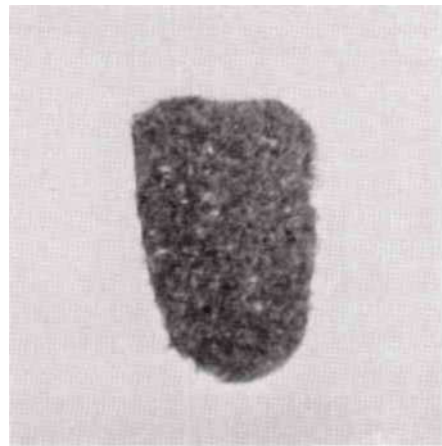


Fig. 18

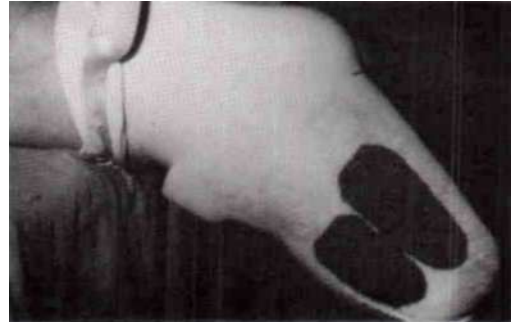
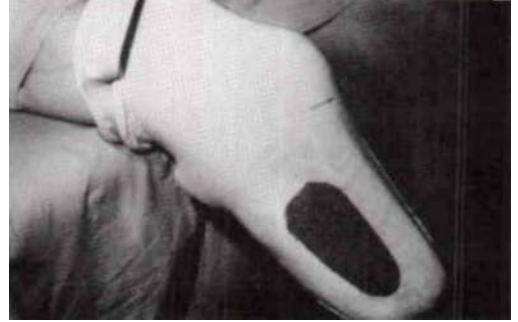
2. Measure the distance between the medial border of the previously applied tibial relief pad at the level of the tibial tubercle and the medial head of the gastrocnemius muscle.

3. Cut a piece of *medium* felt, 3/8-in. thick, to the dimensions recorded in steps 1 and 2.

4. Measure down from one end of the felt compression pad 2 in. and mark that point with chalk.

5. Palpate the width of the tibia medial to the crest and measure this distance.

6. Mark the felt compression pad at the same distance from the long edge one



Figs. 19, 20, and 21

inch below the mark made in step 4 (fig. 15). Mark on the felt compression pad a smooth S curve from the posterior edge of the felt to the marks in steps 4 and 5.

7. Continue the mark made in step 5 with a straight line to the distal end of the felt compression pad (fig. 16).

8. Cut the felt along the marked lines made in steps 4, 6, and 7 (fig. 17).

9. Round off all corners. The entire periphery of the felt compression pad is now provided with a 1/2-in. skived border, with a uniform, gradual taper, finishing in a feathered edge.

For the *long shaft of the fibula*:

1. Measure the length of the fibula from the inferior border of the head to within 1/2 in. of the distal cut end of the bone.

2. Measure the anteroposterior dimension of the head of the fibula.

3. Cut a piece of *medium* felt, 3/8-in. thick, to the dimensions recorded in steps 1 and 2 (fig. 18).

4. Round off all corners. The entire periphery of the fibular compression pad is now provided with a 1/4-in. skived border with a uniform, gradual taper, and finished in a feathered edge.

#### *Application of Compression Pads*

Apply the felt compression pads to the second (lightweight) sock.

1. Spray all felt relief pads with Dow Corning Medical Adhesive Type B on the reverse, or unskived, side and allow the adhesive to dry for five seconds.

2. Spray the corresponding areas of the cast sock where the felt compression pads will be located and allow the adhesive to dry for five seconds.



3. Carefully locate the felt compression pads in their pre-established positions on the thin cast sock (figs. 19, 20, 21). These pads *must not overlap* the areas of the previously applied pressure-relief pads. The felt compression pads should be in firm smooth contact with the thin cast sock to avoid reproduction of wrinkles, rough edges, or other irregularities in the plaster wrap.

#### *Application of Elastic Plaster Bandage*

*Wraps One and Two.* The wrap is always started on the distal lateral aspect of the stump, approximately 1 in. from the distal stump end, to avoid medial displacement

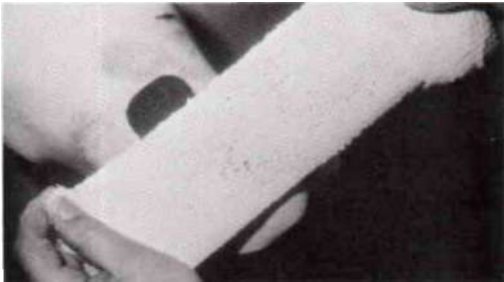


Fig. 22



Fig. 23

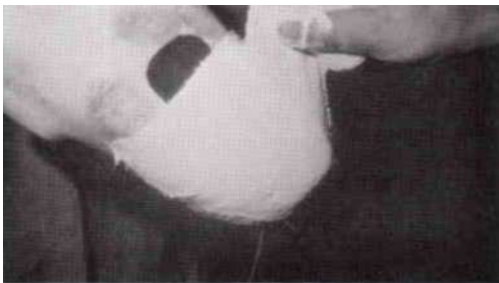


Fig. 24



Fig. 25

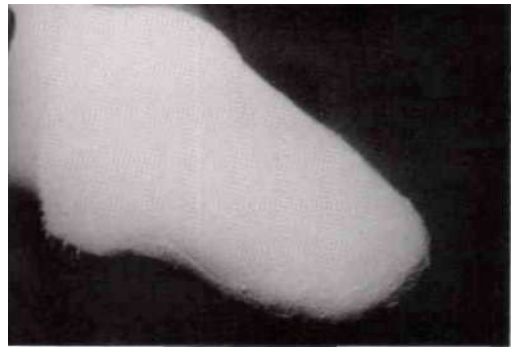
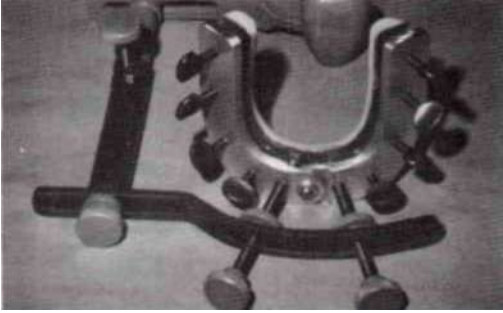


Fig. 26

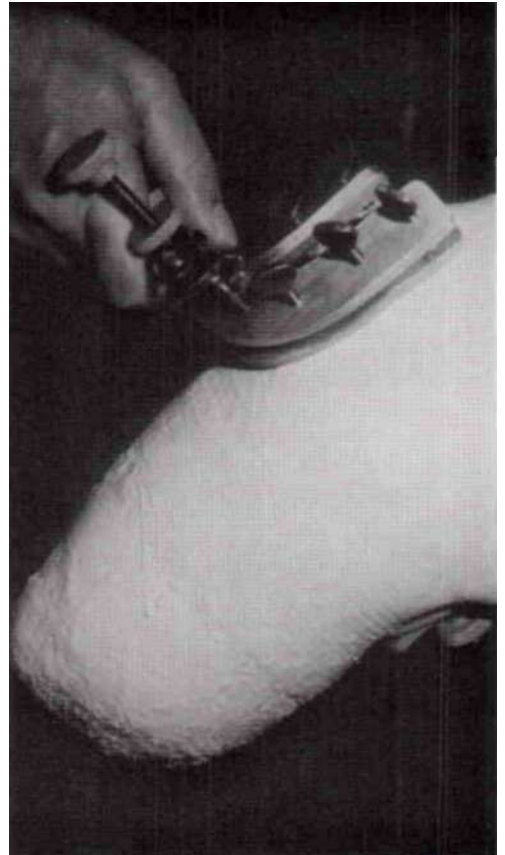
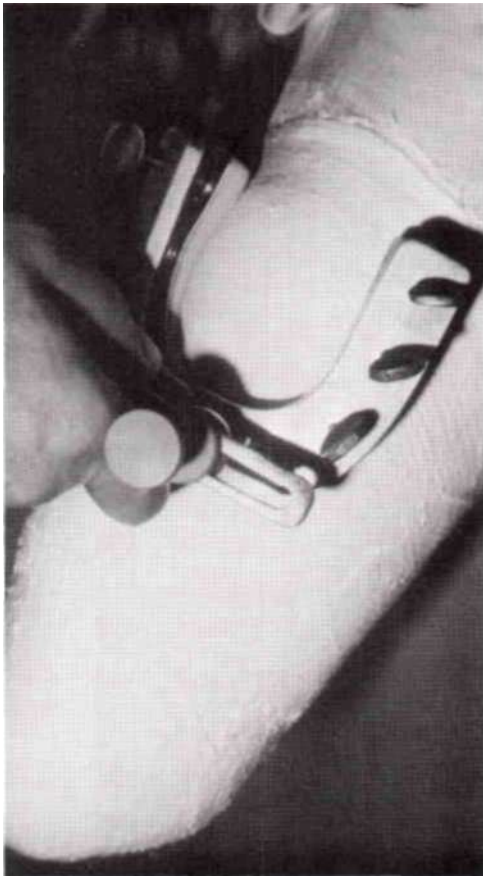
of the gastrocnemius muscle (fig. 22). Minimal tension is applied to the bandage with this circumferential wrap, which is applied clockwise for a right stump and counterclockwise for a left stump (viewed anteriorly). One and three-quarter circumferential wraps will secure the felt compression pads and anchor the elastic plaster bandage to itself (fig. 23).

*Wrap Three.* The wrap is now at a posterior-lateral point on the stump. Bring it anteriorly in a diagonal direction over the distal *lateral* portion of the stump, pulling the plaster bandage almost to its limit of elasticity. At the anterior stump margin, release the tension slightly and carry the wrap medially and then posteriorly, with only a slight pull to the plaster bandage (fig. 24).

*Wrap Four.* This wrap is almost identical to wrap three, except that now the bandage covers the distal *center* of the stump, bandaging in an anteroposterior plane. The direction of the wrap is altered anteriorly and carried toward the lateral



Figs. 27 and 28



Figs. 29 and 30

side of the stump, as if to resume circumferential wrapping.

*Wrap Five.* The wrap is brought anteriorly up over the distal *medial* stump aspect with the same controlled tension to the plaster bandage (fig. 25).

*Wrap Six.* To achieve sufficient cast strength, a second layer of elastic plaster bandage is applied by repeating wrap five.

*Wrap Seven.* Repeat wrap four, again altering the direction of the wrap to the medial side, which will cover the distal

center of the stump with a second layer of plaster bandage.

*Wrap Eight.* Repeating wrap three will now cover the distal *lateral* stump aspect with a second layer of plaster bandage. The remainder of the elastic bandage is wrapped in a circular manner to a level 1/2 in. superior to the adductor tubercle of the femur.

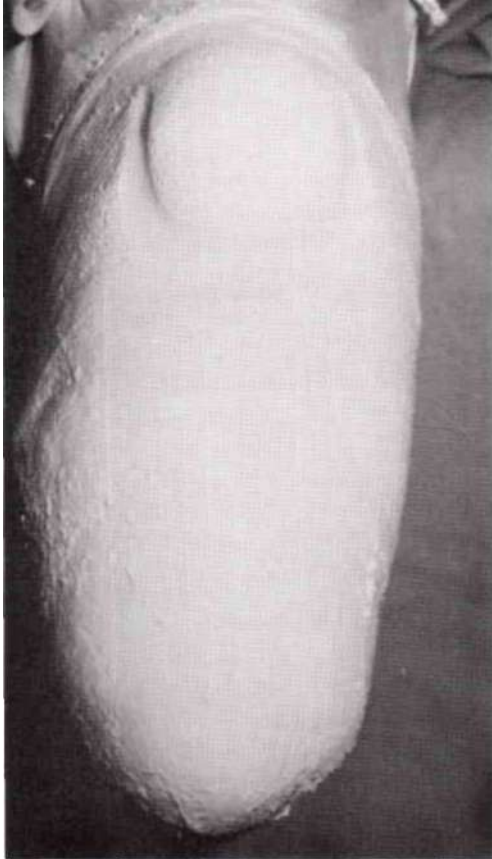


FIG. 31

A second roll of elastic plaster bandage is applied when indicated. Pull the plaster bandage firmly so that it conforms smoothly to the stump without leaving wrinkles or ridges. Maximum tension should be applied to the bandage distally, with gradually decreasing tension as the wrap is extended proximal to the knee joint. Smooth the plaster gently to assure complete adherence of all layers, but avoid molding of the plaster as it hardens (fig. 26).

#### *Application of Below-Knee PRS-Model Casting Fixture*

With the plaster still wet, apply the BK casting fixture (figs. 27 and 28).

1. Open the casting fixture and place the patellar bar on the patellar tendon.

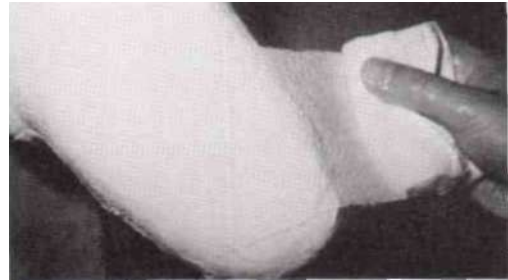
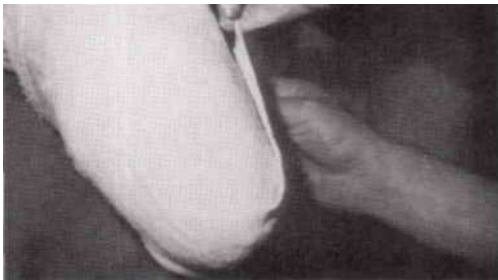
2. Push the patellar bar into the joint space until firm resistance is felt, then release slightly. Push in a direct line with the femur (fig. 29).

3. Attach the posterior popliteal section to the anterior portion of the casting fixture. Contouring of the plaster cast in the area of the popliteal space is achieved by joining the two sections of the casting fixture in proper relationship to the casted stump (fig. 30).

4. Be sure that the patient is completely relaxing his stump musculature and that the knee-flexion angle is maintained at 35°.

5. Adjust the casting fixture to the patellar size by rotating both halves of the patellar inverted-horseshoe section.

6. Recheck and maintain the outline of the patella. Make necessary adjustments by means of the thumbscrews as indicated.



FIGS. 32 and 33

7. Hold the casting fixture in place until the plaster has hardened completely. Check the distal end of the cast to determine final firmness of the plaster wrap.

8. Open the casting fixture and remove carefully (fig. 31).

#### *Reinforcement of Negative Plaster Wrap*

Apply conventional plaster bandage to reinforce the cast.

1. Two double layers of 4 in. x 15 in. plaster splints are applied over the distal portion of the cast, one anteroposteriorly and one mediolaterally (fig. 32).

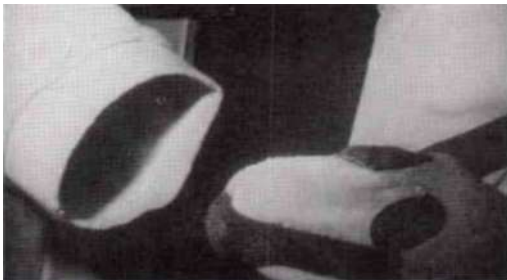
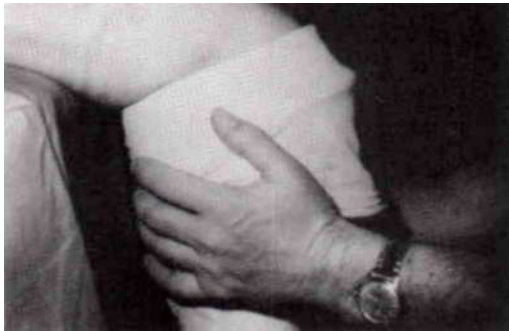


Fig. 37

2. Reinforcement of the plaster wrap is completed with a roll of 4-in. conventional plaster bandage, starting at the distal stump aspect (fig. 33) and wrapping proximally with even, overlapping, circular wraps.

#### *Removal of Negative Plaster Wrap*

Remove the cast negative only after the plaster wrap has completely hardened.

1. Release both elastic-webbing straps which hold the cast socks suspended.

2. Roll the proximal portion of the second (or thin) cast sock down over the brim of the cast negative.

3. Remove the posterior piano-felt hamstring-relief pad from between cast socks 1 and 2. If necessary, use a pair of long-nose pliers or the equivalent (fig. 34).

4. Roll the top of the first (or heavy) cast sock down over the brim of the plaster wrap.

5. Place your fingers in the popliteal space and your thumbs in the patellar-tendon depressions. Direct the amputee to completely relax his stump.

6. With the amputee's knee flexed and relaxed, pull the proximal portion of the plaster wrap towards you to release the area of the patellar tendon by compression of the posterior soft tissue (fig. 35).

7. Carefully remove the first (or heavy) inner cast sock from the negative (fig. 36). Be extremely careful not to disturb the thin cast sock that adheres to the inside of the plaster-cast negative.

8. Inspect the cast critically to be sure that it is smooth and well contoured throughout (fig. 37).



### *Negative Plaster-Cast Measurements*

To check the inside dimensions of the cast negative:

1. Place the inside calipers in the cast to measure the anterior-posterior dimensions between the patellar-tendon shelf and the posterior popliteal bulge. Record this measurement on the prosthetic information form, side B. The measurement should be the same as the AP dimension plus 1/8 inch.

2. Place the inside calipers in the cast at the level of the medial and lateral condyles of the femur. Record this measurement on the prosthetic information form, side B. The dimension should not be more than 3/8 inch larger than the ML stump dimension.



Fig. 38

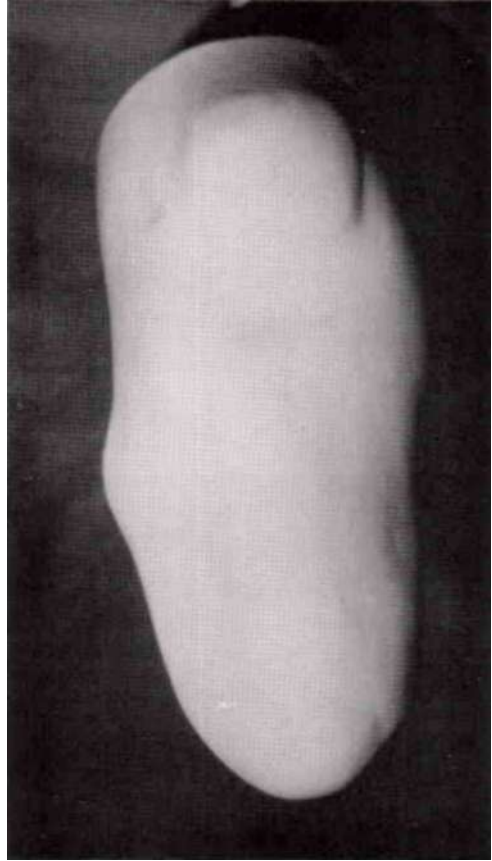


Fig. 39

To check the length of the cast:

1. Place a ruler in the socket and measure the dimension from the deepest point of the cast to the center of the patellar-tendon bar. Keep the edge of the ruler parallel to the line of the crest of the tibia.

2. Compare this measurement to the length of the stump dimension on the prosthetic information form. It must be within 1/8 inch of the recorded length.

NOTE: If any of the measurements recorded in steps 1 and 2 are not within the tolerances stated and cannot be reconciled by remeasurement of the stump, it will be necessary to make a new negative plaster wrap. Also, a new plaster negative must be taken if the plaster wrap has collapsed or if the wrap shows deep ridges or other severe irregularities.



## THE NEGATIVE-POSITIVE PLASTER MOLD

*The Positive Cast Model*

1. Fill the negative wrap cast with liquid plaster of paris in the usual manner.

2. As the plaster begins to harden, insert a length of vacuum pipe to a sufficient depth, but avoid contacting the negative plaster wrap.

3. After the plaster has set for 20 to 30 minutes, cut and strip off all wraps, exposing the positive model. Be careful not to disturb the contours of the model (fig. 38).

4. If necessary, fill all holes in the model left by air bubbles in the plaster. Usually, this will not be necessary if proper care has been taken when filling the negative-cast wrap.

5. With a Surform (TM) rasp, smooth off all minor bumps and the irregularities on the model caused by the seam in the cast sock.

6. Provide a final smooth finish over the entire model with screen wire and finish with wet-or-dry Fabricut (TM) silicon carbide, 180 grit (fig. 39). (Screen-baked Durite [TM] would be equally satisfactory.)

7. Seal the completed plaster model positive with Hosmer-Lac or the equivalent to prevent the dampness in the plaster from affecting the inner PVA bag during lamination.

## SOCKET FABRICATION

Proceed with the standard PTB lay-up used for fabricating a polyester hard-socket laminate. The resulting prosthetic socket accommodates the stump very snugly, in most instances with a three-ply wool stump sock. If preferred, the conventional Kemblo (TM) insert can be prepared in the usual manner prior to the polyester lamination procedure.

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