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Artificial Limbs

*A Review of
Current Developments*

COMMITTEE ON PROSTHETICS
RESEARCH AND DEVELOPMENT

COMMITTEE ON PROSTHETIC-
ORTHOTIC EDUCATION

**National Academy of Sciences
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Artificial Limbs

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Evaluation

FRANK W. CLIPPINGER, M D ¹

Formal and systematic evaluation of materials, fabrication techniques, and components is not only a desirable, but an essential, step in the field of prosthetics and orthotics. Simply having an idea, publicizing it, and letting it "succeed" or "fail" on its merits in general use does not suffice, given the variety of disciplines involved, the financial outlays required for tooling and manufacturing, and the difficulties concomitant with conveying detailed technical information in print.

We have had experience with hit-or-miss "progress" in the past. From the early nineteenth century to 1945, it was difficult to try out others' innovations; it was not worthwhile to innovate one's self; and, both financially and emotionally, the old, tried-and-true processes appeared to be best. It was enough to use something that was relatively effective, economical, and fairly reliable. It is not hard to see why little change occurred.

Since 1945, there has been a new, organized emphasis on the detailed study of patients' problems, and the availability of public funds for research, development, and service has made the application of new ideas practical. Gait mechanisms, hand functions, skin difficulties, and emotional reactions to disability and cosmetic impairment have been studied in detail. New materials have appeared at a rapid rate, and new techniques for their application to the patient have evolved. For instance, plastic molding has revolutionized the technology of prosthetics.

Today, the need is not simply to provide the patient with just any device as a substitute for his impairment, but to get for him the best we can provide: the most functional, comfortable, practical, economical, and satisfying restoration of which we are capable.

The increasing complexity of prostheses and orthoses, while it may result in better function, requires more training of personnel and greater financial outlay. It is not practical to try everything on a wide scale. It is necessary to sift out the best for general use. This process is *evaluation*.

Evaluation has three phases. First, the developer must conduct studies on his own. Will his idea work when applied to a patient? Will it do any harm? Is it possible to make the component?

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Second, trial on a wider scale must be performed. This is best done by a second party who can answer questions such as: Can the developers' results be reproduced by others? Is the technique teachable and how? Will the components survive normal wear and tear? Can the process be made applicable to patients other than those for which it was specifically designed? Are modifications of design or material needed?

Third, the final test is that of acceptance by the people ultimately concerned: the patients, prosthetists, orthotists, physicians, and agencies who have the responsibility to prescribe, purchase, make, and use these products of imagination and technology.

A major problem has been that of transition from the design and development phase to the availability of new techniques and materials to the patient. It is in expediting this transition that an organization such as the Committee on Prosthetics Research and Development, through its Subcommittee on Evaluation, must be active. This is a group which can, without bias, coordinate the efforts of developers, manufacturers, and consumers.

CPRD is in the unique position of having knowledge of, and access to, many scientific and clinical programs throughout the world that will cooperate in trying new products of research. Under the auspices of the National Academy of Sciences—National Research Council, knowledgeable people can be brought together, learn a technique from a developer, try it in their local area, and then meet again for criticism and discussion. Experience can thus be obtained, the need for teaching materials can be assessed and manuals developed, and problems that were not readily apparent in the early phases of development can be identified. Above all, duplication of effort can be kept to a minimum, and unnecessary expenditures of money for development and manufacture can be avoided.

Excellent examples of the role of CPRD appear in this issue of *Artificial Limbs*. Electrically powered prosthetic elbows have become popular items for development. Several designs have arisen, all of which could have been rather costly, in terms of both time and money, to develop and manufacture. By means of the Evaluation Program, specifications have been adjusted, durability requirements established, patient acceptance assessed, and the need for various kinds of redesign noted. This has been done before anyone has committed himself to expensive tooling and the wide-scale manufacture of seemingly attractive items in an imperfect phase of development.

Modifications of techniques continually appear and are in fact a phase of the evaluation of an item; witness the continual development of casting techniques for prosthetic sockets and modification of the design of, and the clinical indications for, the Veterans Administration Prosthetics Center patellar-tendon-bearing brace. In short, evaluation is a critical part of any design and development process.

Rehabilitation Engineering is in its infancy. The next several years will show an exponential growth in the numbers of sophisticated people involved and the complex products of their brains. Identifying needs and sorting out the best and the most practical techniques and components for our patients will be a real challenge. We must be up to it.

Premodified Casting for the Patellar-Tendon-Bearing Prosthesis

Joseph H. Zettl. C.P.². and
Joseph E. Traub. C.P.¹

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.

¹ This work was supported in part by Veterans Administration Contract V663P-505.

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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

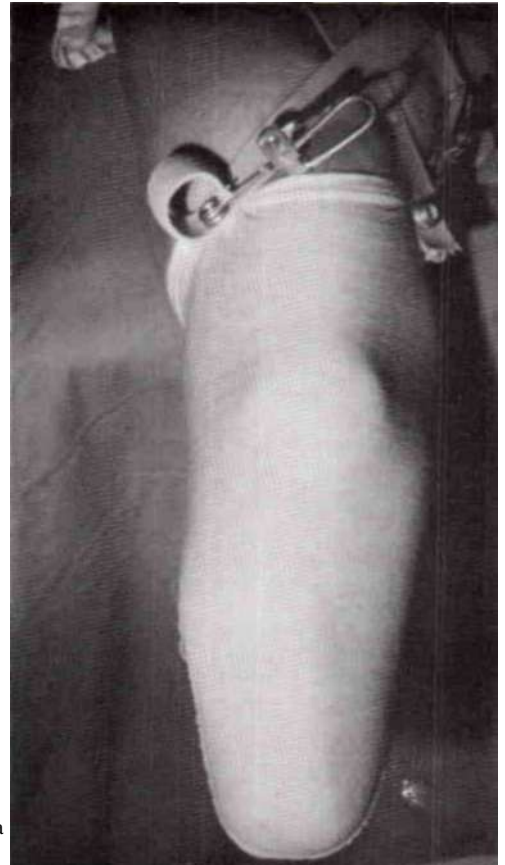


Fig. 2

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.

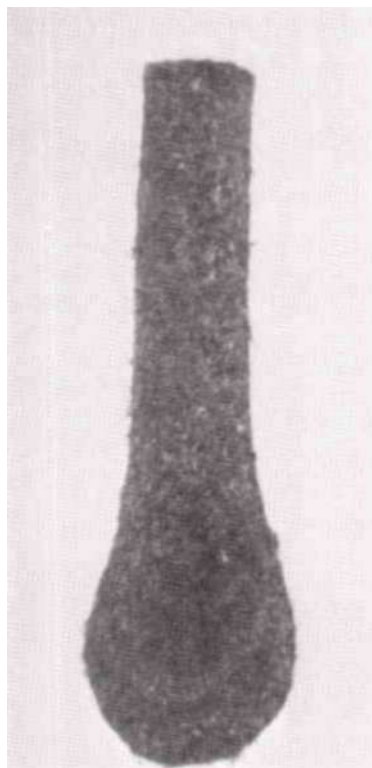


Fig. 3

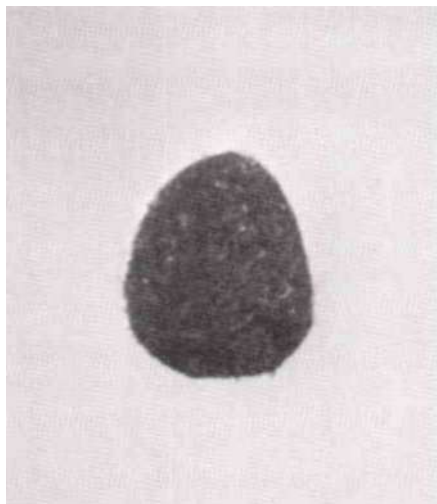


Fig. 4

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).

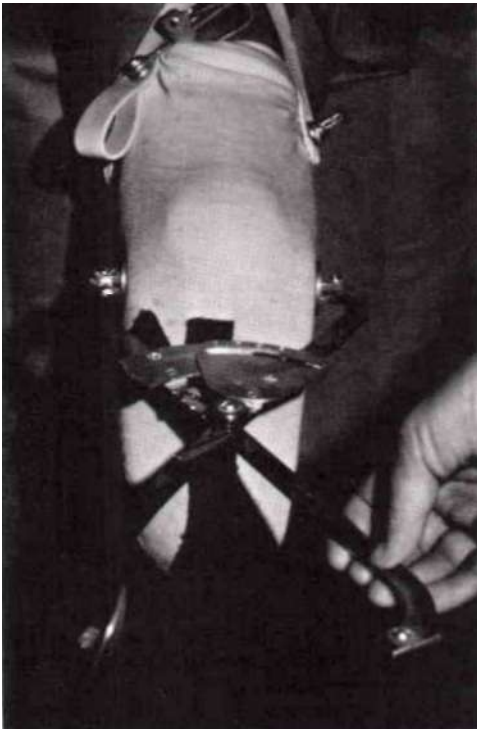
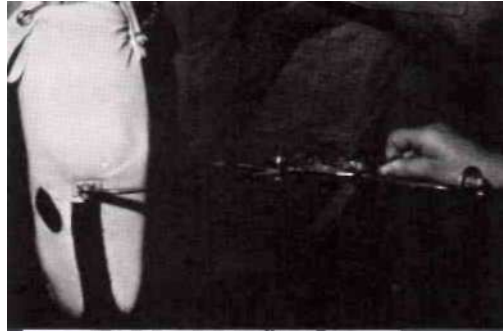


Fig. 8



Kg. 9

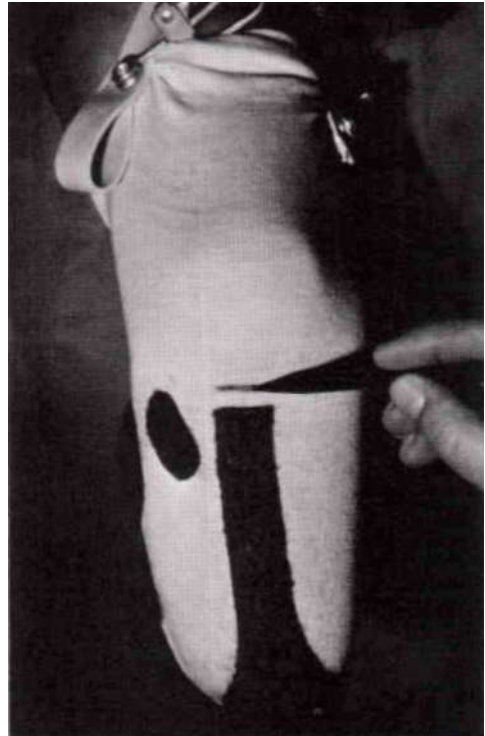


Fig. 10

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.

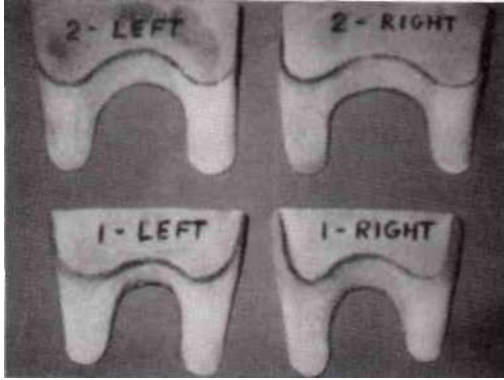


Fig. 11

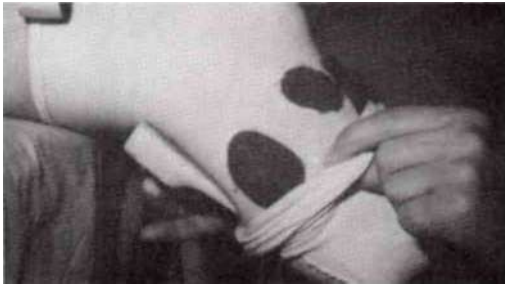


Fig. 12

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° 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° 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

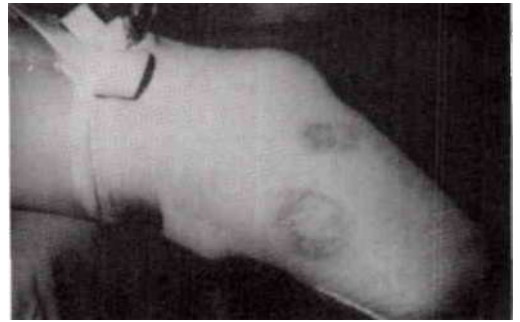


Fig. 13

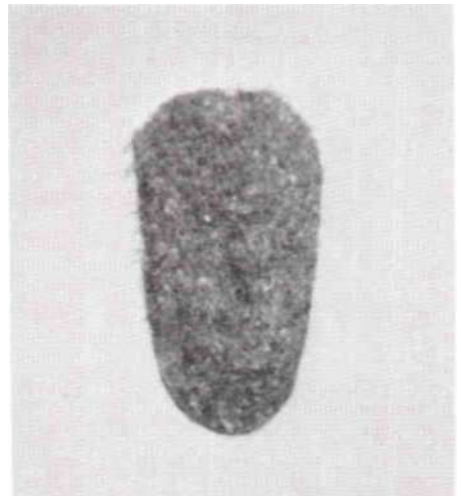
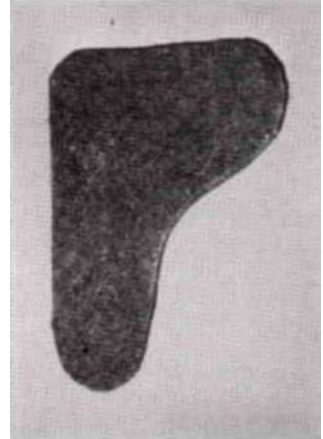
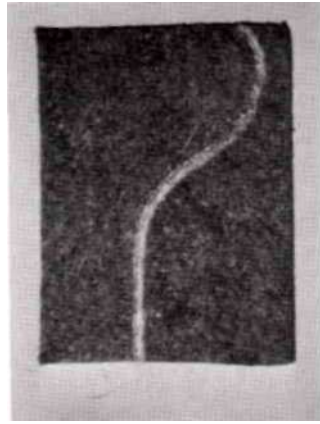
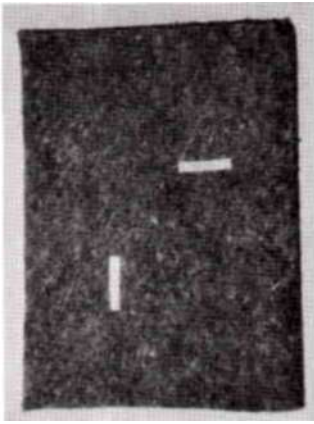


Fig. 14



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.

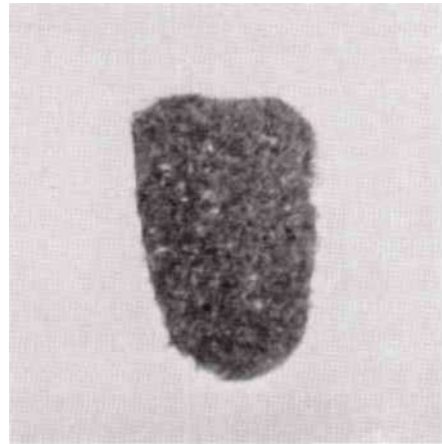


Fig. 18

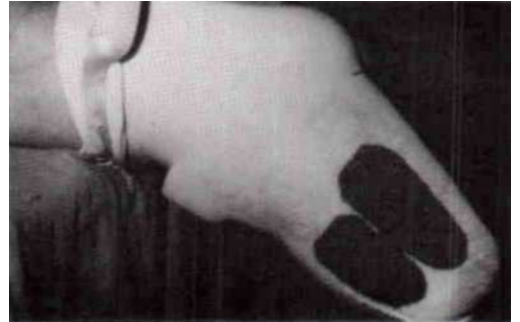
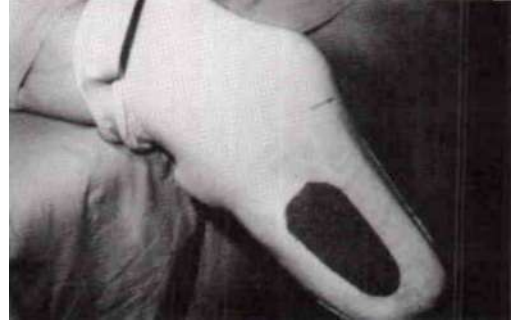
2. Measure the distance between the medial border of the previously applied tibial relief pad at the level of the tibial tubercle and the medial head of the gastrocnemius muscle.

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

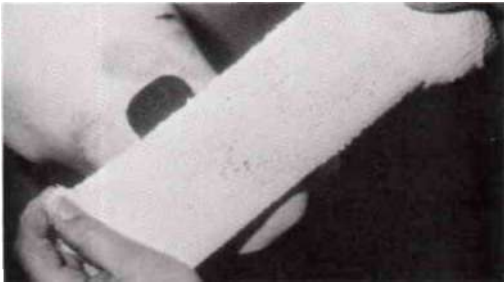


Fig. 22



Fig. 23

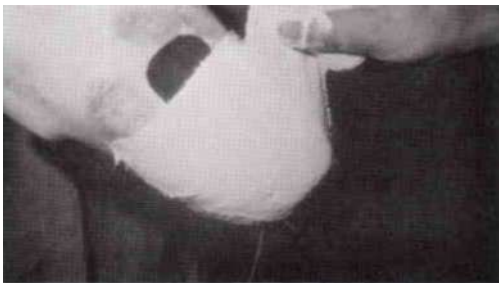


Fig. 24



Fig. 25

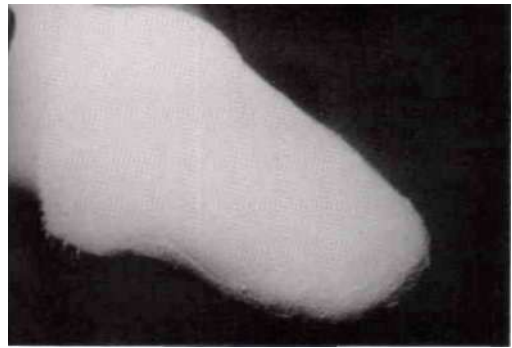
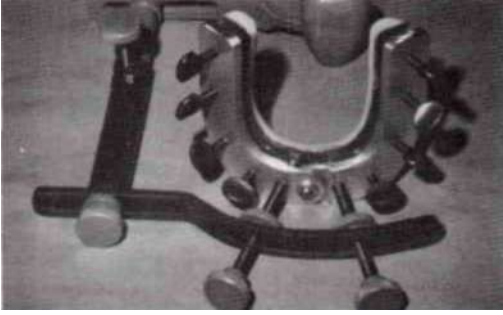


Fig. 26

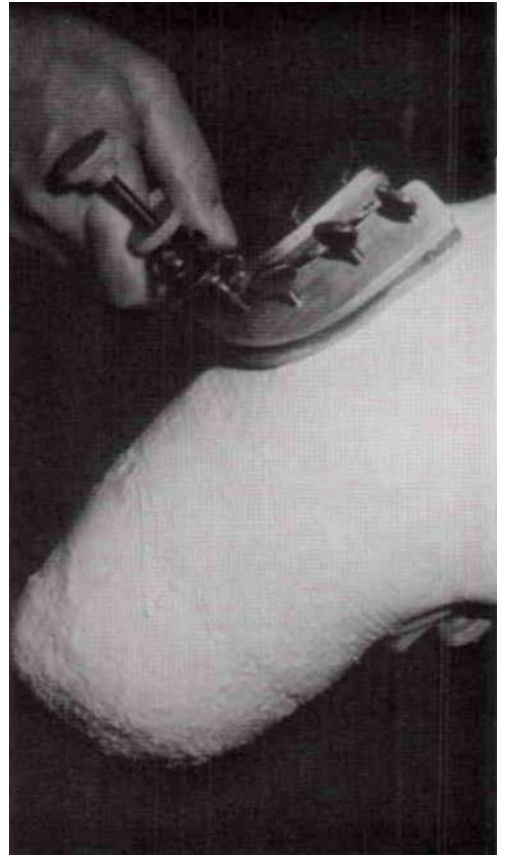
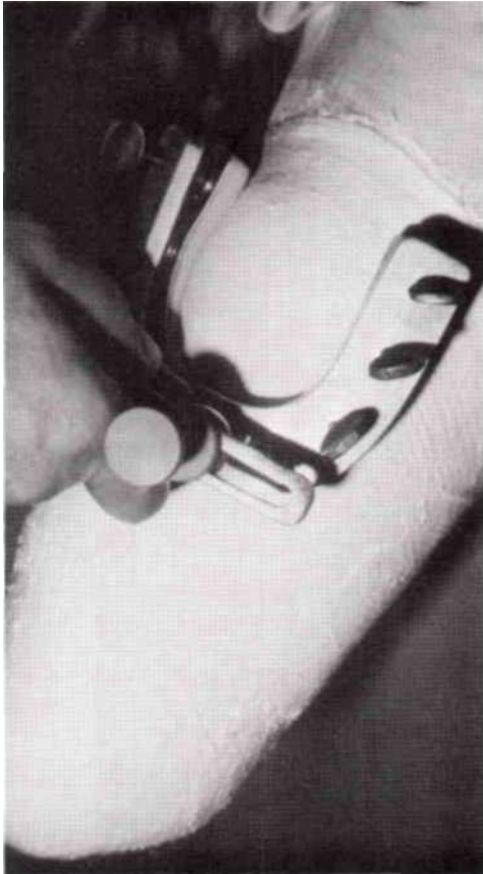
of the gastrocnemius muscle (fig. 22). Minimal tension is applied to the bandage with this circumferential wrap, which is applied clockwise for a right stump and counterclockwise for a left stump (viewed anteriorly). One and three-quarter circumferential wraps will secure the felt compression pads and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

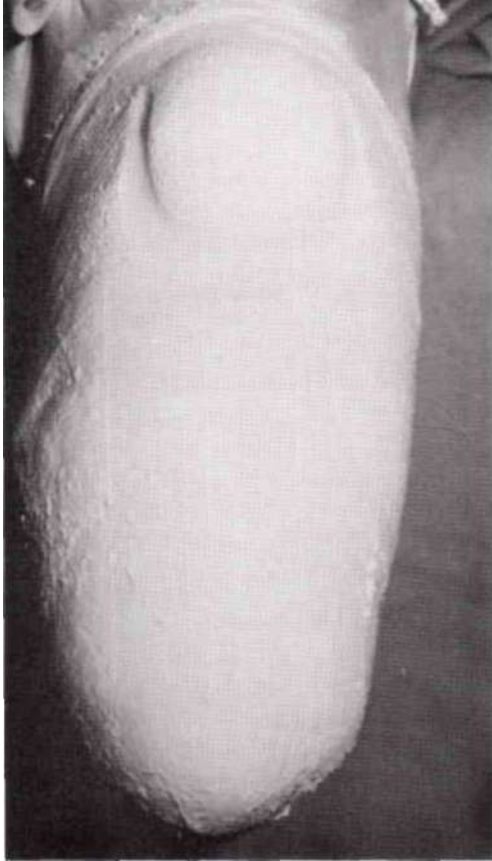


FIG. 31



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.

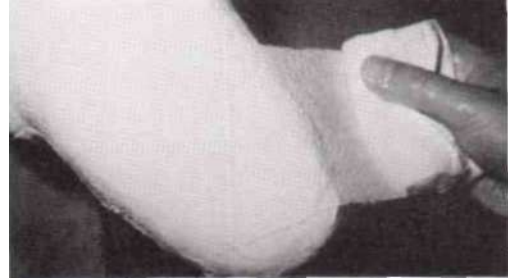
2. Push the patellar bar into the joint space until firm resistance is felt, then release slightly. Push in a direct line with the femur (fig. 29).

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. Makes 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).

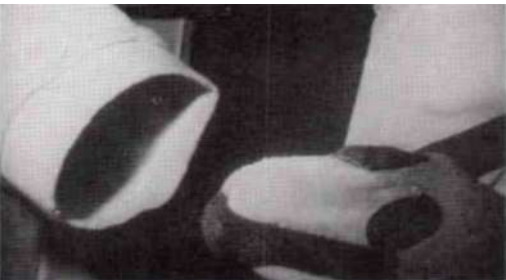


Fig. 37

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

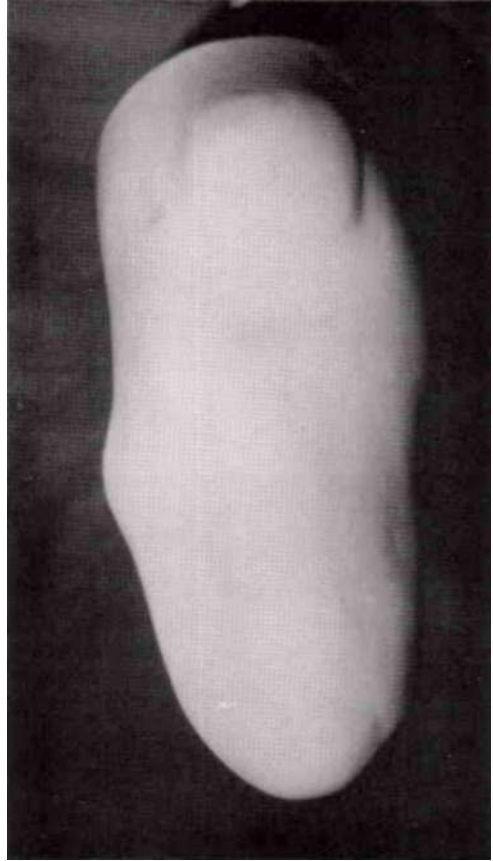


Fig. 39

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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Technique for Forming Sockets Directly on Above-Elbow Stumps

F. L. Hampton, C.P.² and
J. N. Billock, C.P.³

The ability to make a socket by applying a thermoplastic material such as Polysar X-414 (Polymer Corp. Ltd. TM) directly to an amputee's stump offers many advantages to the prosthetist, as pointed out by Wilson (4). Direct forming obviously eliminates the casting procedures necessary to produce a good modified replica of the stump and eliminates the laminating procedures necessary to produce the socket. The thermoplastic properties of Polysar X-414 allows quick postforming of the socket in areas which may require relief, and the material lends itself well to the attachment of components during assembly. These time-saving advantages enable the prosthetist to fit amputees with a temporary prosthesis much earlier than the time normally required for a definitive fitting. This hastens the amputee's rehabilitation and helps to condition him *and* his stump for the definitive prosthesis. The prosthetist also has the advantage of noting any corrections which are applicable to the definitive prosthesis. These advantages are also helpful to the research prosthetist, for he can save valuable time in evaluating new control techniques and testing new components.

A direct-forming technique related to those developed by Staros and Gardner (3) for below-knee PTB sockets and by Labate and Pirrello (1) for below-elbow sockets using Polysar X-414 has been de-

veloped for above-elbow sockets. If done properly, this technique will provide a well-fitting socket which has the above-mentioned advantages. A complete above-elbow prosthesis can be fabricated in approximately three hours.

The technique was used at this center to construct Polysar sockets for four above-elbow amputees who participated in an evaluation study of externally powered upper-extremity prosthetic components. Each amputee (described briefly below) wore his prosthesis successfully for two hours a day, three days a week, during a two-month period without problems.

D. H., a 38-year-old male, with a right above-elbow amputation 11 in. distal to acromion, acquired in June 1964. He was fitted with a standard above-elbow prosthesis, which he has used actively as a laborer since.

R. W., a 35-year-old male congenital amputee, with a right 11-in. above-elbow stump from the acromion. He was fitted with his first standard above-elbow prosthesis in June 1954, and has been an active prosthesis wearer since that time. He is presently employed as a hotel clerk.

J. H., a 44-year-old male with a left above-elbow amputation 8% in. distal to the acromion, acquired in March 1964. He was fitted with a standard above-elbow prosthesis and has been an active prosthesis wearer since that time. He is presently employed as a quality-control inspector for a leather factory.

R. R., a 22-year-old male with a left above-elbow amputation 9 1/2 in. distal to the acromion, acquired in November 1968. He was fitted with a standard above-elbow prosthesis and has used it actively since.

¹This work was supported by Veterans Administration Contract V1005M-1079.

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³Research Prosthetist, Northwestern University Prosthetic Research Center.



Fig. 1. Tubular gauze suspended with elastic webbing.

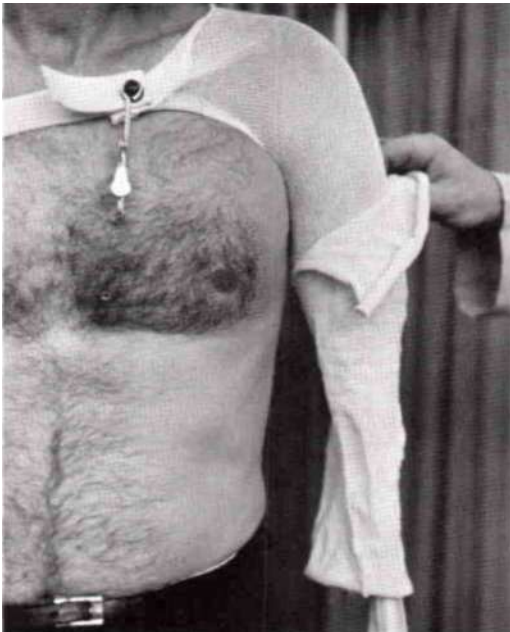


Fig. 2. Heavy cast sock applied to distal one-third of stump.

He is a student in college at the present time.

MATERIALS AND EQUIPMENT

A tube of the synthetic rubber 3 in. ID x 1/4 in. x 12 in. is adequate for the average above-elbow stump. The diameter can be reduced for smaller stumps by elongating the tube after it has been heated. Larger sizes of tubing should be used for larger stumps.

The only special equipment needed is a deep, water-filled container, approximately 20 in. in height and 8 in. in diameter. The water should be preheated to a temperature of 160° F to 180° F.

The following materials and equipment should be available within the prosthetic facility:

- Two 1 in. x 40 in. elastic webbings
- Four Yates clamps
- Tubegauz (TM), size #56 (tubular gauze)
- Heavy cast sock
- Braided Dacron (TM) line, approximately 130-lb-test
- Standard Hosmer elbow turntable
- Hose clamp, expandable to 11-in. circumference
- Hot plate
- Parallel bar
- Pressure-sensitive tape

PREPARATIONS FOR CASTING

Cut a length of tubular gauze approximately 18 in. longer than the stump and slit it 6 in. from the proximal end. Apply the tubular gauze with the slit in the axilla, allowing the tubular gauze to encompass the shoulder proximal to the acromion process. Pass a piece of 1-in. elastic webbing under the axilla on the sound side and attach it to the anterior and posterior wings of the tubular gauze (fig. 1). Cut the toe from a heavy cast sock and slit the proximal end in the same manner as the tubular gauze. Pull the cast sock on the distal third of the stump, with the slit under the axilla (fig. 2).

Mark the proximal section of the synthetic rubber tube to be cut out for the axilla. The width of the section will depend on the stump size, and the depth



Fig. 3. Cutting out axilla section after tube is heated.



Fig. 5. Medial edge rolled to provide a good flare for axilla.



Fig. 4. Synthetic rubber tube stretched at axilla level.

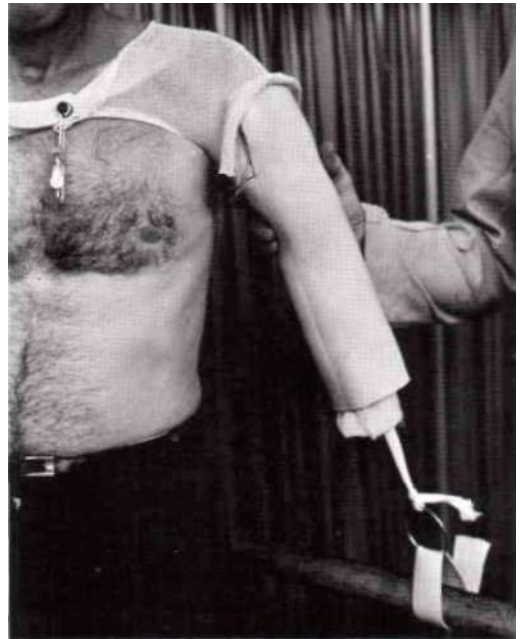


Fig. 6. Synthetic rubber tube applied to the distal end of the stump and t

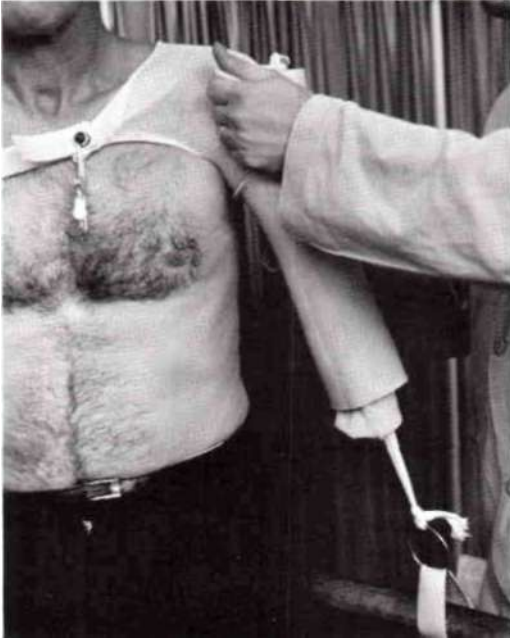


Fig. 7. Synthetic rubber tube is pulled up the stump.

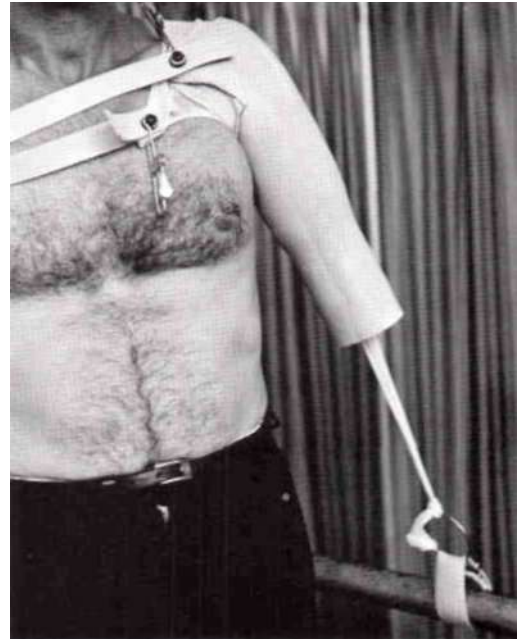


Fig. 8. The tube suspended with elastic webbing.

must be sufficient to allow the synthetic rubber to pass over the acromion. The synthetic rubber stretches well; therefore, caution should be taken not to cut out too large a section. For average stumps, a section 3 in. x 3 in. is adequate.

Completely immerse the synthetic rubber tube in the preheated water. The tube will rise to the surface when it has reached the appropriate temperature. Remove it from the water and cut out the axilla section (fig. 3). Allow the tube to cool until the hand may be placed inside the tube without discomfort.

APPLICATION OF SYNTHETIC RUBBER

Stretch the proximal end of the tube at the axilla level to aid in starting the tube on the stump (fig. 4). Roll the axilla edge to provide a good flare for the axilla (fig. 5). Insert the tubular gauze and cast sock through the tube and apply the tube to the distal third of the stump.

The tubular gauze is anchored to a parallel bar so that the amputee can



Fig. 9. Left hand in the axilla and right hand contouring distal end of socket to accept elbow turntable



Fig. 10. Right hand contouring the proximal socket.

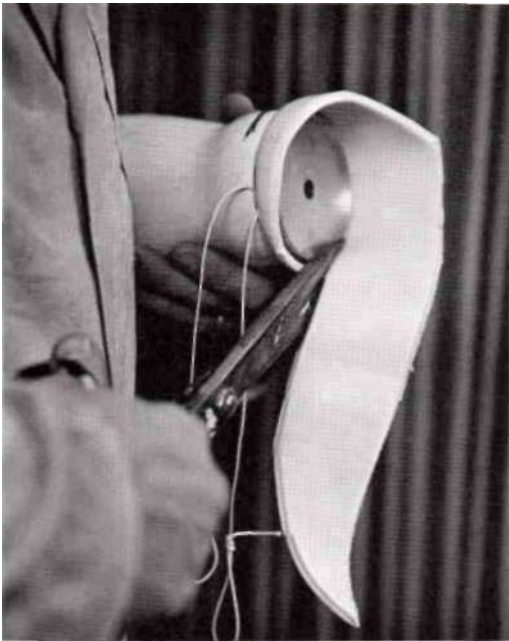


Fig. 11. Turntable tied in place and excess synthetic rubber trimmed.

apply tension on the tubular gauze. The tension will compress the stump tissues and prevent tissue-bunching while the synthetic rubber tube is being applied. An adjustable webbing belt with an O ring is used as the anchoring point on the parallel bar (fig. 6).

Stand the amputee away from the parallel bar with the stump in abduction and the shoulder in depression. This will assist in placing the tube well into the axilla. Pull the synthetic rubber tube onto the stump, using the cast sock to work it up the stump (fig. 7). Make sure it is well into the axilla and over the acromion. Support the tube with a piece of elastic webbing in the same manner as the tubular gauze (fig. 8). This will also aid in forming the proximal end of the socket. Eliminate any wrinkles in the cast sock by pulling on it at the distal end of the tube.

CONTOURING THE SOCKET

When contouring the socket for a left amputee, place the left hand firmly into the axilla, keeping the hand parallel to the sagittal plane. Have the amputee move back to the parallel bar, adduct his stump, and elevate his shoulder to the neutral position (fig. 9).

Firm tension should be maintained on the tubular gauze without causing the amputee to strain. Only the shoulder muscles should be used to maintain the tension. The finished socket will be loose if the stump muscles are contracted during contouring of the socket.

Reduce the diameter of the synthetic rubber distally to conform to the stump and to approximate the circumference of the turntable if necessary (fig. 9). Mold the proximal section by placing the right hand so that the thumb and forefinger outline the anterior and posterior borders of the deltoid muscle group. The thumb is used to mold the anterior wing, and the remaining fingers to mold the posterior wing (fig. 10). Hold the socket in this



Fig. 12. Socket compressed against turntable with pressure-sensitive tape.

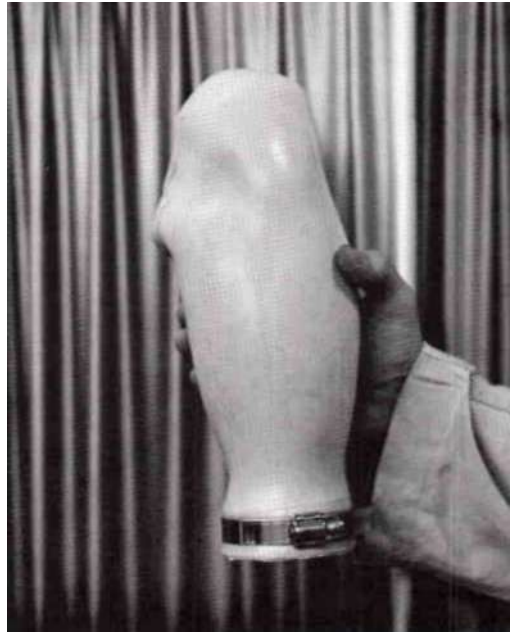
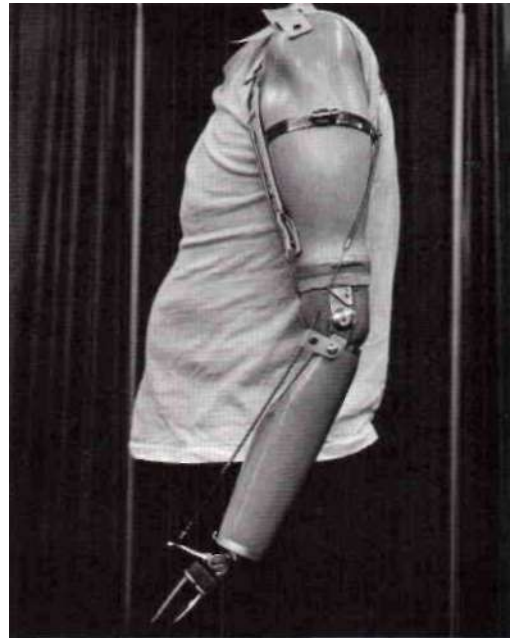


Fig. 13. Turntable attached with hose clamp.



Figs. 14 and 15. The completed prosthesis,

manner until the synthetic rubber cools enough to retain the contours.

Mark the proximal trim line before removing the socket. Either the conventional trim line can be used or the open-shoulder described by McLaurin et al. (2). After the trim line is cut out, the edges can be finished with a felt cone, fine-sand cone, or toluene.

ATTACHMENT AND ALIGNMENT OF TURNTABLE

Determine the proper distance for the elbow center from the acromion process and mark where the turntable will be located on the tube. Reheat the distal end of the tube approximately one-half inch above the mark by immersing it in water. Insert the turntable into the tube and work the synthetic rubber into the knurling and tie-off groove. Secure the synthetic rubber by wrapping 130-lb-test, braided Dacron (TM) line around the tube and pulling it into the tie-off groove (fig. 11). Two passes of line are sufficient. Cut away the excess tubing and apply pressure-sensitive tape around the tube, making sure the synthetic rubber conforms to the turntable (fig. 12). A

hose clamp can be used for more strength if necessary (fig. 13).

Attach the elbow unit and forearm section and check the alignment of the turntable. If it is not properly aligned, reheat the distal end in water and realign.

The harness and cable system are attached in the conventional manner (figs. 14 and 15).

ACKNOWLEDGMENTS

The authors wish to thank Miss Carole Herhold and Dr. Dudley S. Childress for their help in the preparation of this report.

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Elastic-Liner Type of Syme Prosthesis: Basic Procedure and Variations

Maurice A. LeBlanc¹

In the past few years, a number of prosthetists have been fabricating elastic-liner types of Syme prostheses, and their procedures have been described in the litera-

thereby allowing greater strength (with no openings) and a smoother cosmetic finish (with no straps) while maintaining total contact and suspension (fig. 2). However, it

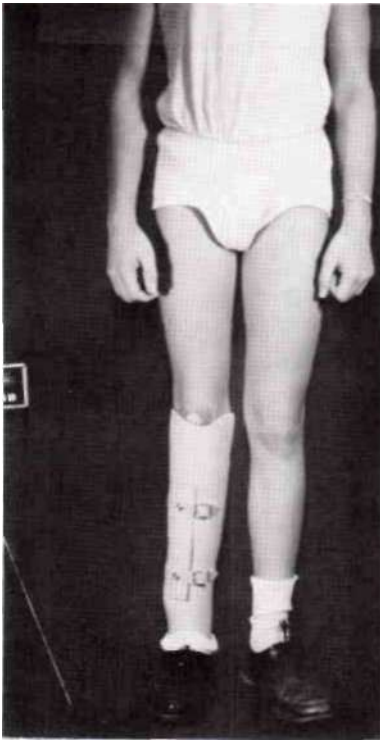


Fig. 1. Conventional Syme prosthesis.

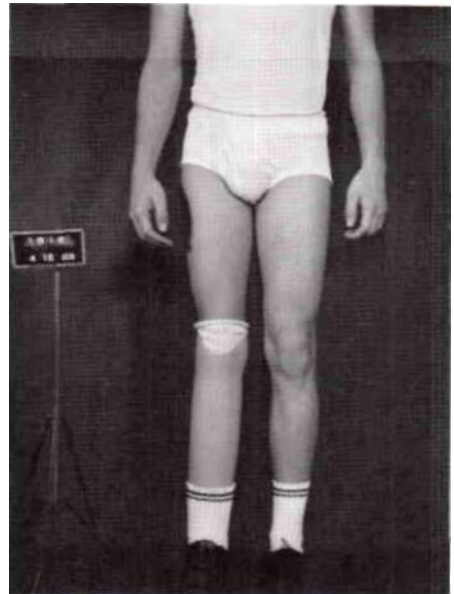


Fig. 2. Elastic-liner Syme prosthesis.

ture (1-5). This article presents the most commonly used procedure and some of the variations to it.

The elastic-liner type of Syme prosthesis has the advantage of eliminating the door on the conventional prosthesis (fig. 1),

cannot be used if the bulbous end of the stump is too large for satisfactory cosmesis of the cylindrical portion or for making the liner (not possible when the distal end is larger than the proximal brim).

BASIC PROCEDURE

1. Felt patches are placed on the stump for relief of bony prominences and/or sensitive areas.

2. A plaster cast is taken of the stump with partial weight-bearing and with blocks making up the length discrepancy.

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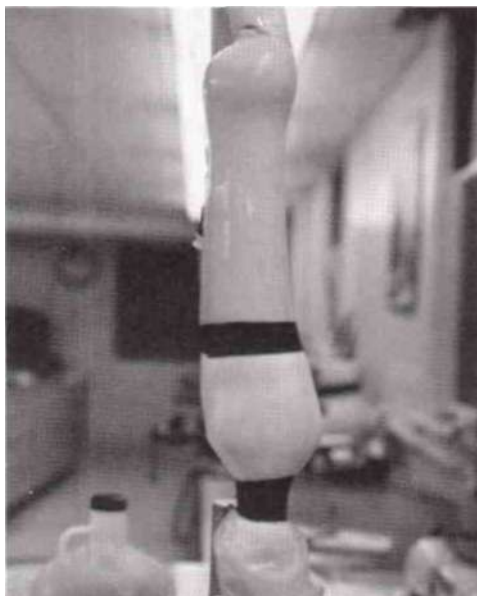


Fig. 3

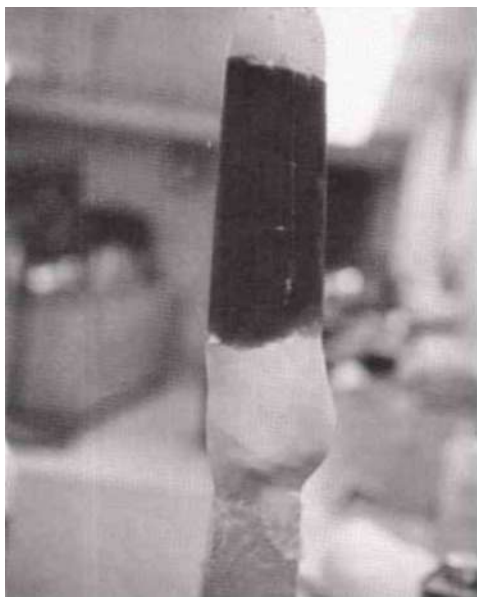


Fig. 4

3. The largest diameter of the bulbous end of the stump is measured, and the proximal level of the stump model is marked where its largest diameter equals that of the bulbous end.

4. Using nylon stockinette, the inner socket is vacuum-laminated with Silastic

(TM) elastomer #384 from the level marked in step 3 to the end of the stump (fig. 3).

5. The remainder of the inner socket (the proximal brim down to the level of the elastomer) is laminated with Laminac (TM) #4110 polyester resin.

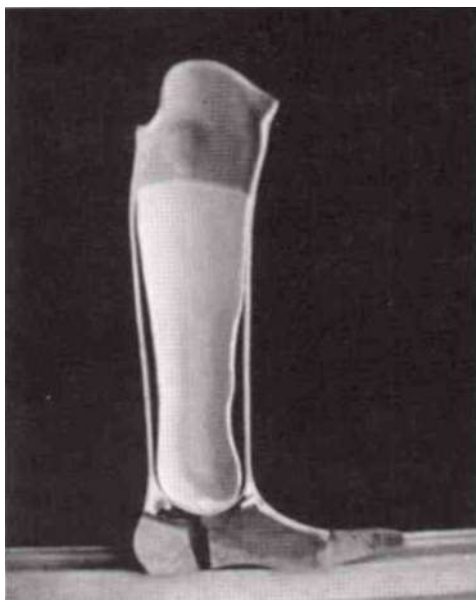


Fig. 5

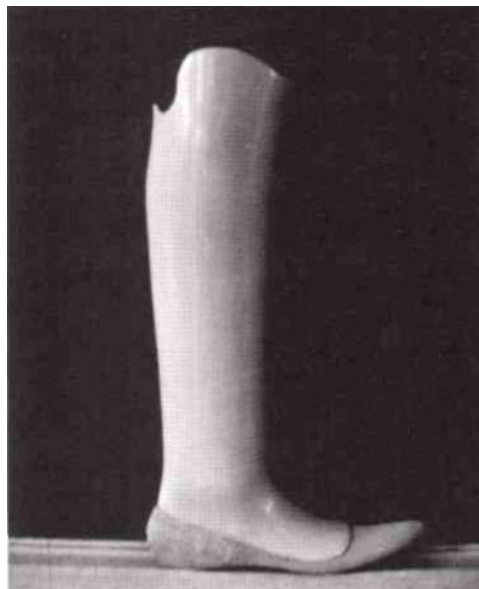


Fig. 6

6. A wax build-up is made over the center portion of the inner socket between the bulbous end and the level marked in step 3 (fig. 4). The build-up is cylindrical in shape to allow entry of the stump into the socket.

7. The outer shell of the socket is laminated with Laminac #4110. Figure 5 shows a cutaway view of the inner socket and outer shell of the prosthesis. Note that the end of the liner must be attached to the outer shell so it will not pull out with the stump.

8. Using reference lines established on the plaster cast, the socket is statically aligned following the attachment of a SACH foot which has been cut and shaped to receive the bulbous end of the socket. (There is normally about a three-inch height discrepancy with the Syme's amputation.)

9. The socket is then dynamically aligned to the amputee's gait. Depending on the

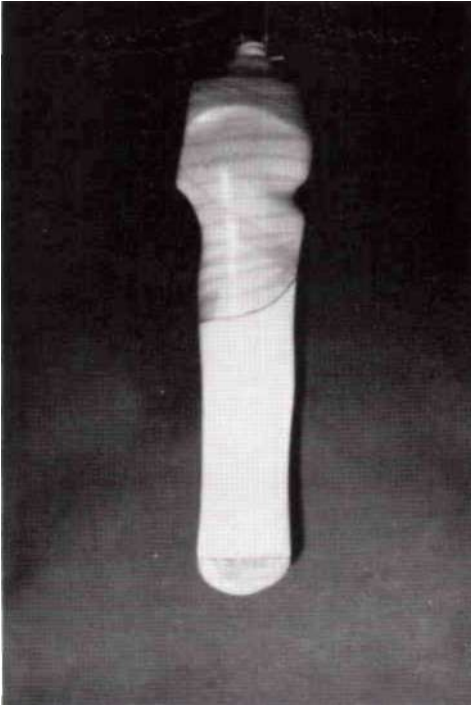


Fig. 7

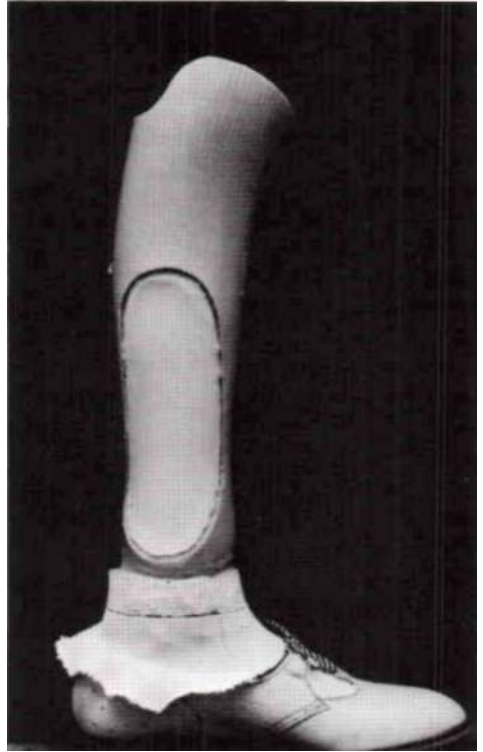


Fig. 8

method of attachment of the SACH foot to the socket, adjustment is usually provided by means of an alignment disc or by repositioning the socket with quick-setting epoxy resin.

10. The prosthesis is completed by laminating the socket and keel of the SACH foot and reattaching the sole (fig. 6). Fiberglass reinforcement is usually used in the lamination.

VARIATIONS

a. Alginate can also be used to make the negative impression of the stump. It gives better detail, and its elasticity allows easy stump removal. However, it is expensive, and one cannot see to position the heel pad while it is setting.

b. Modification can be accomplished on the plaster model instead of using the felt patches. Either way is satisfactory, but

using the patches saves time and is equally effective if they are properly placed.

c. A combination of 80% of Silastic elastomer #384 and 20% of #386 (foam) for the liner can be used to increase its expandability. More than 20% of #386 foams too much and reduces durability (2).

d. One variation on the size of the liner is to laminate the liner down to the largest diameter of the bulbous end rather than including the entire end. It is then not necessary to attach the end of the liner to the outer shell (fig. 7).

e. Another method of sizing the liner is to make an elastic window in the inner socket instead of making a whole inner bladder (fig. 8). This allows entry by rotating the stump as it goes into the socket, and makes possible a very cosmetic prosthesis.

f. Instead of making a wax build-up, it is possible to use Silastic elastomer #386

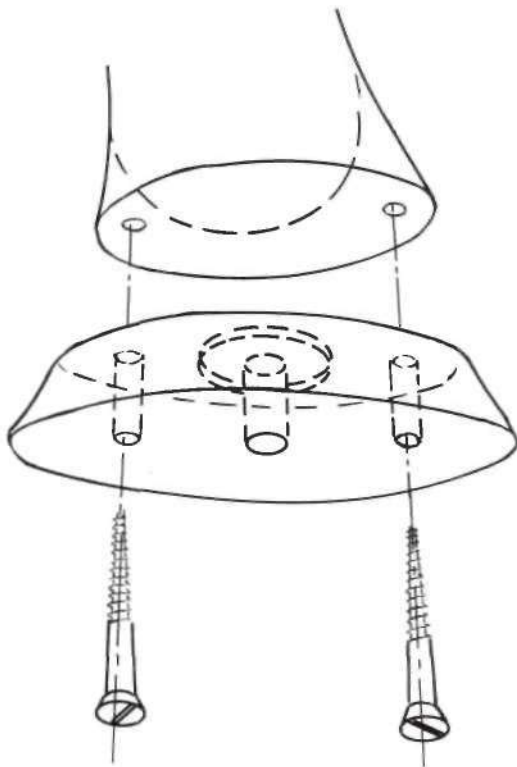


Fig. 9

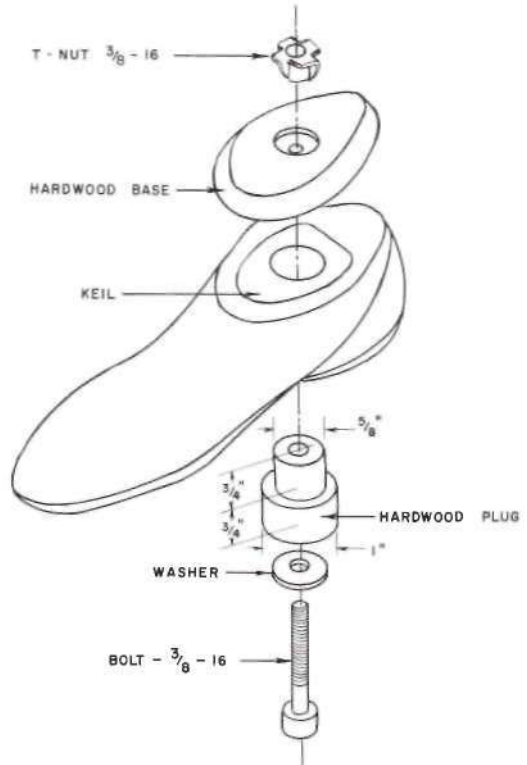


Fig. 10

foam for the space between the liner and outer shell and to leave it in the prosthesis. It is lightweight and can be compressed to allow entry of the stump. (This procedure is being used by William Sinclair, C.P.O., at Jackson Memorial Hospital in Miami, Florida.)

g. Another way to modify the SACH foot and attach it to the socket is shown in figures 9 and 10.

A wooden block is fitted and fastened to the distal end of the socket, and the bottom is sanded so it establishes the flexion and adduction angles of the socket. The wooden block forms a socket base for attachment of the SACH foot with the hardwood base and plug which reinforce the keel.

ACKNOWLEDGMENTS

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A Technique for Fitting Converted Proximal Femoral Focal Deficiencies

Carman Tablada. C.P.¹

Proximal femoral focal deficiency (PFFD) is a congenital limb deficiency affecting the proximal end of the femur and, usually, the iliofemoral joint. The condition is characterized by shortness of the



Fig. 1

affected limb; flexion, abduction, and external rotation of the extremity; inadequate proximal musculature; and unstable proximal joints (1). The condition may be unilateral or bilateral, and other anomalies may be present (fig. 1).

Aitken (2) has demonstrated four types of PFFD based on serial X-rays of patients before and after skeletal maturity:

¹ Mr. Tablada is a clinical prosthetist at the Child Amputee Prosthetics Project, University of California, Los Angeles. This study was made under MCH Project No. 204, Division of Health Services and Mental Health Administration, Maternal and Child Health Service, Department of Health, Education, and Welfare. The photographs were taken by Mary Louise Histon.

Class A: Adequate acetabulum and femoral head. Short femoral shaft. Femoral head and shaft are joined at maturity.

Class B: Adequate acetabulum and femoral head. Short femoral shaft. Femoral head and shaft are not joined at maturity.

Class C: Severely dysplastic acetabulum. Femoral head never ossifies. Short femur.

Class D: No acetabulum or femoral head. Short, deformed femoral segment.

At the Child Amputee Prosthetics Project (CAPP) in Los Angeles, the preferred treatment for children who have unilateral PFFD and functional upper extremities is conversion of the limb deficiency to an above-knee amputation. The surgical pro-



Fig. 2

cedure consists of a Syme's amputation of the foot in all cases, and fusion of the knee in selected cases to give a single skeletal lever (fig. 2). The children are then fitted

as above-knee amputees, using a specially designed socket.

Since 1967, the prosthetists at CAPP have used a socket with a flexible inner wall to fit PFFD patients who have had the surgical conversion described above. This paper describes the total fabrication and fitting procedure as it is done at CAPP. Only its application to the patient with PFFD will be considered here, although we have used the same principle with success in fitting other amputees who have a stump with a bulbous end.

THE STUMP

The converted PFFD stump is relatively fleshy in the proximal area. The shape of the proximal portion is related to the patient's classification: In those with class A or B involvement, the shape is normal enough for the usual anatomic landmarks to be seen, and in those with class C or D involvement, the proximal stump is cylindrical.

The shaft is usually narrow and bony, and the distal end is bulbous, with soft tissue padding its inferior surface. There are bony projections in the bulb which may not be seen but which can be located by palpation. These projections are sensitive to pressure.

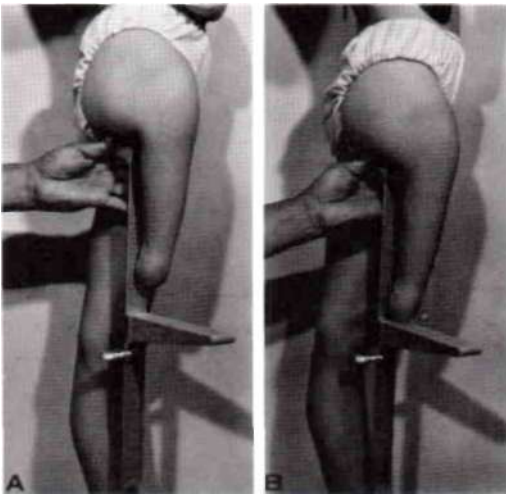


Fig. 3

TELESCOPING

When the structures in the hip region do not provide adequate articulation between the pelvis and the lower-extremity elements, upward pressure under the end of the stump causes upward displacement of the bony elements and apparent shortening of the limb. This motion is called "telescoping," and is frequently seen in patients with PFFD. As much as three inches of telescoping can be demonstrated in some patients.

Telescoping can be a passive or an active motion. In varied cases, some patients can voluntarily retract their limbs and others cannot; they can, however, voluntarily lengthen it beyond the resting position by thrusting down. Traction on the stump also causes lengthening. This apparent shortening and lengthening of the stump in response to pressure and traction has important implications for measuring the stump length, for making the cast, and for weight-bearing (fig. 3).

THE SOCKET

The socket consists of a rigid outer shell and a three-layered flexible inner wall, with an air space between the flexible layers and the hard socket. The flexible layers extend from the bottom of the socket to at least the level at which the bulbous end can pass through freely, comparable to the placement of the window in a standard Syme prosthesis. This arrangement provides room for expansion of the flexible wall as the bulb is inserted into the socket. Once the stump is fully inserted, the flexible wall closes around it, giving a total-contact fit without using a window and making it possible to use the bulb for suspension.

Since the patient has a Syme's amputation, it would seem logical to fit him with an end-bearing socket. However, if this were done, pressure under the end of the stump during the stance phase of gait would cause telescoping and relative shortening of the leg. The patient would then have excessive lateral trunk bending during stance. For this reason, the socket is

designed to be ischial weight-bearing, with the patient taking light contact on the end of the stump. The ischial weight-bearing minimizes the amount of telescoping and therefore decreases the lateral trunk bending. The light contact at the distal end gives him better control over the prosthesis.

MATERIALS AND COMPONENTS

The hard outer socket is formed with 4110 polyester resin.

Considerable thought was given to selecting the materials for the flexible layers. Our clinical experience has shown that, with continued use, RTV develops an odor and the material becomes fuzzy; nor will RTV bond to the rigid shell of the outside socket.

Therefore, flexible polyester resin was selected for the layer closest to the skin. It is durable, is easy to keep clean and free of odor, and has a surface that is relatively friction-free. 384 RTV was used for the center layer because it laminates readily and will stretch and return to the same shape repeatedly. Flexible polyester resin was also used for the layer next to the outer socket, for it bonds to the hard material if the polyester resin is "roughed up" sufficiently. The polyester resin also protects the RTV from impregnation by wax during socket fabrication. In all the cases in our experience, the materials have retained these properties until the child outgrew the prosthesis.

Primary suspension is provided by closure of the flexible layers over the bulbous end of the stump. A Silesian bandage, worn about an inch below the iliac crest, gives lateral support and secondary suspension.

We have used a constant-friction knee and SACH foot for all children fitted with this type of prosthesis. The constant-friction knee is light in weight and has provided good function. All of the children have had adequate strength to lock the knee joint during stance.

SPECIAL MEASUREMENTS

Before describing the fabrication procedure, a brief discussion of the measure-

ments is in order, for much of the success of this method of fitting depends upon having ischial weight-bearing and a total-contact fit.

SOCKET BRIM AND ISCHIAL SEAT

In patients with class A or B involvement, the shape of the proximal thigh is normal enough to enable the prosthetist to make the A-P and M-L measurements as he would for a patient with a standard above-knee amputation. The socket will have a modified quadrilateral shape at the ischial level.

In patients with class C or D involvement, the shape of the proximal stump is cylindrical, and there is no area comparable to the adductor-longus-tendon area of the standard above-knee amputee. In these cases, the M-L dimension is measured with outside calipers at the level of the adductor fold, and the ischial-seat measurement is made on a horizontal line from the ischium to the lateral edge of the stump at the ischial level.

The inside measurements of the socket must be the same as the circumferential



Fig. 4



Fig. 5

measurements of the stump. The prosthetist must reproduce the size and shape of the stump in the cast, positive mold, and socket to insure total contact without looseness or constriction.

The stump length is measured from the ischium to the distal end of the stump with the stump at its greatest stretched length. The importance of measuring the length and taking the wrap with the stump fully elongated cannot be overemphasized, for two reasons: First, it helps ensure that the patient will take most of his weight on the ischium so that telescoping will be minimal; second, the length of the cast can be modified by only 3/8 in. in either direction.

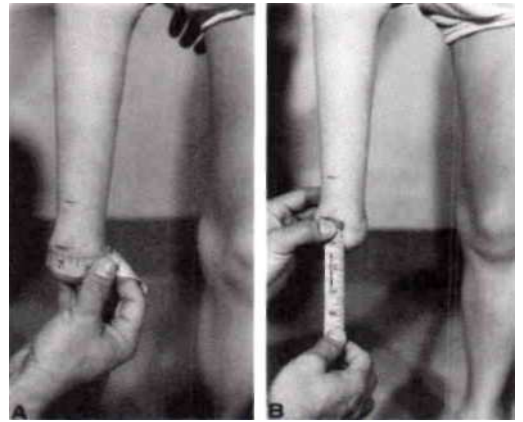


Fig. 7

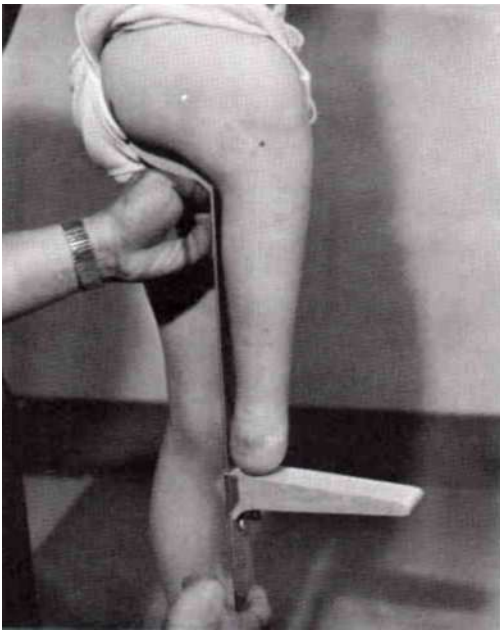


Fig. 6

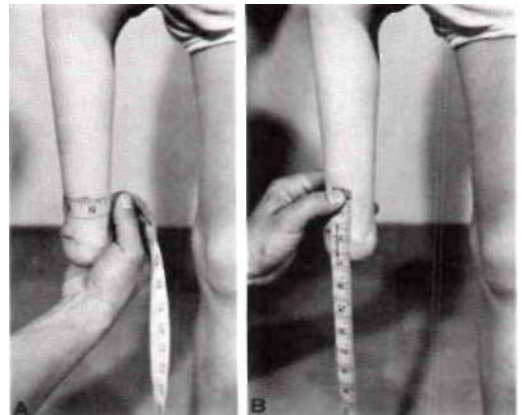


Fig. 8

MEASUREMENTS

BRIM

Mediolateral

In class A and B patients, take the M-L measurement as for a standard above-knee amputee.

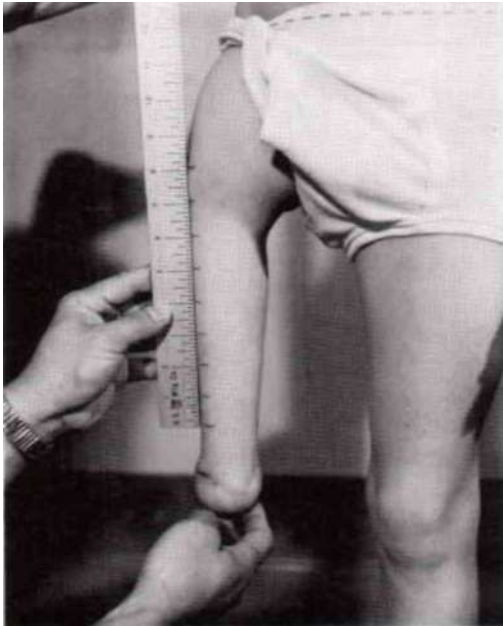


Fig. 9

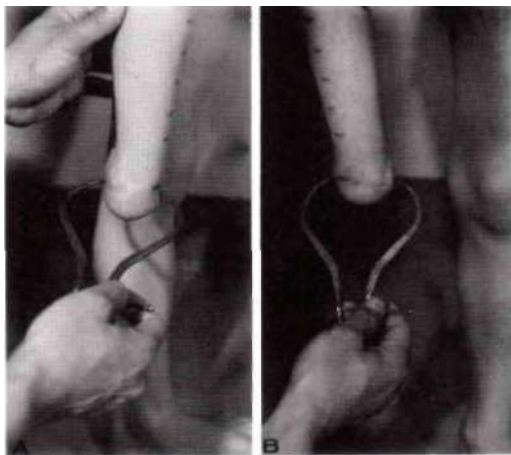


Fig. 10

In class C and D patients, caliper the horizontal distance from the adductor fold to the lateral aspect of the stump (fig. 4).

Anteroposterior

Take standard above-knee A-P measurements for classes A and B.

For classes C and D, to measure the ischial seat, caliper the horizontal distance from the inferior edge of the ischium to the lateral aspect of the stump (fig. 5).

SOCKET LENGTH

With the stump at its greatest length and vertical to the floor, measure from the ischium to the end of the stump (fig. 6).

CIRCUMFERENCE

1. Measure the circumference of the largest part of the bulb, and from this point to the distal end of the stump (figs. 7a and 7b).

2. Measure the circumference of the narrowest part of the shaft, and from this point to the distal end of the stump (fig.8)

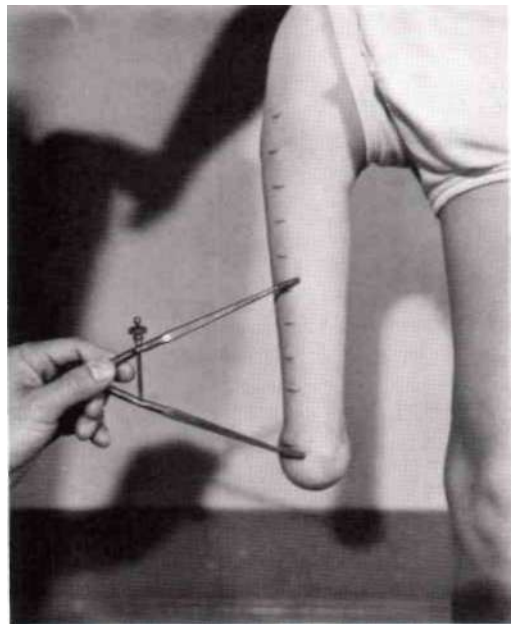


Fig. 11



Fig. 12



Fig. 13

3. Beginning at the narrowest part of the shaft, measure the circumference at one-inch intervals to the adductor fold (fig. 9).

BULB

1. Caliper the A-P and M-L dimensions at the largest part of the bulb (figs. 10a and 10b).
2. Palpate the bulb to locate the bony prominences and mark them with indelible pen.

OVERALL LENGTH

Measure the sound side as for a standard above-knee amputee.

STUMP SOCK

Make a tracing of the stump to accompany the measurements for ordering stump socks.

CAST FABRICATION

MATERIALS

- Fast-setting Johnson and Johnson plaster bandage
- Elastic plaster bandage (Johnson and Johnson Orthoflex)
- Cast sock
- Stockinette
- 1-in. elastic webbing
- A-P caliper
- Yates clamp

FITTING THE CAST SOCK

1. Mark the shaft at the level where the A-P or M-L dimension is slightly larger than the A-P or M-L dimension of the bulb.
2. Measure the distance between the two points selected and cut one piece of stockinette that length (fig. 11).
3. Cut five more pieces of stockinette, each 1/2 in. shorter than the last, and place them on the stump to fill in the narrow part. Place the shortest piece on the stump first, then the longer ones over it, *in reverse of what is shown in figure 12*. This facilitates removal of the cast.

MAKING THE CAST

The patient should stand with his stump vertical to the floor.

1. Using the same technique as for a standard above-knee amputee, make the brim with the 4-in. elastic bandage, beginning at the lateral side of the stump at the level of the iliac crest (fig. 13).

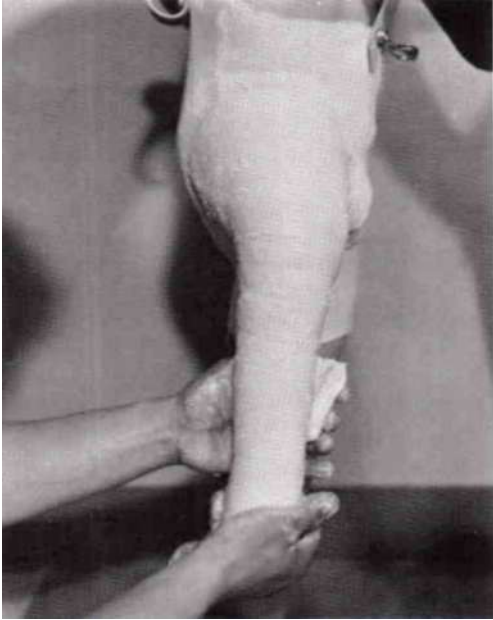


Fig. 14

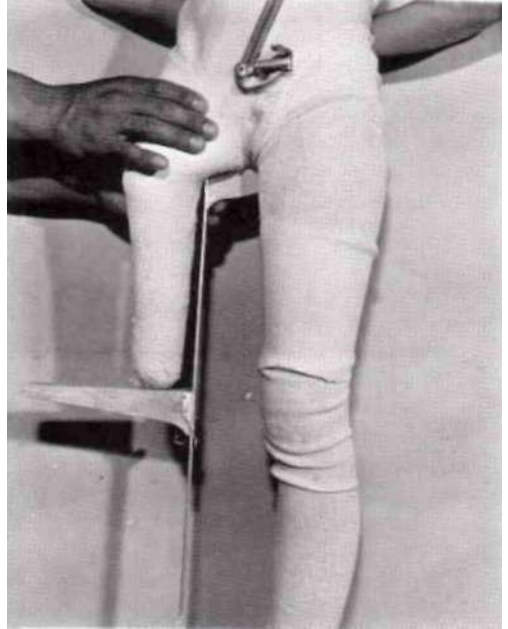


Fig. 16

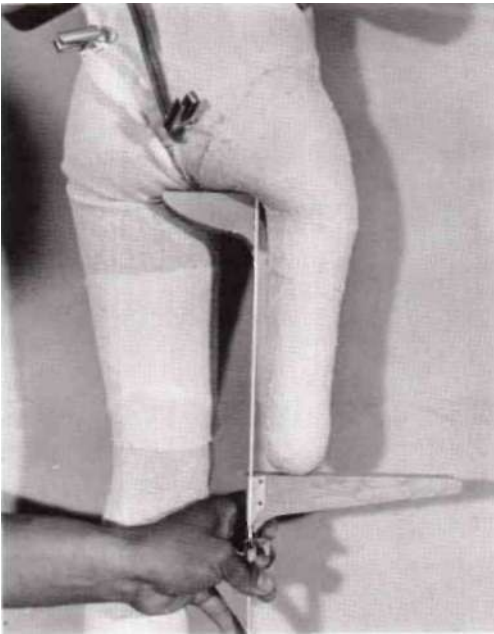


Fig. 15

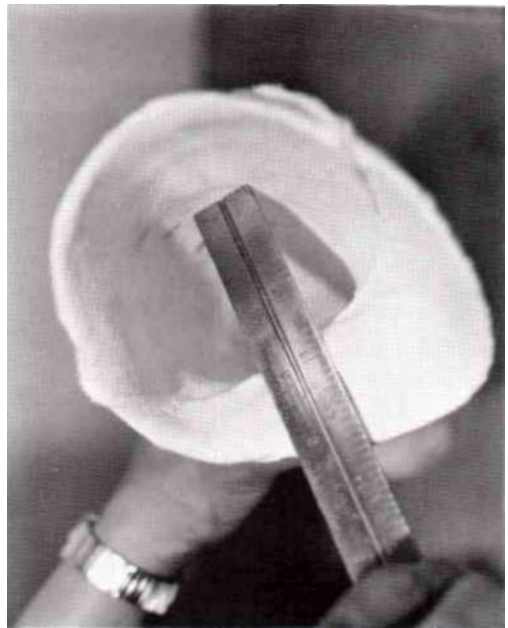


Fig. 17

2. Complete the wrap with the 3-in. regular plaster bandage (fig. 14).

3. Form the ischial seat while the bandage is still wet. With the A-P caliper

set to the length measurement of the stump plus $\frac{3}{16}$ in., place the short end under the ischium and line up the long end under the end of the stump. Then apply pressure

under the ischium and have the patient thrust down until the stump end touches the caliper (fig. 15).

4. At the same time, apply three-fingers' firm pressure to the proximal anterior medial aspect of the cast (fig. 16). This prevents the socket from rotating internally on the stump.

5. The patient must remain in this position and the pressures must be maintained until the plaster sets.

6. Remove the cast.

CHECKING THE CAST

1. Check the M-L and ischial-seat measurements of the cast against those of the patient. Be sure that the ischial seat has a large enough surface for the patient to sit firmly upon it. If necessary, build up the seat with plaster before filling the cast (fig. 17).

2. Check the length of the cast against the patient's stump length. They should be the same. If the cast is longer than the stump, pressure was not applied directly under the ischium. If the cast is shorter than the stump, the patient was not



Fig. 18

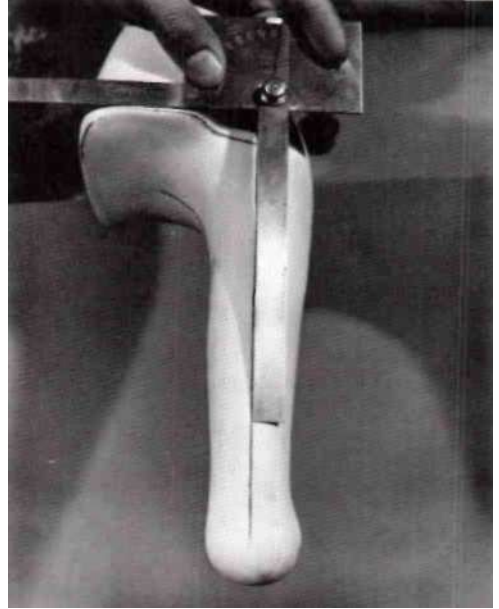


Fig. 19

thrusting down to maximal stretch. If the difference does not exceed $3/8$ in., the mold can be modified. If there is a greater than $3/8$ -in. difference, a new cast should be made.

MODIFYING THE MOLD

To correct the length measurement:

1. Measure from the ischial seat to the end of the mold.
2. Remove or add enough plaster (but no more than $3/8$ in.) to the ischial seat to correct the length.

To correct the flexion or extension angle (fig. 18):

1. Draw a line down the medial aspect of the mold, bisecting it into medial and posterior halves.

2. Set the goniometer at 90 deg.; hold one arm on the line described and the other arm at the level of the ischium. Draw a line at right angles to the line on the medial aspect of the mold.

3. Shape the surface of the seat along this line. The shaft should be at 0 deg. of flexion and extension.

To correct the abduction or adduction angle (fig. 19):

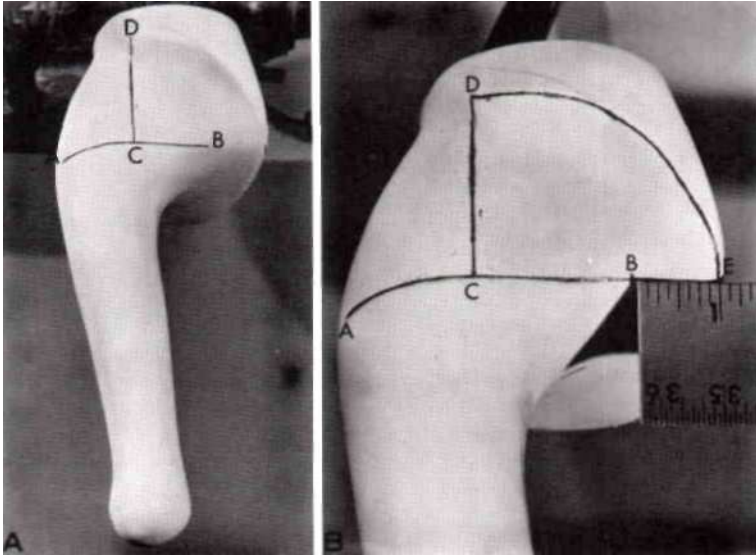


Fig. 20

1. Draw a line down the posterior aspect of the mold, bisecting it into medial and lateral halves.

2. Set the goniometer at 90° ; hold one arm on the line described and the other arm at the level of the ischium. Draw a line at right angles to the line on the posterior aspect of the mold.

3. If the shaft is in *adduction*, remove plaster from the outside edge of the ischial seat. If the shaft is in *abduction*, add plaster to the outside edge of the ischial seat. The shaft should be at 0° of abduction or adduction.

To modify the anterior brim (fig. 20):

1. Form the height of the anterior brim: Draw a line at the ischial level across the anterior aspect of the mold from point A to point B. Divide the line in half at point C. From point C, draw a line at right angles to AB, extending it two inches proximal to point D. Line CD forms the height of the anterior brim.

2. To establish the anterior brim line, extend a line from point B one inch medially to point E. Point E should be in line with the ischial seat when viewed from the front. Draw a line on a smooth curve from point D to point E (fig. 20).

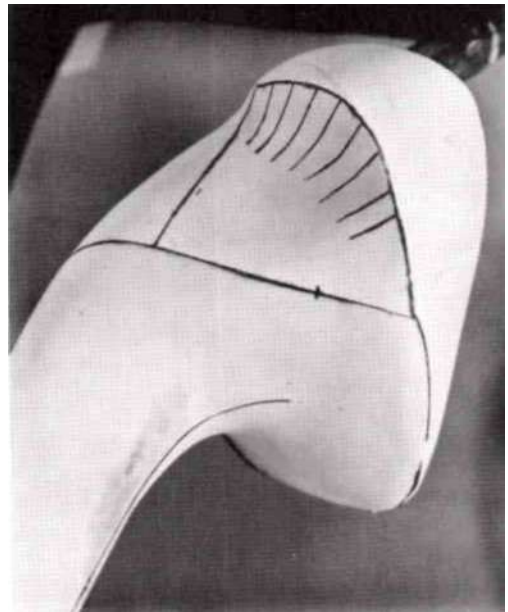


Fig. 21

3. Form a reverse curve along line DE to facilitate sitting and bending. Using a rasp or gouge, remove up to $1/4$ in. of plaster from the area medial to line CD. This will ensure good contact along the anterior

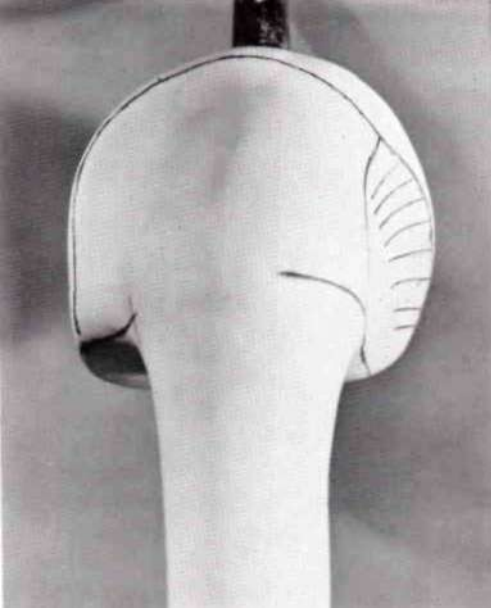


Fig. 22

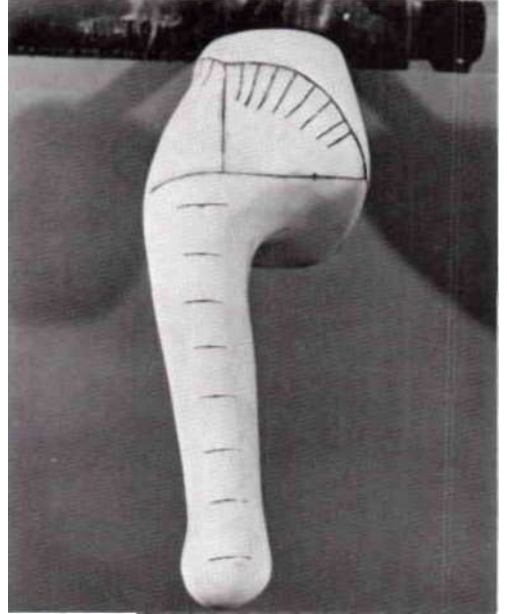


Fig. 24

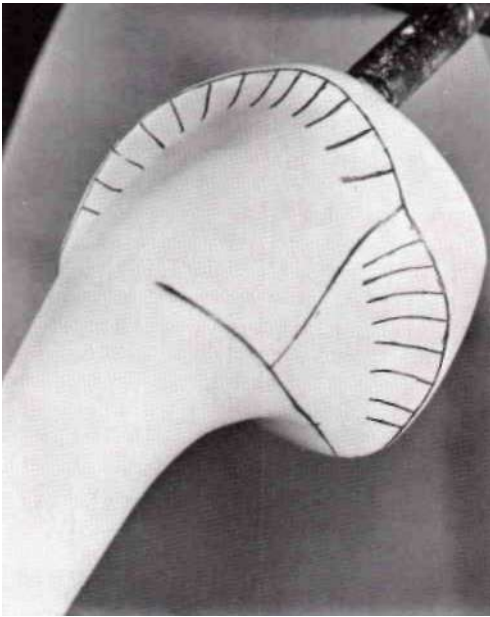


Fig. 23

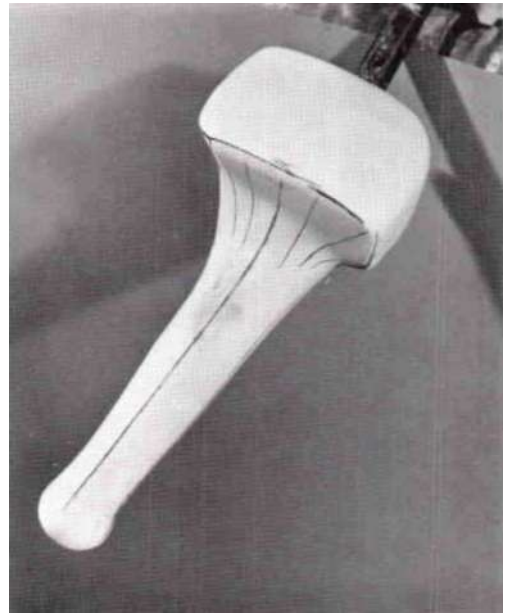


Fig. 25

brim wall with the stump. If necessary, build up with plaster along line DE to form the reverse flare (fig. 21).

To modify the lateral brim:

1. Continue line DE from the anterior brim proximally to encompass two-thirds

of the distance between the ischium and the iliac crest. Continue laterally, following the contour of the lip, then distally to the posterior-lateral corner of the ischial seat (fig. 22).

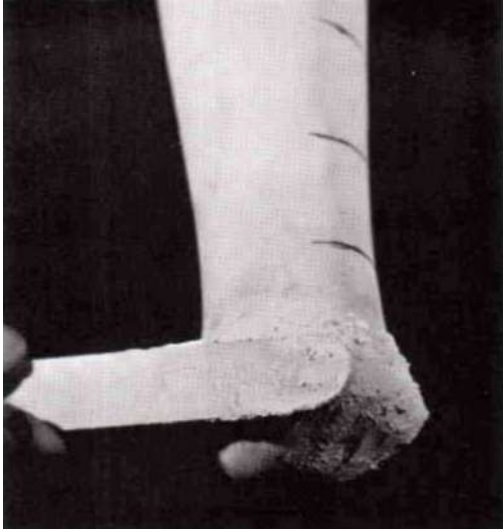


Fig. 26

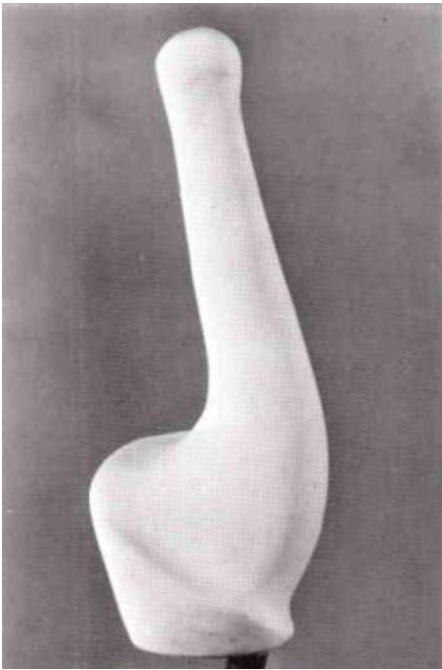


Fig. 27

2. Contour the lateral wall. Do not remove plaster below the ischial level (fig. 23). Establish flare along the lateral brim line.

To modify the shaft:

1. Correct the circumference measurements. Mark off the levels at which the cir-

cumference measurements were obtained. Note each measurement on the mold. Where it is necessary, the circumference measurements of the mold should be modified to be the same as those of the stump (fig. 24).

2. At the brim area, blend the medial and posterior walls smoothly with the medial brim and ischial seat (fig. 25).

To modify the bulb:

Build up over the bony projections no less than 1/4 in. (These projections should be marked during the measurement and casting procedure.) *Be extremely careful while accomplishing this, as attempting relief in this area is extremely difficult* (fig. 26).

Recheck the mold measurements. Smooth the entire mold (fig. 27).

FLEXIBLE-SOCKET FABRICATION

MATERIALS

- Ambroid varnish or the equivalent
- Five PVA sleeves (regular size and shape)
- Two 1-oz. fitted Dacron (TM) sleeves
- Four or five regular-length fitted nylon stockinettes (for fabricating the flexible layers)
- Three extra-long fitted nylon stockinettes (for fabricating the hard socket)
- Cast sock(s) (to equalize the stump sock)
- Flexible polyester resin #4134
- RTV elastomer Dow Corning #384
- Rigid polyester resin #4110
- 150-A yellow wax (available from E. S. Browning Co., Los Angeles, Calif.) or any wax suitable for shaping
- Outside calipers
- Wood rasp
- Vacuum machine
- Oven with at least 200°F temperature range

Make the Dacron sleeves to fit the entire brim area. The Dacron must not be incorporated in the flexible layers.

The number of stockinettes needed depends upon the size and activeness of the patient. Four are used on the less active patient, and five on the more active. These are separate pieces, sewn on one end and trimmed to 1/2 in. of the stitching. The width of the stockinette should be such that it stretches very minimally in what is to be the flexible wall.

The three extra-length stockinettes must be long enough to double over in the brim area.

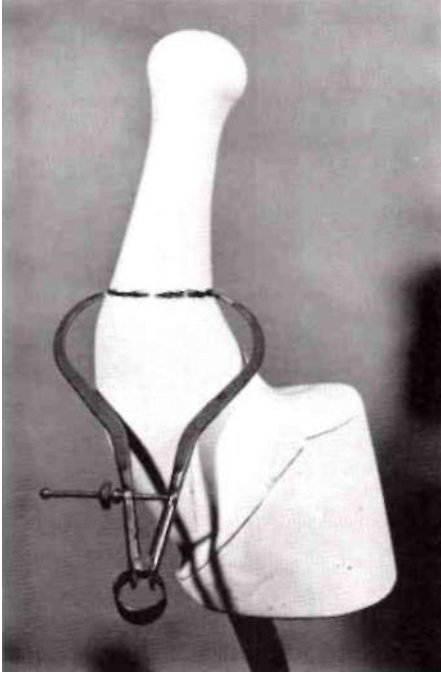


Fig. 28

One heavy and one lightweight cast sock are used for a 3-ply wool sock; two heavy and one lightweight cast sock are used for a 5-ply wool socket, etc.; or an old wool stump sock of the same weight can be used.

The 150-A yellow wax is heated until it is soft enough to work with a spatula. With this type of wax, it is never necessary to melt it completely and pour it into a cone.

PROCEDURE

1. With the outside calipers, measure for the area where the bulb can pass through freely. Mark this area heavily with a pencil (fig. 28).

2. If the cast is wet, seal it with three coats of ambroid varnish.

3. Apply the appropriate number of cast socks (or an old stump sock) needed for stump-sock clearance. Tie them off securely on the mandrel.

4. Apply the first PVA sleeve, which will be the parting agent. Cap it on the end and tie it off on the mandrel.

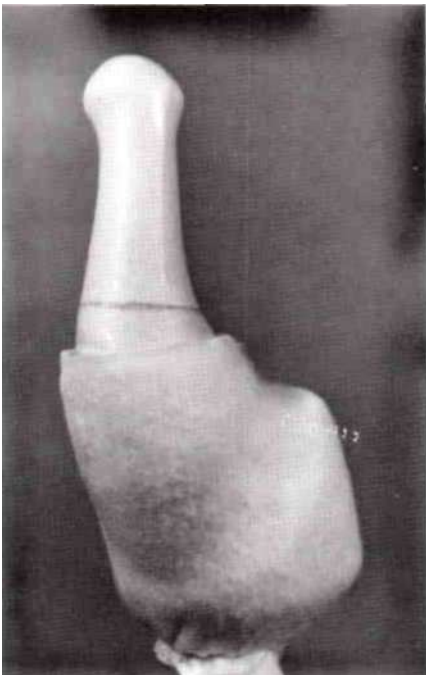


Fig. 29

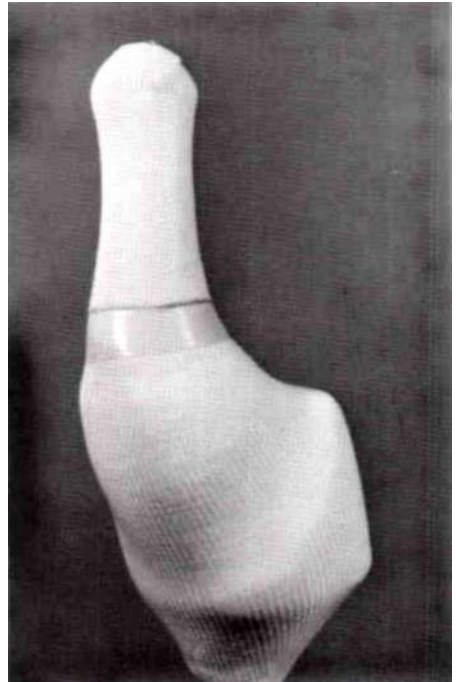


Fig. 30

5. Apply two Dacron sleeves, being sure not to overlap into the flexible walled area which starts at the mark made in step 1. It is advisable to leave at least 1 in. between the mark and the Dacron sleeves (fig. 29).

6. Apply one layer of stockinette and tie it off on the mandrel. If necessary, separate and smooth the extra half-inch of material. With the outside calipers, measure again for the area where the bulb can pass through freely, and mark this area with a pencil.

7. With pressure-sensitive tape, make a full turn around the model at the mark made in the previous step (fig. 30). This seals off the proximal end of the flexible wall.

8. Attach the vacuum line.

9. Apply the second PVA sleeve and seal it off on the mandrel, then repeat step 7.

10. Mix thoroughly enough 4134 flexible polyester resin to cover the area from the tape to the end of the model. Using vacuum, laminate this area *only*. (It is helpful if, at the end of each laminating step, the



Fig. 32

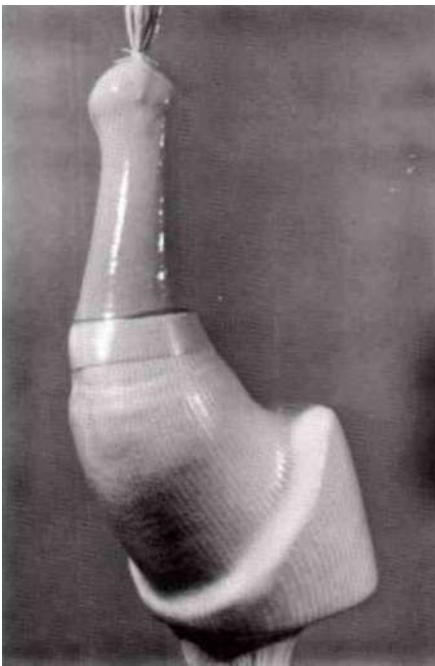


Fig. 31

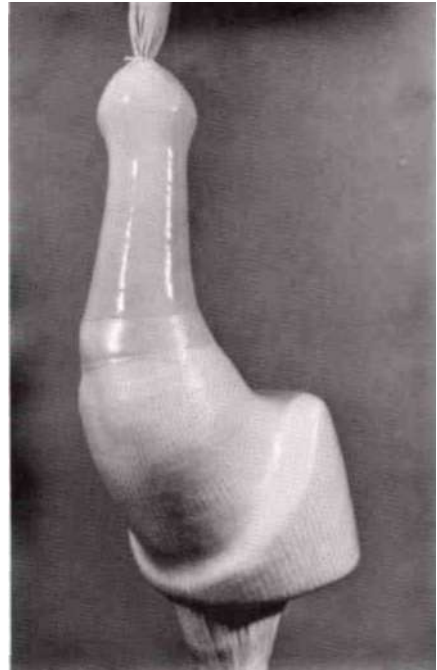


Fig. 33

excess is tied off, thus saving the time of grinding it away.) Allow to set well (fig. 31).

11. Remove the second PVA sleeve. Remove the pressure-sensitive tape around the model. With the wood rasp, roughen the bulbous end enough to raise the half-inch of stockinette. Do not break through to the parting PVA (fig. 32). Apply two more layers of stockinette, again separating and smoothing down the extra half-inch of material. Tie them off on the mandrel, then repeat step 7.

12. Apply the third PVA sleeve, seal it off at the mandrel, and repeat step 7.

13. Mix thoroughly enough 384 RTV to cover the laminated area. Using vacuum, laminate this area only. Allow to set well (fig. 33).

14. Remove the third PVA sleeve. Remove the pressure-sensitive tape around the model. With the wood rasp, roughen the bulbous end enough to raise the half-inch of stockinette beyond the stitching (as in figure 32).

15. Apply one or two more layers of stockinette, again separating and smoothing the extra half-inch of material. Tie

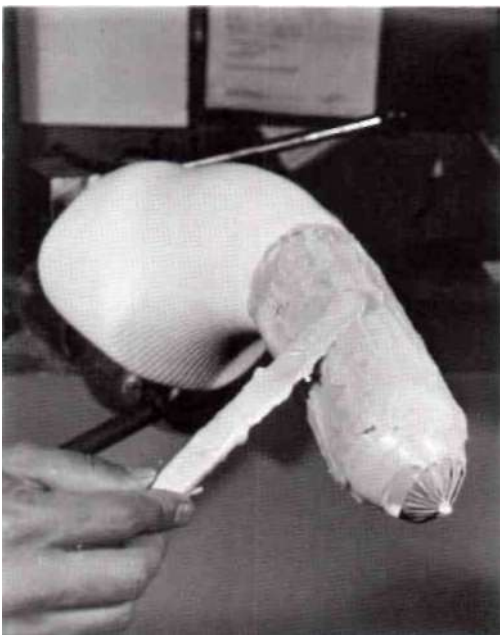
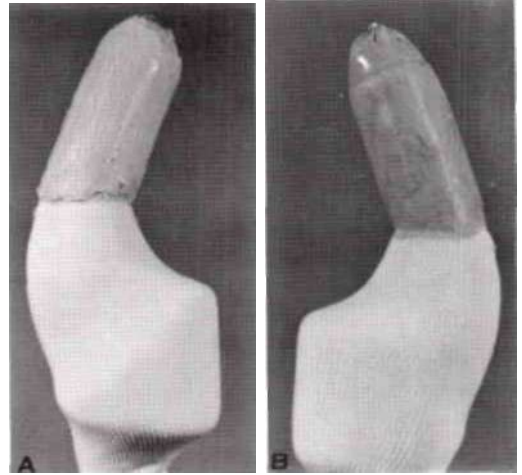


Fig. 34



Figs. 35 and 36

them off on the mandrel, then repeat step 7.

16. Apply the fourth PVA sleeve, seal it off on the mandrel, and repeat step 7.

17. Repeat step 10.

18. Remove the fourth PVA sleeve. Remove the pressure-sensitive tape around the model.

19. For the wax build-up (fig. 34), apply wax to the model from the proximal end of the flexible wall distally to the *largest* circumference of the bulb end. The thickness of the build-up should be sufficient to allow the bulb to expand the flexible wall through the narrow area. Use the outside calipers to measure the thickness of the build-up. Allow 3/16-in. thickness for the flexible-wall lamination. (Keeping in mind some goals for the finished prosthesis, such as cosmesis and lightness in weight, in most cases it is possible and advisable to "go overboard" on the wax build-up. Cosmetic build-up is kept to a minimum, and air space is weightless.) Allow the wax to cool and harden (fig. 35).

20. Smooth the surface and taper the proximal and distal edges (fig. 36).

21. Using the wood rasp, roughen the exposed tip of the bulb end enough to cut through to the RTV layer and to raise the half-inch of stockinette beyond the stitching on the final 4134 resin layers.

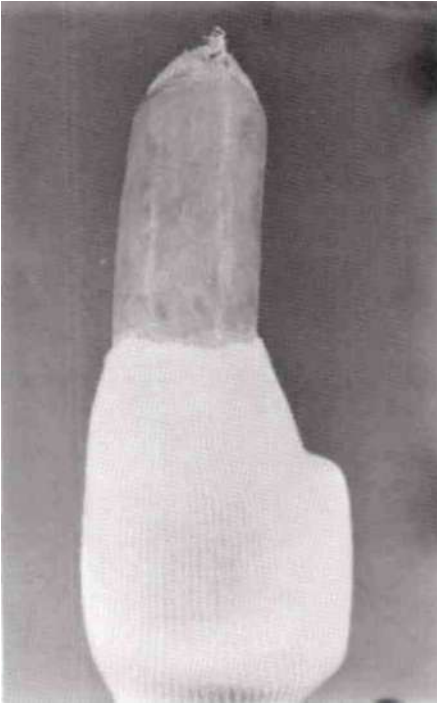


Fig. 37

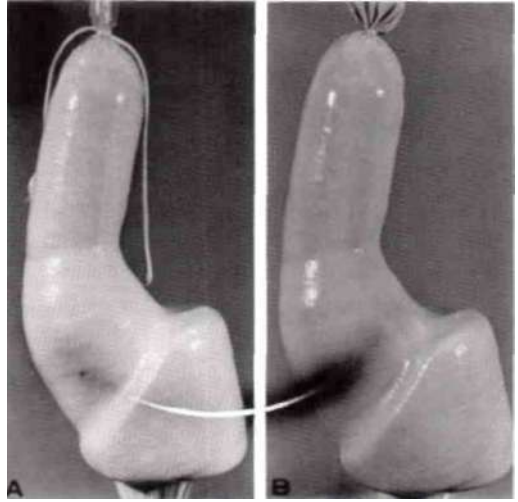


Fig. 39

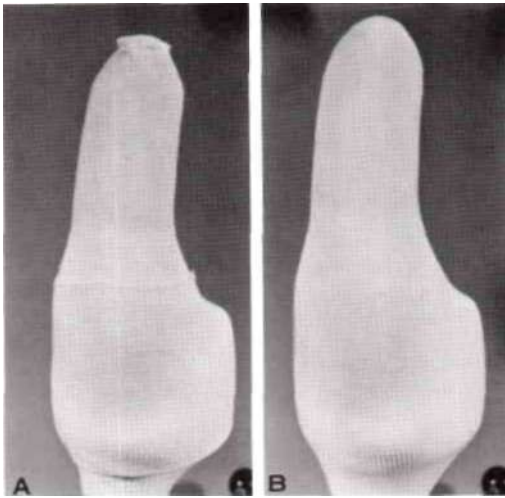


Fig. 38

This step is extremely important, as it will securely bond the flexible portion of the socket to the rigid outside shell (fig. 37).

22. Apply the three extra-long nylon stockinettes, doubling the first two layers back at the brim (fig. 38).



Fig. 40



Fig. 41



Fig. 42

23. Apply the fifth PVA sleeve and seal it off on the mandrel. Mix enough 4110 polyester resin to cover the entire mold. Using vacuum, laminate the entire mold. Allow it to set (figs. 39a and 39b).

24. After the resin has set, cut a flap through it 3/4 in. in diameter at the distal edge of the wax build-up. Tape the flap back (fig. 40).

25. Hang the entire laminated cast in the oven (heated to 175° F) and allow *all* the wax to drain out.

26. Remove the laminated cast from the oven after the wax has drained. Allow the lamination to cool just enough for the rigid shell portion to harden. Mark the approximate trim line and cut along it with a Stryker saw. A strong tug, along with use of a hammer and piece of wood when needed, will separate the socket from the cast (fig. 41).

27. To complete the socket, finish sanding the brim down to the trim lines.

FITTING

MATERIALS

- Fitting stool
- Talcum powder
- Stump sock
- Mandrel padded at the end with stockinette in the shape of a bulb
- Heat gun
- Silicone amputation-stump spray

PROCEDURE

1. Set the socket in a wood block with the seat level.
2. Place the block on a fitting stool to get the correct ischium-to-floor length.
3. Lightly powder the socket.
4. Have the patient apply the stump sock and hold it firmly at the top as he pushes his stump into the socket (fig. 42). (If the patient cannot push all the way into the socket, the flexible layers will need to be stretched as described in the next section.)

5. Check to see that the patient's ischium is firmly on the seat, and that he has light contact at the end of the stump. Do this by having him bear weight on the socket and by requesting him to "reach down into the socket" with his stump. If as he does this, he loses firm contact with the seat, the socket is too short. If he cannot feel contact on the bottom, the socket is too long. A sponge pad in the

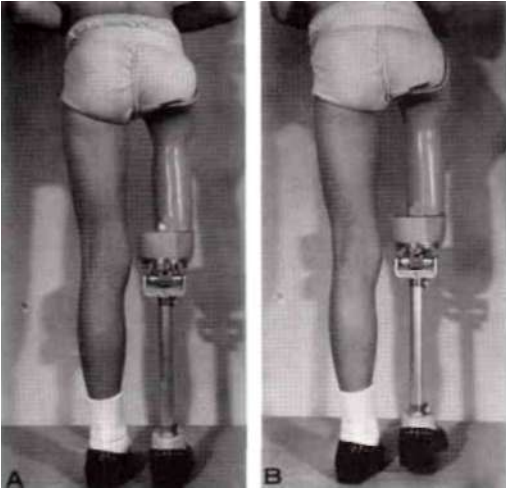


Fig. 43

bottom of the socket may give the necessary light contact.

6. Have the patient lift his hip to take weight off the socket. There should be no more than 1/4 in. of piston action (figs. 43a and 43b).

7. Check for pressure areas in the bulb. With the patient standing, have him flex his hip while you apply resistance to the distal anterior end of the socket. Then have the patient abduct, extend, and adduct the hip, each time applying resistance to the distal end of the socket. There should be no pain from these maneuvers. (Pain may be caused by a wrinkle in the sock, by the presence of wax in the air space, or from inadequate relief over the bony prominences in the bulb.)

8. Establish the anterior and posterior trim lines. In the posterior lateral area, trim the socket so that it does not encase the gluteal area. Then have the patient sit in a chair and lean forward. Check for discomfort in the anterior area, and trim the socket to fit. There should be no gapping of the lateral wall. The anterior brim of the socket should be in firm contact with the skin, for looseness here would allow the socket to rotate internally on the stump when the patient walks.

9. To remove the socket, the patient should pull up on the top of the stump sock



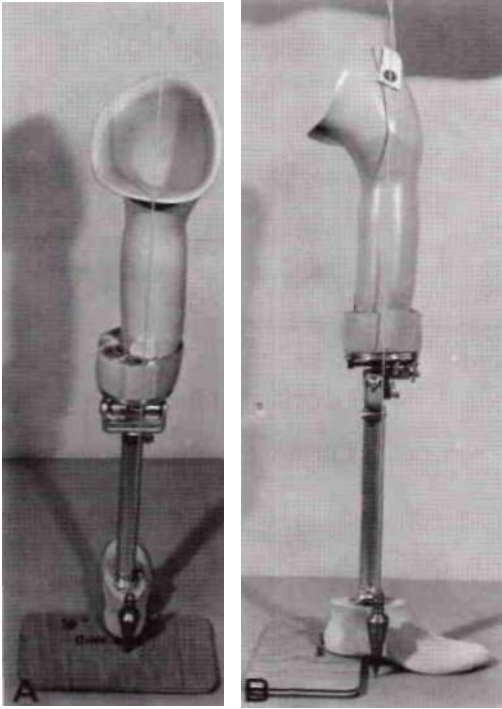
Fig. 44

while pulling down on the socket. In a few cases, this was the only way in which the socket could be removed (fig. 44).

Stretching the Flexible Layers

If the patient cannot push his stump all the way into the socket, it will be necessary to stretch the flexible layers to allow the bulb to pass through the narrow part of the socket. This can be accomplished as follows:

1. Place the padded mandrel in a vise.
2. Heat the inside of the socket to soften the flexible layers.
3. Work the socket back and forth on the mandrel, stretching the flexible layers.
4. Let the socket cool on the mandrel, with the padded end of the mandrel at the narrowest part of the socket.
5. Refit as in the preceding section, using silicone spray in the socket if necessary.



Figs. 45a and 45b



Fig. 45c

ALIGNMENT

BENCH

The initial set-up is made with the ischial seat level. The posterior plumb line for the heel center passes between the center of the end of the socket and the point where the ischium rests on the ischial seat (fig. 45a). The lateral plumb is taken from the center of the end of the socket and passes $\frac{1}{2}$ in. anterior to the knee center (fig. 45b). The socket is set in 15° - 30° of internal rotation to the line of progression to compensate for the patient's tendency to internally rotate the pelvis to advance the prosthetic leg (fig. 45c).

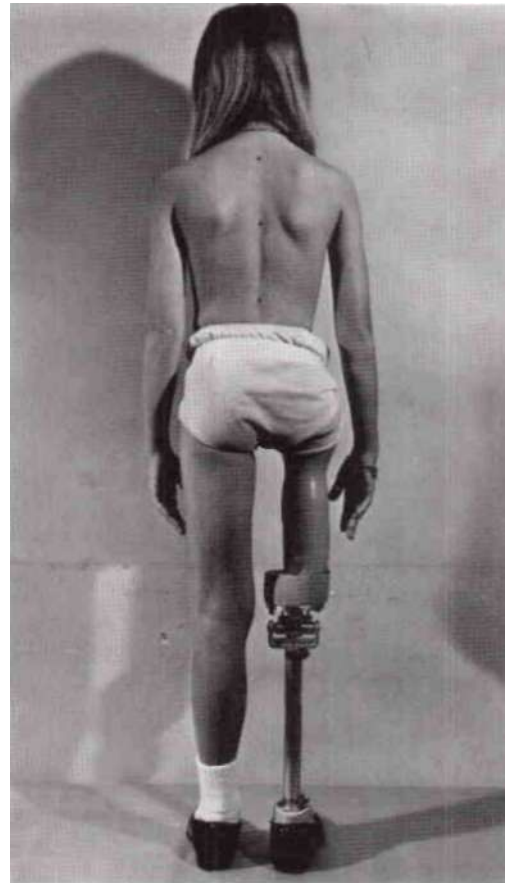


Fig. 46

FUNCTIONAL

The prosthesis is the correct length when the patient's spine is as straight as possible when he stands with his weight on both legs, i.e., in the finished prosthesis. The iliac crests of these patients are not always symmetrical, and it may not be a reliable reference point for judging the length of the prosthesis (fig. 46).

Dynamic alignment is done with the socket set on a child-size above-knee jig. Optimal dynamic alignment is based on standards set for the standard above-knee amputee.



Fig. 47

SUMMARY

This fitting technique can also be used on other stumps with bulbous ends: Syme's and above-elbow amputations and wrist disarticulations, for example.

At CAPP, more than 20 patients have been fitted in this manner: 18 PFFD's, 2 bilateral Syme's amputations, 1 wrist disarticulation, and 1 above-elbow amputation. All of these patients' deficiencies were congenital in origin.

The procedure described does require more fabrication time and material. Once the technique is mastered, it requires about three hours of the prosthetist's time, whereas a solid socket can be fabricated in an hour. However, the CAPP patients have shown a marked preference for this type of socket. It provides a very precise fitting, and in every case the child has expressed a feeling of greater security when wearing this socket (fig. 47).

Another advantage is the apparent absence of skin breakdown. When the patient comes to the clinic for post-fitting examination, the characteristic blanching of the stump skin is absent, as are signs of rubbing, blistering, or callousing so often seen with use of the solid socket.

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Clinical Applications of the Veterans Administration Prosthetics Center Patellar-Tendon-Bearing Brace

Hector W. Kay¹

AN CERTAIN pathological conditions of the lower extremity, the stress of weight-bearing cannot be tolerated because of pain or the possibility of actual tissue damage. Pathologies encountered in such situations fall into three broad categories: (1) those affecting bone—delayed unions or non-unions 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.

In these circumstances, bracing is frequently used as an aid to management, the brace serving as a weight-bearing device to relieve the skin-muscle-bone complex of intolerable stresses.

Historically, the application of a brace to unweight the lower extremity has involved provision for support of the body weight at the level of the pelvis, typically some form of ischial weight-bearing. A variable proportion of body weight is then transmitted to the ground through side bars and a locked knee. This type of brace is inherently disadvantageous because of its bulk and because the locked knee imposes a stiff-legged gait which increases energy costs. In situations where the pathology is located above the knee, avoidance of these

disadvantages may be impossible. However, in selected below-knee lesions, a brace which bears weight about the knee (like the patellar-tendon-bearing prosthesis) appears not only desirable but pos-

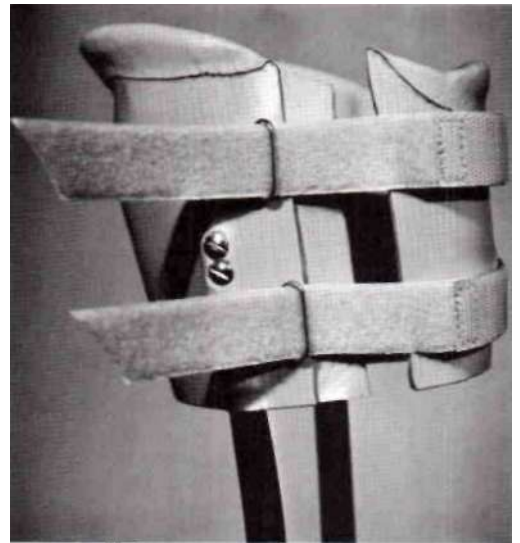


Fig. 1. Proximal weight-bearing portion of the PTB brace.

sible. A brace of this type would not only allow unrestricted knee motion, and hence a more natural gait, but it would have the advantages of reduced bulk and the absence of equipment above the knee.

In 1958, VAPC designed such a below-knee weight-bearing brace (3). The VAPC design was based on the then current below-knee patellar-tendon-bearing (PTB) prosthetic techniques. The primary weight-bearing component is a partial socket of

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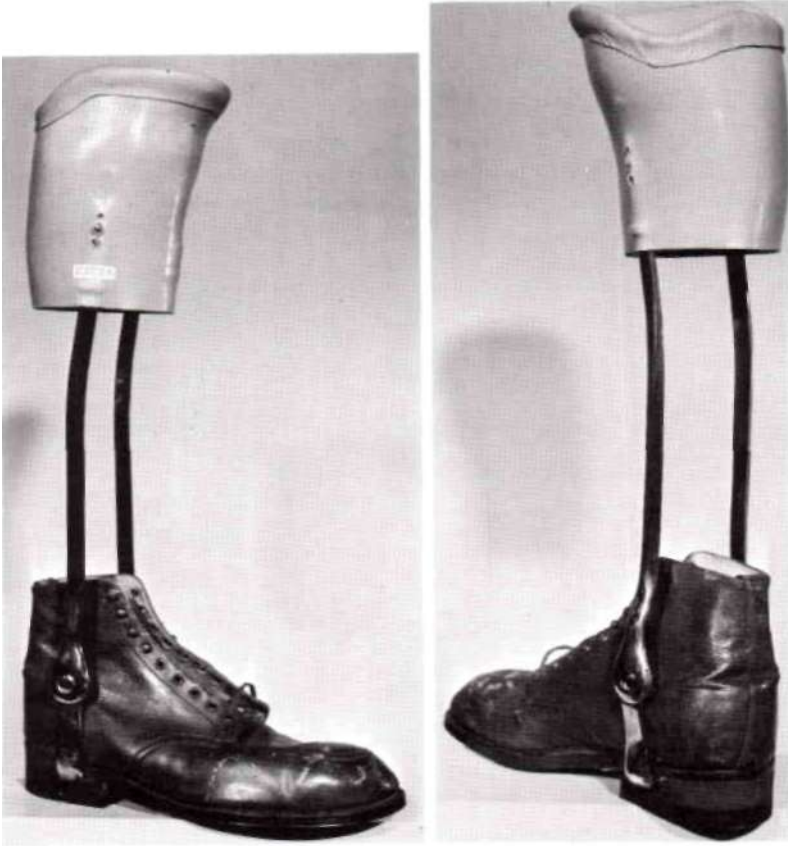


Fig. 2. Completed brace of initial design.

laminated plastic with a soft (Kemblo [TM]) liner similar to the proximal portion of a PTB prosthesis (fig. 1). Stainless-steel uprights were used with a stainless-steel limited-motion stirrup (fig. 2). The ankle joints were modified to permit 10° of plantar flexion and to limit dorsiflexion at 90° . The stirrup and uprights were fitted and aligned as in a conventional ankle brace. In wearing the brace, an open-end wool stump sock was used as with a below-knee prosthesis.

As experience with the PTB-type brace accumulated at VAPC, a number of modifications were introduced (fig. 3). A compressible heel, similar to that of the solid-ankle cushion-heel (SACH) prosthetic foot, and a rocker bar attached to the sole of the shoe became incorporated as standard components of the device. The SACH heel

wedge and rocker bar were incorporated in the shoe to simulate plantar flexion and provide a more natural roll from heel to toe, thus minimizing gait deviations imposed by limited ankle motion (4). The SACH heel wedge is also considered to function as a shock absorber, contributing to a smoother gait. Some patients with painful ankles were unable to tolerate motion in the ankle joint at the brace and were fitted with rigid joints.

The Veterans Administration Prosthetics Center submitted the PTB weight-bearing brace to the Committee on Prosthetics Research and Development for evaluation. Unfortunately, at that time procedures for the testing of orthotic devices were not available. However, in December 1963 an orthotic evaluation program was inaugurated by New York University, and the

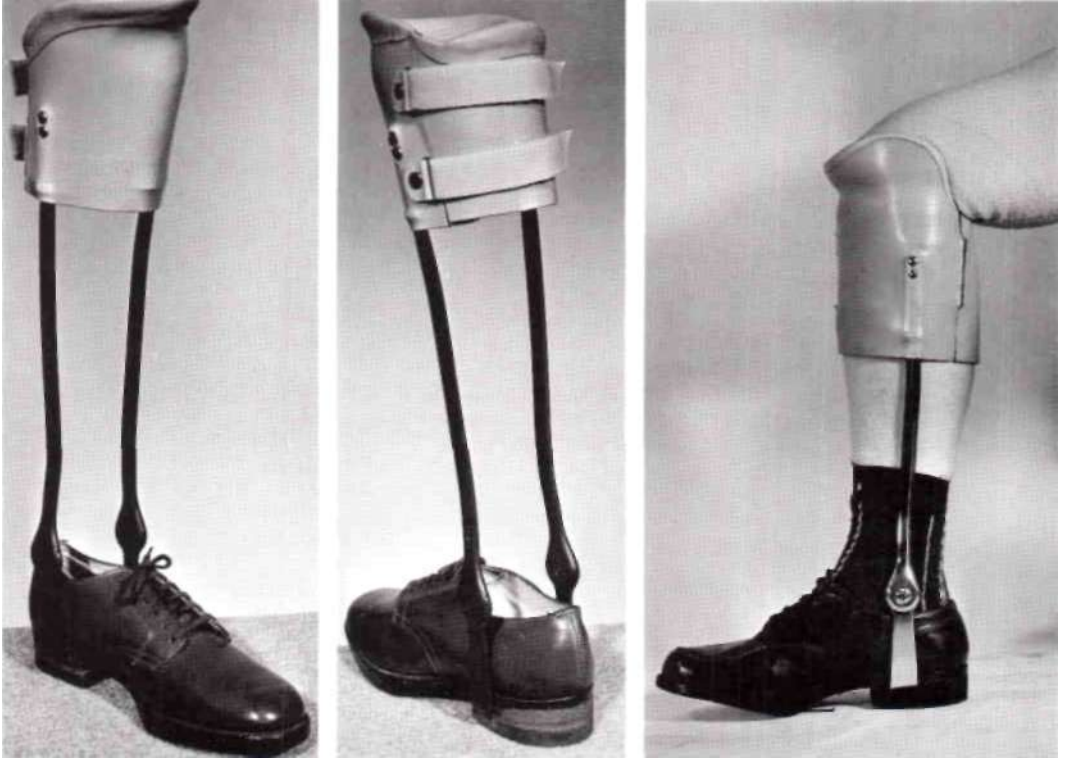


Fig. 3. Views of the modified brace showing application of SACH heel and rocker bar.

VAPC device was selected by CPRD as a suitable item for this program.

The initial phase of the NYU evaluation involved the review and examination of patients fitted by VAPC. Of the 22 patients who had been fitted by VAPC between 1958 and November 1963, 8 accepted the invitation to appear for interview and examination. The findings of this review study indicated that the VAPC patellar-tendon-bearing brace was an effective device from the medical, orthotic, functional, and wearer-reaction points of view (1).

CLINICAL FITTINGS

On September 1, 1966, the National Academy of Sciences—National Research Council entered into Contract SAV-1053-67 with the Vocational Rehabilitation Administration (now the Social and Rehabilitation Service) to establish a pilot program for the clinical evaluation of pros-

thetic and orthotic devices under the jurisdiction of the Committee on Prosthetics Research and Development. Two orthotic items were selected to initiate this program: the Baylor (Engen) hand orthosis and the University of California dual-ankle control system. The Engen study was undertaken (2) but, for various reasons, the UC study could not be undertaken, and evaluation of the VAPC PTB brace was substituted for the UC item.

Since the earlier favorable NYU review, an instructional manual has been prepared by the developer (5). Accordingly, five treatment centers were recruited as participants in a clinical application study of the VAPC PTB brace: the University of Alabama Medical Center, Birmingham, Ala.; Goldwater Memorial Hospital, New York, N.Y.; Jackson Memorial Hospital, Miami, Fla.; Rancho Los Amigos Hospital, Downey, Calif.; and the Rehabilitation Institute of Chicago, Chicago, Ill.

A course of instruction in the fabrication and application of the VAPC PTB brace was conducted at the Veterans Administration Prosthetics Center, New York, by the developers. Orthotists from the participating clinics undertook training for five days (May 8-12, 1967), while physicians had a one-day orientation (May 12, 1967).

A protocol for the study, together with appropriate data-recording forms, was prepared by the CPRD staff.

Following the instructional course, several fittings were accomplished at each of the participating centers. Subsequently, a number of factors arose to militate against the completion of the planned course of study. Two of the clinics suffered the loss of the physician member of the participating team, and two other centers became engaged in studies of cast braces for fractures of the lower extremity. These fracture-cast braces had some of the same characteristics and performed similar functions as the test item. The physician member of the fifth participating team suffered a prolonged illness, which disrupted the progress of the study at his center.

The clinical study of the VAPC PTB brace was reactivated early in 1970 when the physician who had been ailing recovered his health and it was discovered that the orthotics clinical group at the Duke University Hospital had been fitting the test item since 1962 and had accumulated a sizable series of patients. Arrangements were made, therefore, to review patients fitted in Birmingham and Durham. The data obtained in these reviews form the basis for this report. The experience of these two centers is presented in the following sections of this report.

BIRMINGHAM, ALABAMA

Following the return of the physician—orthotist team from the instructional course at VAPC, seven patients were fitted in the study. Two of these patients were civilians (one woman and one boy) and five were veterans. The injuries of three of the veterans were non-service-connected.

Review of the data available on these seven patients fitted in Birmingham indi-

cates that in four instances the experimental brace was used satisfactorily and successfully. In two cases, the results were inconclusive in that the follow-up data are not available. The seventh patient must be considered a probable failure, although again follow-up data are not available. Condensed case histories on these patients follow.

SUCCESSFUL OUTCOMES

Case No. 1

P.S. was born on February 28, 1953. He suffered from congenital pseudarthrosis of the right tibia and fibula, essentially constituting a defect similar to an ununited fracture. Prior to referral to the Crippled



Fig. 4. X-ray of *P.S.*'s leg at time of fitting the VAPC PTB brace.

Children's Service Clinic in Birmingham, he had undergone surgery at an early age. This surgery, involving the use of metallic screws and sutures, was unsuccessful. Further surgical procedures were attempted subsequently, an onlay bone graft being done on July 20, 1965. This surgery was followed by infection and was unsuccessful. A sliding bone graft was attempted on June 6, 1967, but this also was unsuccessful.

The VAPC PTB brace was fitted in April 1968. The condition of the right tibial and fibular defects at that time is shown in figure 4. The brace prescription included a SACH heel and a rocker bar incorporated into the shoe build-up (the right leg being shorter than the left). Initially, no motion was provided at the ankle joint.

Following application of the brace, the leg shrank rapidly, and a new socket was required in approximately one month.



Fig. 5. P.S.'s leg after wearing the experimental brace approximately 14 months.



Fig. 6. C.S.'s X-rays after wearing the experimental brace for 9 months. Good bone union is evident at the fracture site.

Because of this loss of fit, the amount of weight borne on the defective limb was increased. This boy was a very active user; he played basketball and reported that he went hunting almost every day. As a result of this active use, numerous breakages occurred at the junction of the brace upright and shoe plate. The upright was eventually strutted for extra strength, and after about a year and a half of wear a few degrees of motion were introduced at the ankle joint. This limited motion resulted in reduction of the breakage problems.

Although the patient was well pleased with the brace and wore it satisfactorily, the tibial and fibular defects failed to unite (fig. 5).

The physician, orthotist, and patient all considered this brace to be superior to any previously worn.

Case No. 2

C.S. was born on April 17, 1915. He was injured on March 2, 1967, when he slipped

on the ice and fell, sustaining fractures of the left tibia and fibula. He was treated with plaster casts, but union of the tibial fracture was delayed.

He was fitted with the VAPC PTB brace in September 1968. The prescription was standard, and included a SACH heel, a rocker bar, and a rigid ankle. A full leather cuff was applied over the fracture site.

This patient's treatment program proceeded uneventfully, and by June 1969 a good bone union was evident clinically and confirmed by X-ray (fig. 6). This patient was discharged from the doctor's care.

Case No. 3

H.E. was born on October 25, 1933. He was hit by a car on October 12, 1966, sustaining a fracture of the right tibia, which failed to unite. Draining osteomyelitis also was present.



Fig. 7. *H.E.*'s X-rays show indications of healing of fracture after the brace was worn for 10 months.



Fig. 8. X-ray of *J.C.*'s right ankle 5 months after injury.

He was fitted with the experimental brace on October 25, 1968. The prescription included a SACH heel, a rocker bar, a fixed ankle, a short leather cuff, and a high shoe. He initially walked with crutches or canes but later discontinued these aids.

This patient is a large, heavy man and very active. Many repairs were required at the shoe-plate junction, and eventually a strut had to be added for additional strength.

This patient's treatment program proceeded relatively uneventfully. In August 1969, the brace was reported as working well, and no drainage had been experienced since October 1968. Although the fracture had not healed, X-rays revealed some indications of healing (fig. 7). In March 1970, apparent ankylosis of the ankle joint was noted, and progressive ossification within the fracture area was evident. The patient continues to wear the brace and tolerates it well. He still wears

an elastic below-knee stocking, but this is apparently more for insurance than because of actual need.

Case No. 4

J.C. was born on October 27, 1948. He was injured by shrapnel on May 14, 1967, sustaining a fracture of the neck of the talus on the right leg and loss of soft tissue on the right heel. Figure 8 shows the condition of his right ankle approximately five months after the injury.

The experimental brace was prescribed for this patient on November 21, 1967, and it was delivered on December 13. The prescription incorporated a SACH heel, a rocker bar, a reinforced foot plate, and no ankle motion. This patient experienced no particular problems other than the need for shoe changes. He found the brace useful

and comfortable. X-rays taken on April 9, 1968, showed marked improvement (fig. 9). His injuries proceeded to complete healing, and he is no longer wearing the VAPC brace.

Case No. 5

S.D. was born on May 18, 1927. She was injured on August 30, 1967, sustaining a comminuted fracture of the right tibia and fibula. The tibial fracture failed to unite.

She was treated with long and short leg casts and fitted with the PTB brace on May 29, 1968. The prescription was standard, and included a SACH heel, a rocker bar, and no ankle motion. The patient tolerated the brace well, and X-rays taken on July 1, 1968, indicated satisfactory progress (fig. 10).



Fig. 9. Marked improvement is evident in *J.C.*'s ankle after wearing the experimental brace approximately 5 months.



Fig. 10.S.D. shows satisfactory progress one month after fitting with a PTB brace.

Few maintenance requirements were found, except that the shoes had to be changed and one upright and one foot plate broke.

The patient was seen in August 1969, at which time she was using the brace with crutches. She has not been seen since, so the end result is unknown.

Case No. 6

D.E. was run over by a truck in May 1966, and he sustained fractures of both legs and the left foot. The left tibia failed to unite, as indicated in X-ray films taken six months after the injury (fig. 11). He was fitted for the VAPC PTB brace in December 1968, but left the hospital before the brace was delivered. The brace was delivered at home just before Christmas 1968, and he apparently has not been seen since except for a casual encounter with the orthotist on the street, when it was reported that the fracture had healed and that the patient no longer needed the brace. Again,

because of the loss of this patient to active follow-up, the full story is not known.

ASSUMED UNSUCCESSFUL OUTCOME

Case No. 7

R. McK. was born on May 21, 1908. His injury occurred as a result of a land-mine explosion on February 27, 1942. He sustained the loss of the os calcis and the heel pad bilaterally.

He was fitted with the VAPC PTB brace on the right side only, the device having a fixed ankle, SACH heel, and rocker bar.

This patient was apparently dubious about the brace from the outset, and expressed lack of confidence in the doctors and the course of treatment. He wore the experimental brace for a very limited pe-



Fig. 11. Condition of D.E.'s leg prior to fitting with a PTB brace.

riod (approximately five days) and claimed that it limited his freedom, particularly when driving. This patient subsequently became lost to follow-up, and all indications were that the application of the brace in this case was unsuccessful as well as perhaps ill-advised.

DISCUSSION AND CONCLUSIONS

The evidence in the Birmingham fittings of the VAPC PTB brace was strongly positive with respect to its value as a means of patient management. In some instances, this value was in providing partial unweighting so that the damaged part could heal. In other instances, the unweighting provided by the brace permitted the patients to engage in vigorous programs of activity despite a lack of union in the tibia.

In addition to these general findings, some specific findings of interest emerged.

1. Following application of the VAPC PTB brace, shrinkage of the limb enclosed

by the plastic cuff was encountered. Close control of the fitting during this period is essential in order to avoid the development of loose fit and a reduction in the amount of weight borne by the brace.

2. As in all prosthetic-orthotic applications, judicious selection of patients is essential. In the Birmingham group, one fitting was apparently doomed to failure from the outset because of the patient's attitude, while another patient was a chronic alcoholic, so that the possibility of securing follow-up data was negated from the outset.

It should be emphasized that the Birmingham fittings closely followed the technique practiced and taught by the Veterans Administration Prosthetics Center. Review by one of the co-developers of the device on a number of the cases fitted early in the study indicated good workmanship and generally excellent fit and alignment.

Some observations by the orthotist member of the fitting team were:

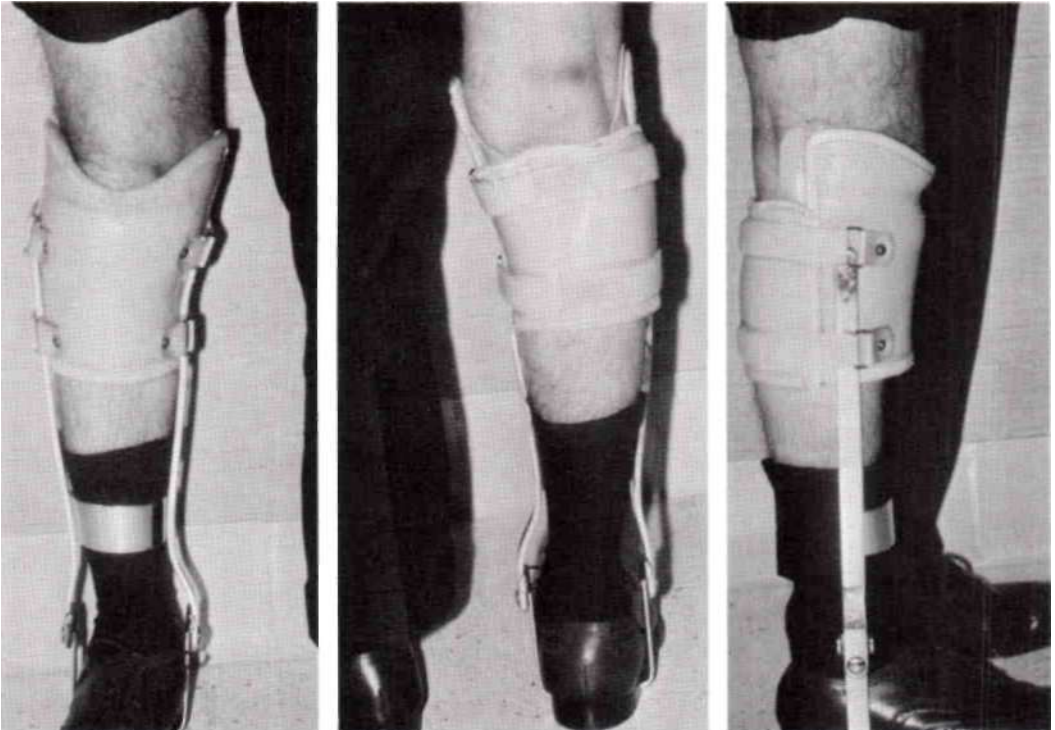


Fig. 12. Front, rear, and side views of PTB brace with earlier Durham bivalve socket lined with horsehide,

DURHAM, NORTH CAROLINA

1. Fabrication of the VAPC PTB brace requires experience in both prosthetics and orthotics, since elements of both specialties are involved.

2. A course of instruction in the technique during which the braces are actually fabricated under competent instructors is a most desirable means of transmitting fitting knowledge and skill.

3. The selection of patients for the device is most important and should include not only considerations of psychological factors such as those described above but also of physical factors which may increase the difficulty of fitting. (The presence of loose tissue around the knee which could become a flesh roll above the brace cuff was cited as an example of this type of difficulty.)

4. All patients fitted in the Birmingham group were initially provided with braces with no provision for motion at the ankle joint. In active and/or heavy patients, this resulted in numerous brace-upright and shoe-plate breakages. Later, some patients were provided with a small amount of ankle motion, and this had the effect of reducing incidence of breakage. Criteria for the prescription of fixed or limited motion in ankle joints should therefore be defined more carefully.

Mr. Bert Titus, director of the Department of Prosthetics and Orthotics, Duke University, began fitting the VAPC-PTB-type brace in 1962. The initial braces were fabricated in accordance with the VAPC manual of January 3, 1961 (5). Over the years, however, the original VAPC procedures were modified at Duke in a number of ways. Although the original concept of patellar-tendon weight-bearing for reduction in the amount of weight borne by the affected part of the limb was maintained, the changes are significant enough to be worthy of note.

1. The socket, which in the VAPC version was hinged on the medial side, was first changed to a bivalve construction involving anteroposterior sections joined by adhesive tape (fig. 12). The type of socket now fitted in Durham involves a plastic laminate without liner which is flexible on the posterior aspect and the posteromedial corner (fig. 13). The socket is split along the posterolateral corner and closure is effected by two or more Velcro (TM) straps (figs. 14 and 15). The fabrication of this socket is described in a report being prepared by Titus. An abbreviated description of the Duke procedures appears as a supplement to this article.

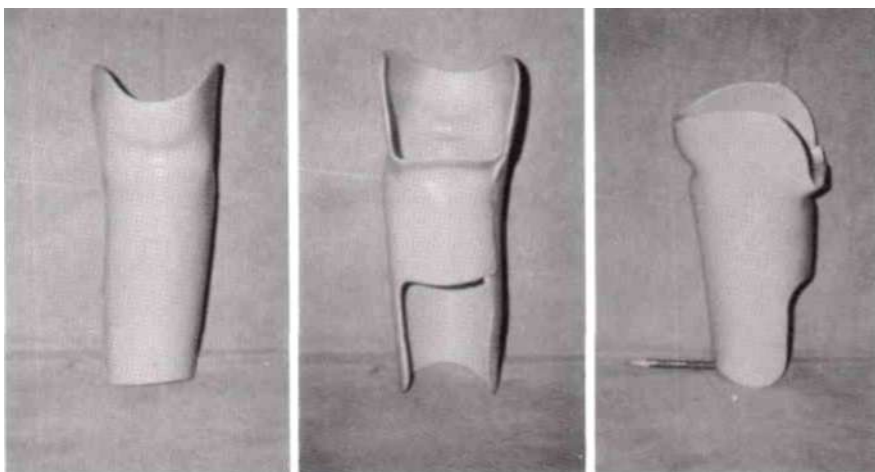


Fig. 13. Front, rear, and side views of current Durham socket.

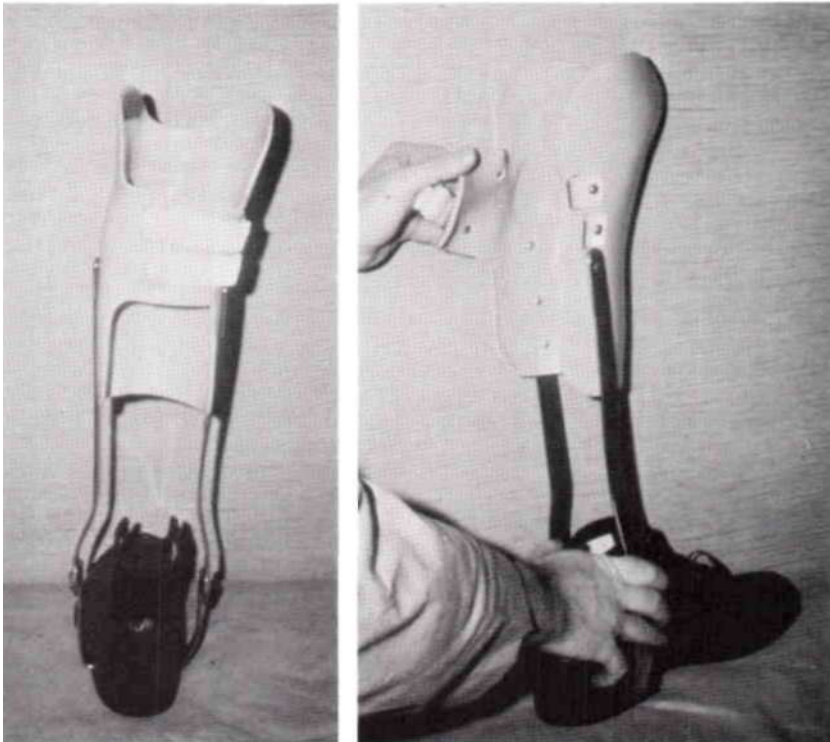
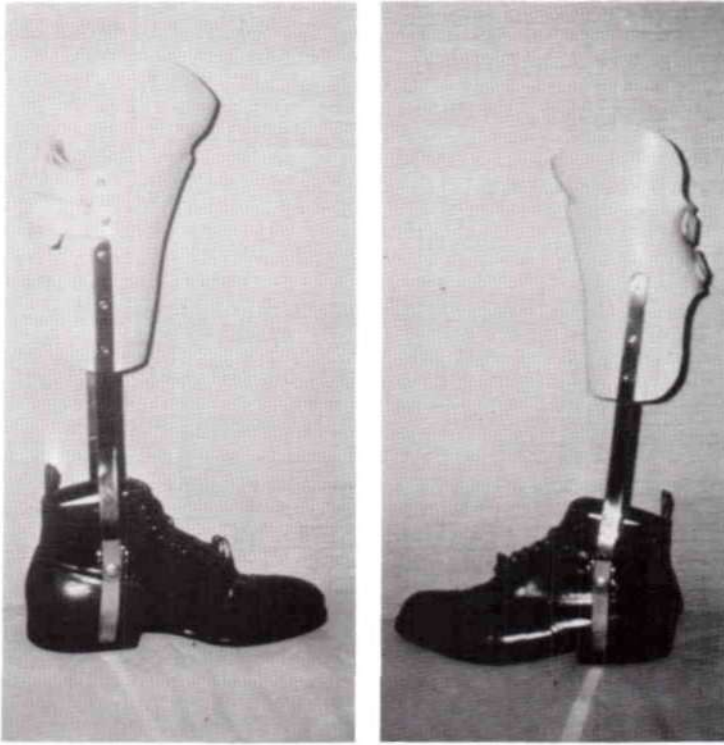


Fig. 14. Medial, lateral, rear, and oblique views of socket with sidebars and shoe attached.

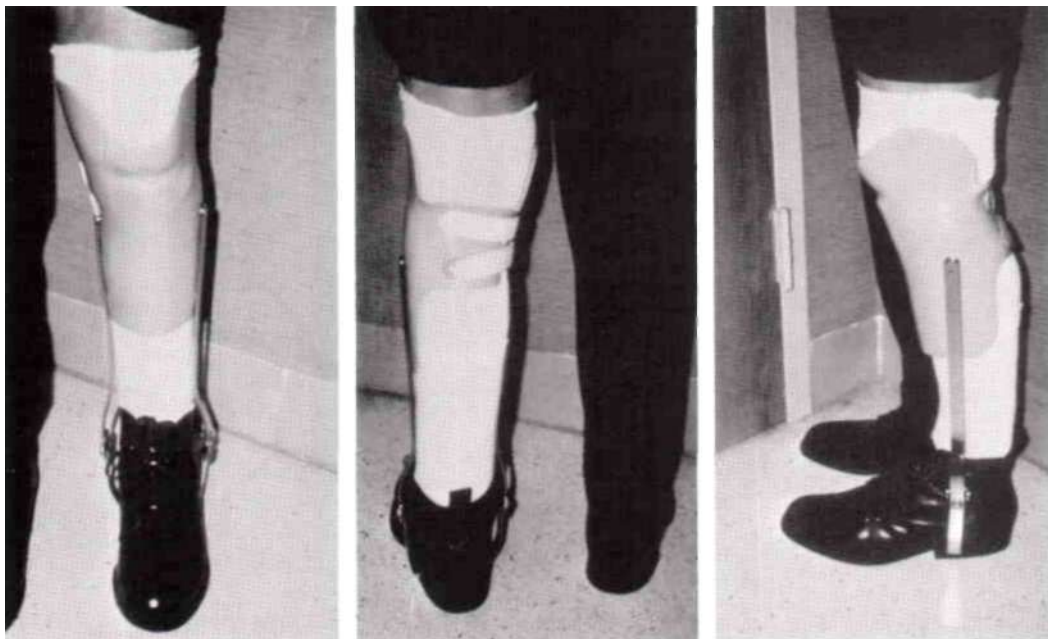


Fig. 15. Current version of Durham modification fitted to patient.

2. The sidebars in the Durham version of the weight-bearing brace are of either stainless steel or aluminum, and most recently have been attached to the outside of the socket with rivets. This procedure is in contradistinction to the VAPC method, which involves insertion of the proximal ends of the sidebars into prepared channels. Distally, the bars are detachable from the shoe.

3. All the VAPC-type braces fitted at Durham incorporated some degree of ankle motion. Typically, this was 20° to 25° of dorsiflexion with a 90° stop. However, some of the ankle joints were completely free. This feature again contrasts with the VA practice in which the brace ankles are frequently of the rigid type. It was reported that none of the braces fitted at Durham had completely rigid ankles.

4. Typically, the Durham version of the weight-bearing brace does not include either a SACH heel or a rocker bar. Doubtless, the need for such aids to roll-over is

reduced or eliminated by the provision of ankle motion.

Between the initial fittings in 1962 and June 15, 1970, the Duke Limb and Brace Shop fitted approximately 27 PTB-type braces. Of these patients, 20 were civilians seen through the Orthopaedic Department of Duke University Hospital and 7 were veterans who were treated through the Veterans Administration Hospital at Durham. Three additional braces were being fabricated at the time of this review.

On June 22-23, 1970, the author, accompanied by William McIlmurray from the VAPC, reviewed 8 patients who had been fitted through the Duke University Department of Prosthetics and Orthotics. The group of patients reviewed included 5 civilians and 3 veterans. The case-history files of 12 additional patients were also reviewed. The data obtained in these reviews are presented below in three sections—one indicating the types of disabilities for which the brace was used, the second containing

illustrative case histories of patients treated, and the third containing comments on fit and alignment. In general, the outcomes of the fittings appeared to be very positive.

TYPES OF DISABILITIES

Chronic osteomyelitis with secondary deformity of distal tibia and fibula and partial ankle fusion.

Slow-healing spiral fracture of the tibia and fibula.

Compound fracture of the tibia and fibula and fracture of the left foot followed by infection and numerous operative procedures culminating in ankle fusion.

Fracture of the tibia and fibula.

Nonunion of the tibia and fibula with compression-plate fixation.

Nonunion of a tibial fracture with draining osteomyelitis.

Comminuted fractures of the distal right tibia and proximal right fibula and fracture dislocation of the right ankle. A painful ankle led to the performance of a triple arthrodesis.

Comminuted fractures of the ankle mortice bilaterally (right medial malleolus and tibia, left spiral fracture of tibia and fibula; both ankles stabilized with pins). Six pins were subsequently removed.

Traumatic arthrosis of the right ankle following fracture of the distal right tibia and fibula.

Compound trimalleolar fractures of the left ankle with dislocation.

Nonunion of a left tibial fracture with osteoporosis.

Calcaneal valgus deformity of the right foot treated with a triple arthrodesis of the right foot and ankle; delayed healing of subtalar, talonavicular, and calcaneocuboid joints with severe osteoporosis.

Pain on plantar aspect of heel following fracture of the os calcis.

Foot pain following football injury; triple arthrodesis performed.

Degenerative changes in left knee secondary to old fracture of the tibial plateau.

Nonunion of medial malleolus following trimalleolar fracture sequelae of traumatic arthrosis and arthrodesis.

Comminuted fracture of os calcis leading to a crushed heel pad, osteoporosis, and triple arthrodesis subsequently.

Right heel pain, characteristic of traumatic or degenerative arthritis.

Fracture of the right os calcis with painful right foot and ankle.

CASE HISTORIES

Case No. 1

W.J. was born on April 3, 1927. From early childhood, he had suffered from a defect in his left leg which had been attributed to an aftermath of diphtheria. His condition was reported as being chronic osteomyelitis with a secondary deformity of the distal tibia and fibula combined with partial ankle union.

The patient was fitted with a PTB brace in August 1962, and thus had worn the device for almost eight years. The brace worn had an ankle with a positive 90 deg. stop and approximately 30 deg. of dorsiflexion motion. He wore a low shoe with a 2 1/2-in. build-up. Otherwise, the brace was of the Durham type as described previously. He reported that he wore the brace for more than nine hours daily, and that it was generally quite comfortable and satisfactory. His condition was reported to have stabi-



Fig. 16. *J.G.*, with nonunion of fractures and draining osteomyelitis.

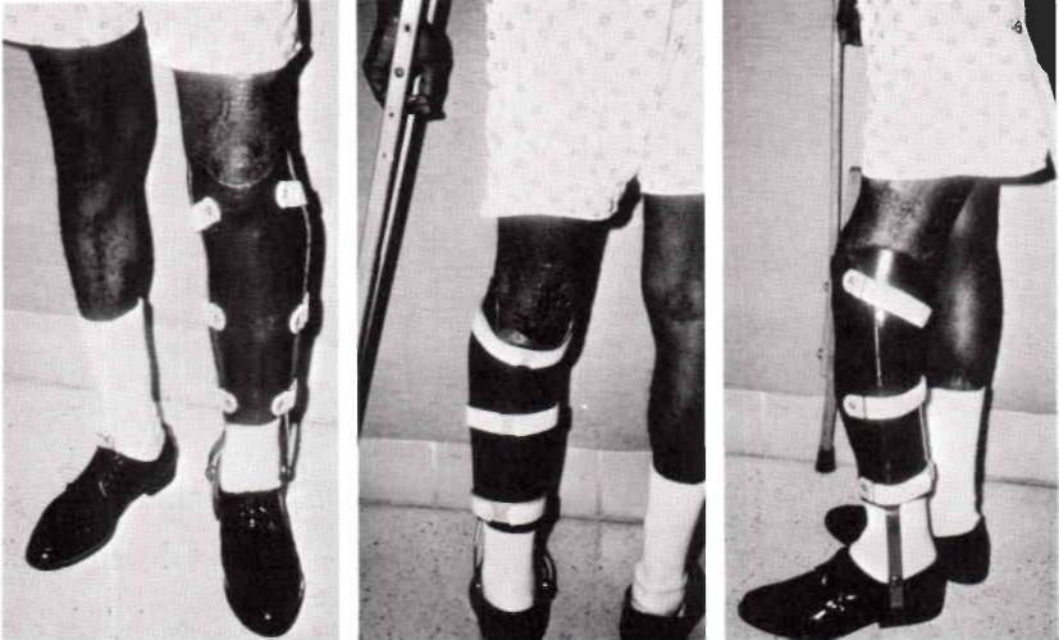


Fig. 17. J.G., with Durham bivalve-type brace.



Fig. 18. Views of T.L.'s fractures before fitting with PTB brace.

lized, although his ankle and shin sometimes ached after prolonged standing or walking. He stated that he felt that he was bearing more than 50% of his weight on the

brace. From his remarks, it would appear that the brace was a definite aid to his mobility.

Case No. 2

J.G. is a 30-year-old male garbage collector who was jammed between the garbage truck and a brick wall, sustaining a fracture of his left tibia and fibula on March 22, 1967. A nonunion of the fractures with a draining osteomyelitis ensued (fig.16).

The patient was fitted with a PTB brace in September 1969. He reported that he was feeling fine, the osteomyelitis had stopped draining, and he had returned to work driving a garbage truck.

The brace worn was the Durham bivalve device with the ankle completely free (fig. 17). He wore the brace all day every day and reported absolutely no problems with it.

From the patient's remarks, his return to work, and his comments concerning the brace, it would appear that this fitting was quite successful.

Case No. 3

T.L., a physician, sustained a spiral fracture of the tibia and fibula on February 5, 1969. He wore a long leg cast for six months following the injury, and on August 8, 1969, he was fitted with the PTB brace. The condition of his fractures just prior to fitting is shown in figure 18. With the device, he was able to return to his medical

practice. The fracture was pronounced healed in November 1969, and the PTB brace was discarded. His brace was of the standard Durham type with a completely free ankle joint.

When interviewed, the patient's comments concerning the brace were very positive. So much so, in fact, that when the interviewer remarked that he seemed like a happy customer, he retorted that he was



Fig. 19. X-rays of F.E.'s distal leg, ankle, and foot.



Fig. 20. Condition of F.E.'s limb 9 months later.



Fig. 21. Condition of H.H.'s fractures 8 months after injury (2 months' wear of PTB brace).

more than happy—he was delighted—and in fact had sent two patients with fractures to be fitted with the same type of brace.

Case No. 4

F.E., a 43-year-old male, was buried under eight to ten tons of chemical in March 1966, sustaining compound fractures of the left tibia and fibula, a fracture of the left foot, and fractures of the pelvis and of the right upper femur. Following open reduction and internal fixation, the injury became infected and the fixation was removed. The patient had a number of operative procedures on his right hip, and on October 3, 1967, underwent multiple fusions of the ankle bones.

He was fitted with a PTB brace on March 27, 1968, and thus had worn it for slightly more than two years. The device is of a standard Durham type with a 90° ankle stop and with approximately 5° of dorsiflexion. The sidebars were of aluminum with an anterior aluminum calf

band. A low shoe was worn with a build-up on the opposite side because of a shortening of the right leg related to the pelvic and femoral fractures. The brace was of the bivalve type. Figures 19 and 20 show the condition of the foot and distal tibia and



Fig. 22. Persisting nonunion of fibula approximately 4 1/2 years after injury.

fibula over the period from January to October 1969. The patient reported that without the brace he experienced discomfort at the fracture sites, but that with the device he was reasonably comfortable and could wear the brace all day. He claimed that he took about 30% of his weight on the brace. Again, it appeared that this brace is a highly acceptable aid to the mobility of the patient.

Case No. 5

H.H., 40 years of age, sustained multiple fractures of the lower extremities on August 4, 1969. His injuries included fractures of the left femur, tibia, and fibula, and right tibia and fibula. He was fitted with a PTB-type brace in February 1970. His condition two months after fitting (eight



Fig. 23. Nonunion of tibial fracture 10 months after accident.



Fig. 24. Nonunion persisting 3 years after accident. PTB brace worn 3 months.

months after injury) is shown in figure 21. His device was of the single-lamination type and incorporated a free ankle and a high shoe. The fit of the socket was somewhat loose, and the patient expressed the opinion that no weight was being taken on

the socket. He used Canadian-type crutches bilaterally. The clinical notes on his condition indicated good alignment of the bony fragments and no pain. He was wearing the brace all day and had no problems with it.

Case No. 6

J.H., born in 1927, suffered his injury in December 1966. Nonunion of the left tibia and fibula ensued, with compression-plate fixation.

The patient had been fitted initially with the bivalve-type socket (separate anterior and posterior sections), but was currently wearing the one-piece laminated socket with a flexible posterior section. The brace incorporated a free ankle, and a low shoe was worn.

Recent clinical notes on this case indicated that on March 25, 1970, there was good alignment of the bony fragments,

and early bridging of bone had begun in the tibia and fibula. On May 27, 1970, the patient was reported to be feeling well, but there was still nonunion of the fibula (fig. 22). The patient reported no problems with the brace.

Case No. 7

R.C.M., 39 years old, sustained a comminuted fracture of the left tibia and fibula when a tree fell on his leg in March 1967. Nonunion of the left tibial fracture ensued, with chronic osteomyelitis and drainage (fig. 23). A bone graft to the tibia was attempted in March 1968.

The patient wore a long leg cast, followed by an initial weight-bearing brace. He was fitted with the PTB device in December 1969. His clinical record indicated that there was intermittent drainage in December and January but no drainage in February or March 1970 (fig. 24). On April



Fig. 25. *Left*, R.McC.'s initial injury, Nov. 15, 1969. *Right*, after open reduction and internal fixation, Jan. 2, 1970.

1, 1970, it was reported that no active osteomyelitis was evident. However, at the time of the review (June 24, 1970), the patient reported that drainage had restarted.

His brace included a 90° posterior stop with about 10° of dorsiflexion motion evident. The patient wore a built-up low shoe to accommodate a 2 1/2-in. shortness of the affected limb. His socket was of the two-part (bivalve) type. He used a cane as an aid in ambulation.

The patient reported that the brace felt comfortable most of the time, although he had occasional swelling of the leg after long use and some discomfort at the site of the fracture after prolonged sitting.

Case No. 8

R.McC., 69 years old, was injured in an automobile accident on November 15, 1969. He sustained fractures of the head of the tibia, the head of the fibula, and the proximal third of the fibula (fig. 25). He was fitted with the PTB brace on April 6,



Fig. 26. *Left*, R.McC.'s fractures at time of fitting the PTB brace, 4 1/2 months after injury, April 1970. *Right*, after 1 month's wear of PTB brace, May 1970.

1970 (fig. 26). Thus, at the time of the review, he had been wearing the device for approximately two and one-half months. He reported that the brace was generally comfortable, but that he had had some problems with swelling and stiffness in the ankle. He estimated that the brace was taking approximately 25% of his body weight. His brace was a standard Durham type with a 90° posterior stop and dorsiflexion motion of approximately 30°. When first fitted with the PTB brace, he had used two crutches, but now was only using one.

Although in this instance the period of brace wear was too short for definite conclusions to be drawn, the brace was being tolerated well by the patient and was of assistance to him in ambulation.

Case No. 9

J.B., 67 years old, was admitted to Duke University Hospital on March 12, 1969, with a closed comminuted fracture of the left distal tibia, fibula, and ankle joint, and an open trimalleolar fracture of the right ankle. Operative procedures were carried out the same night, and the patient was discharged from the hospital on April 11, 1969, with the wounds healed and the feet in apparently satisfactory condition, with the right foot in a better state than the left.

X-rays taken on January 12, 1970, showed an old fracture of the right ankle with fixation by metallic pins and screws and good external bony bridging and normal alignment (fig. 27). On the left side, internal-external bridging of the fibula with marked angulation, as well as poor healing of the tibial fragments, was evident.

He was fitted with the PTB brace in February 1970. Four weeks later, the clinic notes reported that the fibula had healed, and that the tibia was nontender.

No significant further changes were noted at examination on May 26, 1970. However, that patient reported that since wearing the PTB brace he had experienced practically no pain in the ankle or foot. He was to continue wearing the brace.



Fig. 27. *Left*, J.B.'s left ankle 10 months after reduction, Jan. 1970. *Right*, views of ankle 12 months after reduction (1 month after fitting with PTB brace) March 1970.

CRITIQUE OF FABRICATION AND ALIGNMENT

William McIlmurray of the Veterans Administration Prosthetics Center, one of the co-developers of the PTB brace, participated in the review of patients at the Durham facilities. Mr. McIlmurray described the fitting and alignment of the braces seen as generally good. He noted some of the characteristics of the Durham devices previously mentioned: the one-piece socket lamination, the ankle motion provided in all prostheses in contrast to the need that VA found to fit some braces with rigid ankles, the external attachment of the sidebars, the use of detachable stirrups, and the absence of SACH heels and rocker bars on the shoes of the patients. The absence of a liner in the sockets fitted and the fact that some patients did not wear stump socks was also noted.

Mr. McIlmurray subsequently discussed these features of the Duke fittings with Werner Greenbaum, the other co-devel-

oper of the VAPC technique. Their joint comments follow.

No objection is raised to the use of hard, unlined sockets which have a flexible medioposterior corner. However, it should be emphasized that, if this portion of the socket is too flexible, it will not offer support and the weight-bearing effectiveness of the brace will be reduced.

In courses of instruction on the PTB brace, it would be desirable to teach fabrication methods for both lined and unlined sockets. Clinics would then have the choice of using either method, thus creating a situation similar to current practice in the prescription of PTB prostheses.

VAPC also employs a one-piece socket fabrication procedure, and the use of this method is endorsed by the Duke experimentation.

The channels which are prepared in the socket for insertion of the sidebars result in a product which is cosmetically more acceptable than one with bars externally attached. Moreover, these channels are very necessary for alignment adjustability during the fitting procedures. They permit us to make minute height adjustments and to tilt the socket either medially or laterally. This adjustability is a most important feature, and we would not agree to its elimination.

We think that, in general, detachable stirrups are contraindicated, although they might possibly be used on lightweight, inactive patients.

Usually we do allow some ankle motion if warranted by the pathology. However, the weight-bearing characteristics of the brace are better maintained if only plantar flexion is allowed. When mechanical ankle-joint motion is not provided, SACH-heel and rocker-bar principles are applied.

DISCUSSION AND CONCLUSIONS

The clinical records of 27 patients fitted with the patellar-tendon-bearing brace through the Department of Prosthetics and Orthotics at Duke University were reviewed. A number of the patients in this series were interviewed and examined. From the data gathered, it appears incontrovertible that this type of brace has useful applications for a variety of below-knee problems.

Two broad areas of application were noted:

1. In instances where fractures or operative procedures were slow to heal, the brace was used as a means of mobilizing the patients more rapidly than might otherwise have been the case.

2. In cases of chronic pain in the leg, ankle, or foot arising from fractures, traumatic arthritis, and the like, the weight-bearing relief provided by the brace permitted patients to be ambulatory with considerably less pain and discomfort than was the case without the brace.

The review data indicated that the outcomes of the application of the brace were viewed very positively by the orthopedists, the orthotists, and the patients.

The variations in fabrication and fitting procedures used at Durham as compared with those originally promulgated by VAPC are noteworthy:

1. One-piece fabrication of the PTB-type socket or cuff without a liner appears to be a possible improvement over the original VA procedure.

2. The external attachment of sidebars appears somewhat less cosmetic than the original technique, but is probably somewhat simpler and faster to do.

3. Detachable stirrup-type upright applications showed some loosening tendencies.

In some cases, the provision of ankle motion in the brace undoubtedly eliminated the need for a SACH heel and a rocker bar, and resulted in less breakage of sidebars at the shoe attachment. However, the question as to whether some of these patients should have had rigid ankles with a SACH heel and/or rocker bar is unclear. The rule of thumb used at Duke appeared to be that, the closer the disability was to the ankle joint, the less motion had to be provided. However, as reported, all patients were given some degree of ankle motion.

In conclusion, it would appear that the Duke application of the PTB brace was in general highly successful. Some of the changes made in the original VAPC procedures appeared to have definite merit.

RECOMMENDATIONS

Since the results of this study indicate that the VAPC PTB brace can be successfully and beneficially applied by unaffiliated treatment centers, thus corroborating the developer, it is recommended that: (1) the results of the study be broadly disseminated by publication in *Artificial Limbs* and by other means, (2) the prosthetics—orthotics schools be encouraged to include instruction in the PTB brace as part of the lower-extremity orthotics curriculum, and (3) the fabrication modifications introduced by the Duke University Department of Prosthetics and Orthotics be tried at VAPC, and that following these trials the two institutions collaborate on the production of a fabrication manual for the PTB brace which will incorporate the best procedures currently known.

SUMMARY

In the late 1950s, a brace to unweight the leg was designed at the Veterans Administration Prosthetics Center (VAPC), New York, N.Y. This brace incorporated a lined plastic cuff essentially similar to the prox-

imal portion of the patellar-tendon-bearing (PTB) prosthesis. By varying the tightness of this cuff and the lengths of the uprights connecting it to the shoe, the amount of body weight borne on the proximal shank could also be varied. By these mechanisms, the distal portions of the limb could be unweighted to the desired degree.

The VAPC PTB brace was reported by the developer as having beneficial applications in cases of delayed or ununited fractures (tibia and fibula), painful ankles, and soft-tissue damage to the heel and the plantar aspect of the foot. It appeared potentially useful in any leg condition which produced pain on weight-bearing. Patients fitted by VAPC were reviewed by an independent agency (New York University) in 1963, and the developer's claims for the device were essentially substantiated.

The present report presents the results of VAPC PTB brace fittings performed by two groups other than the developer. The clinical records of 36 patients were reviewed, and approximately one-third of the patients were examined and interviewed.

The studies generally corroborated the positive findings previously reported by the developer. Wide dissemination of information concerning the VAPC item and its incorporation in orthotics instructional courses is recommended.

ACKNOWLEDGMENTS

To all who participated in the various phases of the VAPC PTB brace evaluation study, we express our sincerest appreciation. To Chestley L. Yelton, M.D., Moody L. Smitherman, Jr., of Birmingham, Ala., and Bert R. Titus of Durham, N.C., we extend our special thanks for their extraordinary efforts in scheduling and reviewing patients and in providing the X-rays and pictures for this report.

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A Modification of the VAPC PTB Brace

Bert R. Titus, C.P.O.¹

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, the ankle, and the foot.

Using the Veterans Administration Prosthetics Center manual dated January 3, 1961, for the fabrication of below-knee weight-bearing braces, we measured, fabricated, and fitted two devices for patients with painful ankles. After the patients wore the patellar-tendon-bearing-type socket for some time, changes occurred in the anteroposterior measurement of their legs. With the hinge on the medial side of the socket, no adjustment could be made in that area. The lateral side could be adjusted by tightening the strap; however, the patients felt that the socket was not fitting the leg properly, and that it was twisted on the leg. Additional strips of Kemblo (TM) could be glued to the socket, but this increased its bulk.

We then made 13 braces, using the same method of measuring, casting, and correcting the positive mold, except that in the posterior area we built up the cast to obtain a roll in the popliteal and hamstring area. The distal edge of this build-up was at the mid-patellar-tendon level. The lay-up was then made in the same manner as for a hard PTB socket, using Dacron (TM) felt and a mixture of 70% rigid and 30% flexible resin. Vacuum is required to obtain a uniform socket thickness and to pull the PVA bag into the cast at the patellar-tendon and posterior areas. When the plastic resin has set and before it has completely cooled, the proximal end of the socket is trimmed as for a hard PTB prosthesis. The distal end of the socket should be cut off, leaving the socket as long as

possible or as planned when the measurements and casts were taken. The posterior area of the socket is cut down the midline, and it is removed from the mold.

The foot piece is placed on the shoe, using either a regular rubber heel or a SACH-foot-type heel with or without a rocker bar on the sole. Limited ankle motion is usually prescribed; therefore, ankle-joint placement is critical. The uprights are contoured to the tracing and attached to the foot piece and shoe.

The socket is placed on the patient (a narrow section of the posterior socket may have to be cut out) at the proper height and taped in place. The shoe and brace are put on, and the brace uprights are aligned on the socket. The contours of the uprights are adjusted along the surface of the socket as necessary. The height of the socket is adjusted to remove the desired amount of weight from the patient's heel. The uprights are marked and taped to the socket, the fit being checked both standing and sitting. The brace and socket are removed, the excess upright length is cut off, and the socket is temporarily attached to the uprights with screws. The socket is replaced on the patient, and as little as possible of the posterior area of the socket is removed. The edges of the socket are trimmed and sanded. The entire brace and socket is removed from the patient. The socket is disassembled from the uprights and replaced on the mold. A PVA bag is pulled over the socket. A second socket is laid up, and the posterior two-thirds is laminated. The second socket is removed and the edges are trimmed. The first socket is then removed from the mold, and the uprights are riveted to the second socket. The edges of the second socket are adjusted to obtain the proper A-P dimension. The edges of both sockets are

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A MODIFICATION

trimmed and finished. Velcro (TM) straps are added to hold the sockets in place.

If the anteroposterior aspect of the socket needs to be changed, the edges of both sockets may be adjusted to decrease the A-P measurement.

This type of brace has also been fitted on six patients with the socket laminated in one piece with the posterior aspect made of 80% flexible and 20% rigid resin. The sides and anterior portions of the socket were

made of 80% rigid and 20% flexible resin. The posterior area of the socket is cut so that it is only 2 to 2 1/2 in. wide and opens at the posterolateral corner. A Velcro strap is used for closure. Anteroposterior adjustment is obtained by laminating a piece of Dacron felt across the entire posterior area.

This socket has the least bulk of the three described and has been preferred by the majority of the patients fitted thus far.

Clinical Evaluation of Externally Powered Prosthetic Elbows

Maurice A. LeBlanc¹

During the past few years, several externally powered prosthetic elbows have been developed and attention has been called to them in the news media. On October 21-23, 1968, the Panel on Upper-Extremity Prosthetics of the CPRD Subcommittee on Design and Development met to survey seven different elbows. Functional characteristics were examined, the elbows were demonstrated on amputees, and recommendations for future development and evaluation were made.

Based on the recommendations of the Subcommittee on Design and Development and subsequent discussion and approval by the CPRD Subcommittee on Evaluation at its meeting on May 27, 1969, a clinical evaluation program was undertaken on the following: (1) the American Institute for Prosthetics Research (AIPR) elbow, (2) the Army Medical Biomechanical Research Laboratory (AMBRL) elbow, and (3) the Boston elbow.

Because of the unavailability of the AIPR elbow, the Rancho Los Amigos Hospital elbow was later substituted for it. It was also decided that the elbows would be evaluated in the following six clinics: Jackson Memorial Hospital, New York University Prosthetics-Orthotics Studies, Northwestern University Prosthetics-Orthotics Center, Rancho Los Amigos Hospital, University of California at Los Angeles Prosthetics-Orthotics Program,

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and the Veterans Administration Prosthetics Center. To acquire additional clinical experience with the elbows, J. E. Hanger, Inc. of Georgia was later added to the list.

DESCRIPTION OF ELBOWS

The AMBRL elbow (fig. 1) is a battery-powered, electrically driven unit, which is controlled by a pull switch in the shoulder harness. It has free swing when the elbow is positioned at full extension.



Fig. 1. The AMBRL elbow.

The Boston elbow (fig. 2) is a battery-powered, electrically driven unit, which is myoelectrically controlled by use of surface electrodes on the stump. It has a feedback system that maintains the speed of motion regardless of load.

The Rancho elbow (fig. 3) is a battery-powered, electrically driven unit, which is controlled by a pull switch in the shoulder harness. The McCulloch fast charger is used in conjunction with it.

PROCEDURE

ORIENTATION SESSION

An orientation session was held on October 21-23, 1969, for the developers to familiarize the clinic teams with the elbows and for CPRD to familiarize the clinic teams with the evaluation forms. The agenda and list of participants are attached as appendix A to the full report (E-4).

ALLOCATION OF ELBOWS

The final allocation of the elbows to the clinics is given in Table 2.

MECHANICAL TESTING

All the elbows were tested to ensure that they operated satisfactorily and conformed to the mechanical specifications before being sent to the clinics for fitting. Some of the units had to be returned to the developers for additional work before being sent to the clinics.

SELECTION OF PATIENTS

Unilateral above-elbow amputees were selected as subjects for the evaluation because: (1) most of the elbows and their control systems had been designed for use on AE amputees, (2) the unilateral above-elbow-amputee population is much larger than the shoulder or bilateral upper-extremity-amputee population, and (3) it was necessary to have a common base for comparative purposes. Further, the subjects were selected on the basis of having been previous wearers of a conventional, bodily powered, above-elbow prosthesis, because it is now the standard.

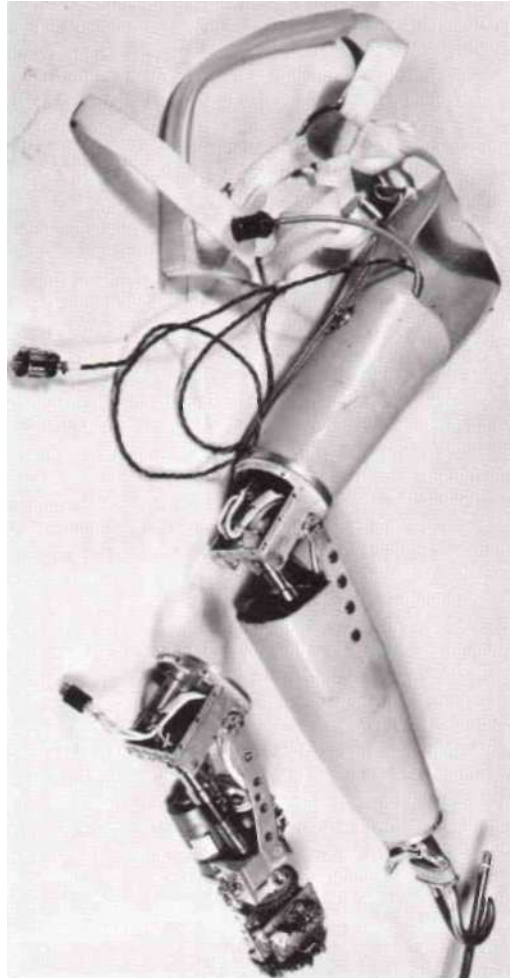


Fig. 2. The Boston elbow.



Fig. 3. The Rancho elbow.

TABLE 1. SPECIFICATIONS OF THREE EXTERNALLY POWERED ELBOWS

	Acceptable Specifications	AMBRL Elbow	Boston Elbow	Rancho Elbow
<i>Dimensions (in)</i>				
Width at axis inside saddle	2 $\frac{1}{4}$	2 $\frac{1}{4}$	2 $\frac{3}{8}$	2 $\frac{3}{16}$
Minimum distance, axis to stump end	2	5 $\frac{1}{4}$	1 $\frac{7}{8}$	2 $\frac{1}{8}$
Total length in full extension	3 $\frac{3}{16}$	6 $\frac{13}{16}$	3 $\frac{3}{16}$	3 $\frac{3}{8}$
<i>Weight (oz)</i>				
Elbow unit only	12	15.6	33.7	18.5
All additional equipment worn	40.0	12.3	60.0	27.0
<i>Range of motion (deg) (flexion-extension)</i>	10-135	0-125	10-135	0-135
<i>Speed (sec) (flexion)</i>				
No load	2.0	2.0	1.0	2.5
With 12 in-lb load	2.0	2.6	1.0	3.5
<i>Maximum lift (in-lb)</i>	100	72	84	36
<i>Resistance to load (in-lb)</i>	600	192	600	unknown
<i>Noise level at 12 in. (db)</i>	< 68	64	65	60
Standard turntable interchangeable	Yes	No	No	Yes
Standard forearm interchangeable	Yes	Yes	No	Yes

Adapted from Report of Sixth Workshop Panel on Upper-Extremity Prosthetic Components of the Subcommittee on Design and Development, October 21-23, 1968, Santa Monica, Calif.

The candidates for the AMBRL elbow were further restricted to AE amputees with relatively short stumps, because the elbow unit protrudes about five inches above the elbow center of rotation. For the Boston elbow, AE amputee subjects had to demonstrate sufficient biceps and triceps EMG activity to operate the control system. The Rancho elbow fitted most AE amputees because it protrudes only about two inches above the elbow center of rotation.

EVALUATION FORMS

Amputee subjects were properly fitted and trained by the clinic teams and were asked to wear each externally powered elbow for a month. Evaluation forms completed before and after the trial-wear period have provided information for considering the results of the evaluation. These forms are attached as appendix B to the full report.

MEETINGS

There was a meeting of the clinics, developers, and Subcommittee on Evaluation on May 12-13, 1970, to consider the preliminary results of the evaluation. The

TABLE 2. ALLOCATION OF ELBOWS

Organization	Number of Elbows			Total
	AMBRL	Boston	Rancho	
New York Univ.	2	1	2	5
Northwestern U.	2	2	2	6
U. Calif., LA	2	2	2	6
Rancho Los Amigos	2	2	0	4
Jackson Mem. Hosp.	2	0	1	3
Vet. Adm. Pros. Ctr.	2	0	1	3
J. E. Hanger, Atlanta	0	1	2	3
Total	12	8	10	30

agenda and list of participants are attached as appendix C to the full report.

A second meeting of the clinics, developers, and subcommittee on November 9, 1970, considered the final results of the evaluation. The agenda and list of participants are attached as appendix D to the full report.

RESULTS

SUMMARY

Total number of elbows 30

Number of elbows not evaluated due to inadequate subjects or insufficient data 9
Total number of elbows evaluated 21

Number of amputees preferring conventional elbow	17
Number of amputees preferring externally powered elbow	3
Undecided	1

Number of amputees preferring conventional elbow	6
Number of amputees preferring AMBRL elbow	1
Undecided	1

To begin with, all the amputee subjects were asked what they liked and disliked about their conventional elbows. Most of them cited the positive lock as the best feature, and the control motion and cable needed for the lock as the most undesirable feature.

The best features were ease of flexion and free swing.

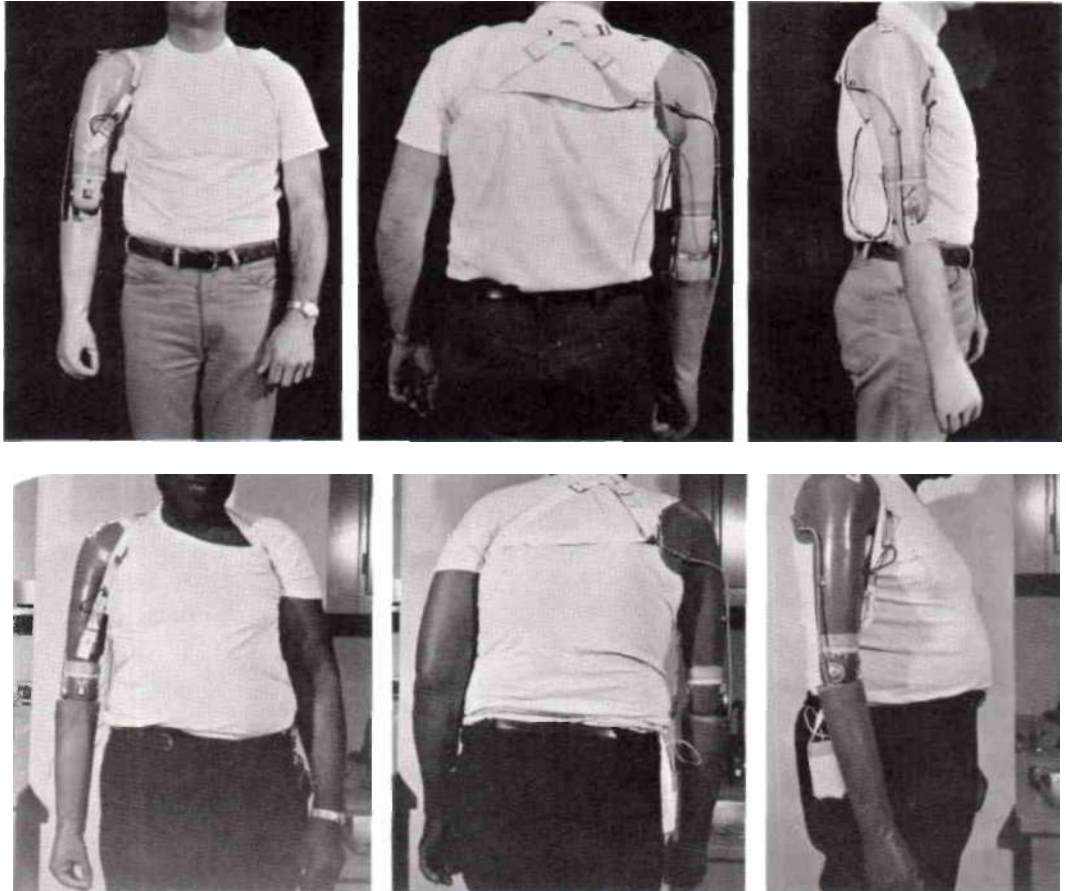
The most undesirable features were: weight, speed, noise, bulkiness, inadvertent operation of switch, lack of positive elbow lock, and size of unit proximal to the elbow joint.

CLINICAL FITTINGS OF THE AMBRL ELBOW

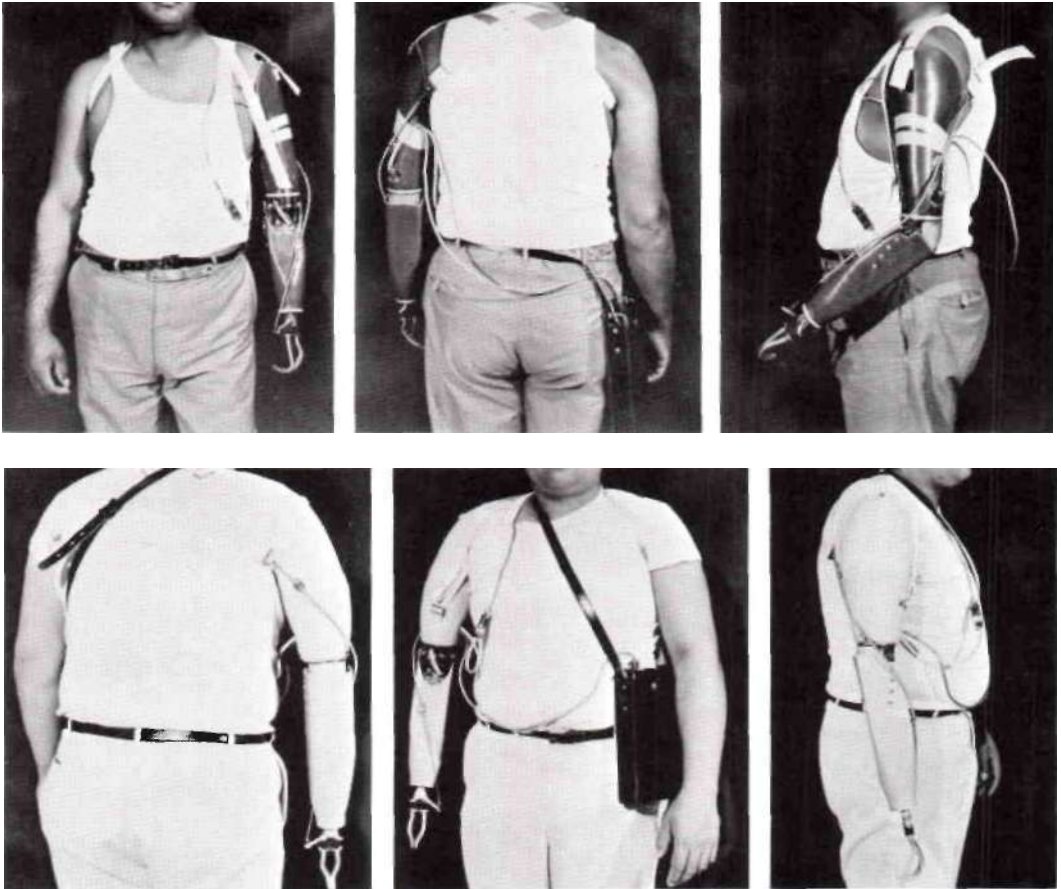
Total number of elbows	12
Number of elbows not evaluated due to inadequate subjects or insufficient trial wear	4
Total number of elbows evaluated	8

CLINICAL FITTINGS OF THE BOSTON ELBOW

Total number of elbows	8
Number of elbows not evaluated due to inadequate subjects or insufficient trial wear	3
Total number of elbows evaluated	5



Figs. 4 and 5. Amputees fitted at UCLA with the AMBRL elbow.



Figs. 6 and 7. Amputees fitted at UCLA with the Boston elbow.

Number of amputees preferring conventional elbow	4
Number of amputees preferring Boston elbow	1

The best features were ease of flexion and independent elbow flexion and TD operation (not accomplished by all subjects, however).

The most undesirable features were: weight, speed, noise, bulkiness, donning of electrodes, need for tight harnessing, and lack of cosmesis.

The Rehabilitation Clinic of the Liberty Mutual Insurance Company (one of the developers of the Boston elbow) also fitted two amputees with the Boston elbow during the evaluation period. One preferred the Boston elbow, and one preferred his

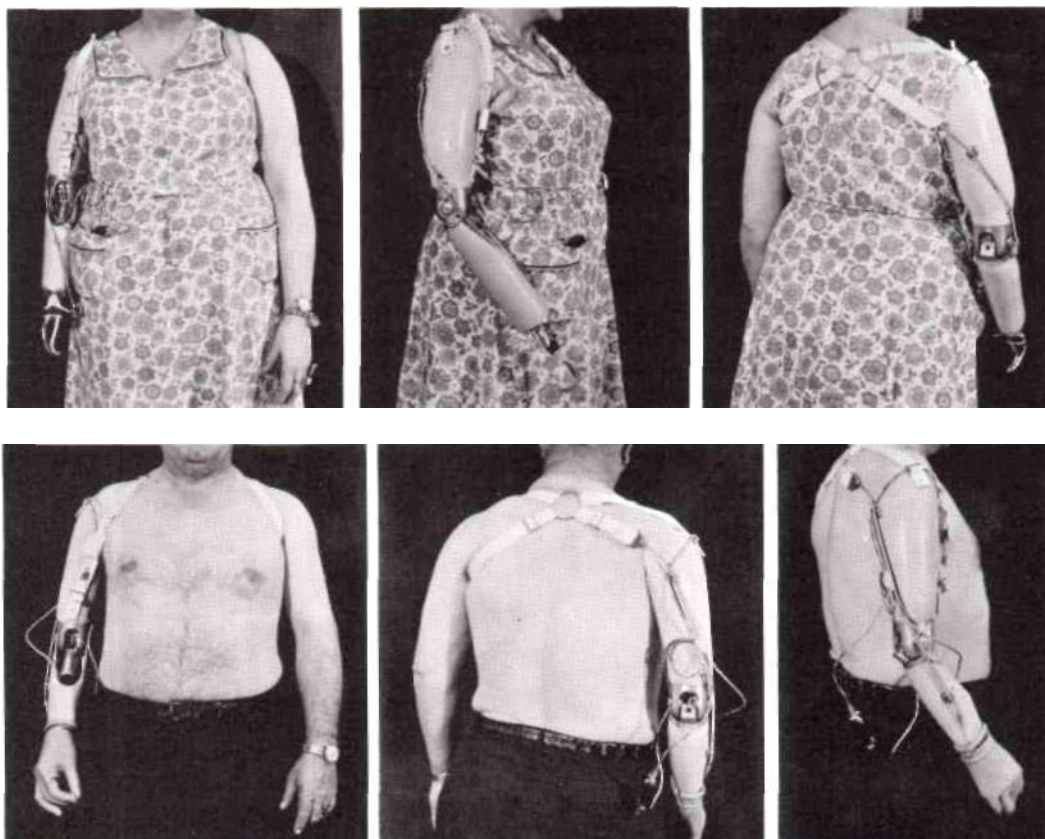
conventional elbow. Both offered comments which substantiate the relative merits listed above.

CLINICAL FITTINGS OF THE RANCHO ELBOW

Total number of elbows	10
Number of elbows not evaluated due to inadequate subjects or insufficient data	2
Total number of elbows evaluated	8
Number of amputees preferring conventional elbow	7
Number of amputees preferring Rancho elbow	1

The best features were ease of flexion and the McCulloch quick charger.

The most undesirable features were: weight, speed, noise, bulkiness, inadvertent operation of switch, lack of positive elbow



Figs. 8 and 9. Amputees fitted at UCLA with the Rancho elbow.

lock, lack of control in positioning elbow (override), and lack of full range of motion.

OTHER CONSIDERATIONS

Because of the difficulty in finding AE amputee subjects with suitably short stumps, the protocol was modified to permit the clinics to fit some of the AMBRL elbows to unilateral shoulder amputees as well. Therefore, of the eight AMBRL elbows evaluated, six were fitted on "short" AE amputees and two were fitted on shoulder amputees.

Because the clinics had difficulty finding suitable subjects for all the elbows, they fitted the following amputees (who did not conform to the original selection criteria) on the premise that it was better to get some evaluation than none at all: (1)

a new amputee with a unilateral shoulder disarticulation; (2) a new amputee with a unilateral AE amputation following brachial-plexus injury, with a fused shoulder on the amputated side; (3) a bilateral AE amputee who was a previous wearer; and (4) a relatively new AE amputee who had worn a conventional prosthesis for seven months.

Of the three amputees who stated a preference for the externally powered elbow, their specific reasons were as follows:

1. The subject who had positive comments about the AMBRL elbow was the new, unilateral, AE amputee with brachial-plexus injury and fused shoulder. He liked it because it allowed him to flex his elbow without using his sound arm.

2. The subject who preferred the Boston elbow was the relatively new AE am-

putee. He liked it primarily because it made elbow flexion easier.

3. The unilateral AE amputee who preferred the Rancho elbow liked it because of the ease of flexion and because it eliminated the elbow-lock-control motion.

For information, the bilateral AE amputee preferred his conventional elbow because he had inadvertent operation with the AMBRL elbow. The new shoulder amputee elected not to keep the AMBRL elbow, and was listed as "undecided" because of no experience with a conventional prosthesis for comparison.

Most of the amputees said that their main uses of the conventional and externally powered elbows are to hold objects with the elbow flexed and to carry objects with the elbow flexed or extended.

A few of the amputees expressed a liking for the "live lift" feature of the externally powered elbows, but none said it was a functional requirement.

Most of the amputees said there was nothing or little they could do with the externally powered elbows that they could not do with their conventional elbows.

RECOMMENDATIONS

It was obvious that the externally powered elbows that were evaluated are not yet ready for routine patient usage. This is understandable since most are first-generation units on amputee subjects. It was decided, therefore, that the best way in which the Subcommittee on Evaluation could help in the further development of powered elbows would be to offer recommendations for standards for future work. The standards listed below, which are based on the discussions by the participants and which directly reflect the clinical evaluation on amputee subjects, are therefore recommended for externally powered elbows.

Speed

The elbow should operate from full extension to full flexion in *one second or less*

with the terminal device and forearm loaded or unloaded. (The range of motion from full extension to full flexion is considered to be 0 deg. to 135 deg.)

Control

1. Operation of the elbow should be independent of the operation of the terminal device.

2. For the amputee to satisfactorily position the elbow at the speed specified above, *voluntary variable control* may be necessary. This should be determined by separate study.

3. If myoelectric control is used, the electrodes should be incorporated within the socket.

Torque

The elbow should produce at least 3 1/2 foot-pounds of torque. This represents 1 1/2 foot-pounds for the weight of the terminal device and forearm and 2 foot-pounds for lifting objects.

Lock

The elbow should have a lock capable of withstanding at least 25 foot-pounds of resistance in any position (except free swing) for carrying objects, etc.

Weight

The total weight of the elbow, including the unit itself, the power source, and any other auxiliary equipment, should not exceed *18 ounces*. The use of lightweight battery packages, and more frequent charging using recently developed fast chargers, is recommended to keep the weight as low as possible when using electrical systems.

Noise

A noise level of 60 db or more is emphatically too high. *The lower the noise level the better*. A separate study is recommended to determine a realistic standard for noise level and means to measure it.

Cosmesis

It is obvious that improvement in the appearance of the elbow is needed. Amputees understandably object to wires showing, mechanical parts protruding, the necessity of wearing equipment on the waist, etc. It is strongly recommended that

the elbow and its related parts be *self-contained* within the prosthesis, with *cosmetic improvement of the exterior surface*.

Free Swing

Free swing is a desirable feature and should be included in the elbow.

Technical Notes

Suction-Type Prosthesis for Below-Knee Amputees, A Preliminary Report

Below-knee amputees are fitted most often with a patellar-tendon-bearing prosthesis. In certain groups of patients, however, the PTB prosthesis presents difficulties owing to the configuration of the stump, a tendency for skin lesions to develop, or other reasons. In some cases, the symptoms only manifest themselves upon heavy physical activity, and therefore a number of below-knee amputees are given a prosthesis with a thigh corset. With these problems in mind, an attempt has been made to suspend the prosthesis to the

below-knee stump upon extension and flexion present additional problems. Therefore, the fitting of a suction-type total-contact below-knee socket is complicated and is considerably more difficult than is the case for an above-knee amputee. In spite of this, it seemed appropriate to follow the same principles in fitting a suction socket to a below-knee stump. Establishment of total contact means firmer anchorage of the prosthesis to the body. Under optimal conditions, movement between the skin and the socket will be eliminated. The tendency to skin lesions is thereby diminished, even in pa-

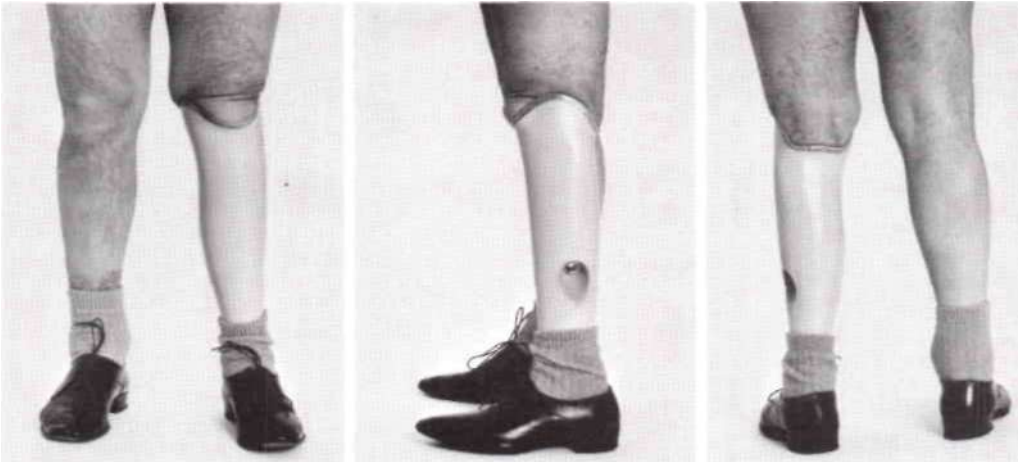


Fig. 1. Three views of the suction-type prosthesis for below-knee amputees.

below-knee stump by "suction" or pressure differential.

SUSPENSION PROBLEMS

The tissues of the proximal portion of the below-knee stump are firm, and the relationship of the stump to the patella and the femoral condyles is relatively constant. The weight-bearing surface of a below-knee stump is considerably smaller than that of a femoral stump, and there is considerably less soft tissue in relation to skeletal tissue than there is in the above-knee stump. The changes in shape of the

tients with reduced sensitivity. Further, total contact continuously maintains a distribution of weight over the entire stump. The prosthesis is also more attractive cosmetically because the junction at the knee is less evident.

Many factors such as volume changes in the stump during the day, perspiration, extreme movements of the knee joint, and training must be considered if success is to be attained.

MATERIAL AND METHODS

The below-knee prosthesis presented here is a further development of the PTB

TABLE 1. RESULTS OF USE OF SUCTION PROSTHESES BY SIX BELOW-KNEE AMPUTEES

Sex	Age (years)	Occupation	Stump length (cm)	Tendency to skin lesions in PrB prosthesis ^a	Healing of lesions in suction prosthesis	Durability of suction effect (hours)
1. Male	31	Plastics worker in prosthetics	18	++	Yes	8-12
2. Female	37	Teacher	14	0		5-9
3. Male	32	Motor mechanic	10	+	No	1/2-1
4. Female	31	Housewife	5	0		2-3
5. Male	33	Traffic controller	18.5	+	Yes	6-7
6. Male	46	Florist	19.5	0		7-8

« Scale: 0, +, ++ ».

prosthesis. It consists of a rigid plastic socket, without a soft lining, that completely encases the stump. In the distal portion of the socket, there is a hole with threads for a valve. At present, a manual valve is used to relieve pressure and force out air. The amputation stump is pulled down with a stocking and the screw valve is inserted during weight-bearing in the same way as for the above-knee prostheses.

The following data have been noted before fitting of the prosthesis: length of stump, circumferences of the stump (at the level of the tibial tuberosity and at every fifth centimeter level distally), the increase in distance from the end of the tibia to the stump-end skin surface caused by a distal drawing of the soft tissue toward the end of the stump, length of the residual fibula and its relationship to the tibia, appearance and location of the amputation scar, tendency to skin lesions, stump tenderness, any loss in sensation, adaptability to other types of below-knee prostheses, and the reason for amputation. In the study, which is to be published later, a roentgenological examination of the stump with the previous prosthesis in position was made for each patient.

RESULTS

The suction prosthesis presently is being tested on 19 patients. Six of them have undergone a follow-up examination after six months (table 1). In all of these six patients, the amputation resulted from trauma.

The first patient was given his prosthesis because sores on the stump were present almost constantly with the conventional PTB. The lesions healed when he started using the suction prosthesis, and he now uses the suction-type prosthesis daily.

The fifth patient takes a very active part in sports, and skin lesions often appear on the stump when he uses the conventional PTB prosthesis. The suction prosthesis is used to promote healing of the lesions. For sedentary work, he uses the suction prosthesis less often, because it has a tendency to loosen with the extreme flexion of the knee that can occur when sitting.

Patient no. 2, a teacher, uses her suction prosthesis regularly and considers it more attractive cosmetically than the PTB prosthesis. With her particular job, she considers it advantageous for her amputation to be as unnoticeable as possible, but she has experienced loosening of the prosthesis when sitting with her knee in an extremely flexed position.

Patient no. 6 has problems similar to those of patients 2 and 5. Patients 3 and 4 both have short amputation stumps (10 cm and 5 cm, respectively). During the three months in which they have tested the suction prosthesis, they have managed to get it to remain in position one hour and three hours at the most, respectively.

Generally, it can be said that all of the patients feel that the suction prosthesis is identified more closely with the lower leg. Some have said that "it feels like a real leg." None of the patients has felt cold in the prosthesis during the winter months.

This tends to negate the idea that blood flow in the stump may be impeded when the suction prosthesis is used. One especially positive aspect is that lesions on the stump heal while this prosthesis is being worn. Because of this characteristic, it can reduce the number of days away from work and may be used alternately with other prostheses for just that purpose.

DISCUSSION

The suction prosthesis is being evaluated clinically. This preliminary report is based on the follow-up examination of six patients who have used the experimental prosthesis for six months. A larger series of patients and a longer observation time are desirable before final conclusions can be drawn as to the advantages and disadvantages of the prosthesis. However, the suction prosthesis would seem to be suitable as a "change" in certain situations and in the case of complications which may arise with other types. It may also be regarded as a "leisure-time prosthesis," as it is considered more attractive for wearing on special occasions, e.g., dances or other social events. Some difficulty in maintaining the suction has been encountered upon ex-

treme flexion of the knee joint. However, with improvement of the socket and the suction effect, it should be possible to overcome this problem.

One disadvantage of the prosthesis is the difficulty in application. If the prosthesis should loosen when the patient is out in a public place, it would be troublesome since the amputation stump has to be pulled down with a stocking.

Those amputees who have been followed-up have found, however, that the prosthesis never loosens instantaneously, but that there is always a few minutes' warning before it comes off entirely. For the four patients who wear this type of prosthesis regularly, the time for which it has been worn without signs of loosening has varied between five hours and twelve hours. It has been stated, further, that as the patients have become more accustomed to the prosthesis, that time has increased.

—Sven Grevsten and Lennart Marsh

From the Department of Orthopaedic Surgery, University of Uppsala, Sweden (Amputee Training and Research Unit (ATRU)—"Gaskolan"). Supported by grant T. Hierton 70-377/U 308, Swedish Board for Technical Development.

Book Review

Ortholen: A Material for Orthopaedic Appliances. By Jan Prahl. Introduction by Leonhard Roeser. Paperbound, 112 pages, 200 illustrations. Published in *Technische Orthopadie*, Fritz Blohmke, Ed. 1970. Stuttgart: Georg Thieme Verlag. Price: DM 39 (approx. \$10 U.S.).

Ortholen is a high-molecular polyethylene, developed and in popular use in orthotics and prosthetics in Germany. Although the material is commercially available in this country, it is not yet in common use, probably because of lack of information on its properties and application in orthotics and prosthetics. This book fulfills the need for such information exceptionally well.

There are two main sections, the first dealing with the physical characteristics of the material. It includes a number of tables of comparison with conventional materials in orthotics and prosthetics. The portion on workability and machinability of Ortholen and thermoforming techniques should be of special interest to the orthotist, who is generally not trained or well versed in the use of plastics.

The second section, which deals with examples of the application of Ortholen in

orthotics and prosthetics, is probably of the greatest interest to the reader. Not only does it show that the material has great potential in these fields, but it also shows unique orthotic designs for which this material and, for that matter, any other material may be used. This section is quite comprehensive and well illustrated. It includes, in orderly sequence, the function and indication of the device described, casting and molding techniques, assembly, and fitting, along with drawings of the appropriate pattern for each device. Nearly all areas of orthotics are covered and constitute the major portion of this second section. In prosthetics, the material has limited application, from the reviewers' own experience, because of workability problems in conventional AK and BK sockets. On the other hand, it has definite possibilities in hip disarticulation sockets and thigh corsets, since the molding techniques are similar to those for orthotic devices.

Overall, the book is well written and illustrated in an orderly progression from the physical description of the material to its application in orthotics and prosthetics. Translation of many sections seems worthwhile, not only to acquaint the reader with the material Ortholen but also to expose him to unique design considerations in orthotics and prosthetics which are not necessarily related to the material itself.—*H. R. Lehneis, C.P.O., and Herbert W. Marx, C.P.O.*

News and Notes

Prosthetics-Orthotics Education

New York University

Two advanced courses for prosthetists and orthotists at the New York University Post-Graduate Medical School were announced by Dr. Sidney Fishman, Program Coordinator.

"Advanced Lower-Extremity Orthotics," scheduled for 2 one-week sections in January and June 1971, is intended for students who have successfully completed basic instruction in lower-extremity orthotics. The course introduces a new orthotic technique in the use of a plastic shoe insert for foot correction and as a distal attachment for above- and below-knee braces. As time permits, weight-bearing braces utilizing patellar-tendon-bearing and quadrilateral-socket principles will be included.

The second course, "Advanced Below-Knee Prosthetics," is concerned with the fabrication and fitting of current variants of the patellar-tendon-bearing artificial limb, such as the air-cushion, STP-wedge, and PTS designs. The next section of the course will be presented from June 28 through July 3, 1971. Successful completion of basic instruction in below-knee prosthetics is a prerequisite.

These new orthotic and prosthetic procedures have also been integrated into the courses offered to physicians, surgeons, therapists, and rehabilitation counselors at the Post-Graduate Medical School.

* * * *

Robert L. Burtch has been appointed Associate Director of Child Prosthetics-Orthotics Studies and Associate Chief of the Clinical Studies Unit in Prosthetics and Orthotics, New York University. As the senior fulltime researcher, he will be in charge of day-to-day operations and supervision of the project staff in the formulation of research designs, their execution, compilation of research data, and writing of reports. He will also be responsible for the coordination of the activities with other

research disciplines as they relate to child-evaluation projects, as well as monitoring liaison with the cooperating prosthetic-orthotic clinics.

This appointment marks a return for Mr. Burtch, who has had two previous associations with the NYU Medical Center. His last position was Administrator of Rehabilitation Medicine Service at the Coney Island Hospital Affiliation of Maimonides Medical Center, Brooklyn, N.Y.

* * * *

In January 1970, New York University conferred Bachelor of Science degrees on four students who completed the School of Education's four-year undergraduate curriculum in prosthetics and orthotics: Alan Jenks Bardsley of Hartford, Conn.; Robert Charles Hartson of Rutland, Mass.; Michael J. Quigley of Chicago, Ill.; and Lloyd Alfred Stewart of Ephrata, Wash. With the graduation of these students, the number of degrees in prosthetics and orthotics awarded since June 1965, the year of the first graduating class, has risen to 33.

* * * *

Dr. Sidney Fishman, Coordinator of Prosthetics and Orthotics, and Dr. Ralph Lusskin, Professor of Clinical Orthopedic Surgery, New York University Post-Graduate Medical School, completed a survey of Polish and Yugoslavian orthopedic, prosthetic, and orthotic centers for the Maternal and Child Health Service of the U.S. Public Health Service during November 1970. The 18-day trip was conducted under the Interchange of Experts Program of PL-480 and was designed to explore the possibilities of establishing cooperative research projects in the field of orthopedically handicapping conditions of children. In Poland, the doctors visited rehabilitation institutes, orthopedic clinics, medical training schools, and crippled-children centers, and met with rehabilitation and medical officials in Warsaw, Konstancin, Krakow, Poznan, and Swiebodzin. Similar Yugoslavian facilities were visited

in Belgrade, Skopje, Kamnik, Ljubljana, and Zagreb.

En route to Poland, Dr. Fishman presented a paper on "Psychological and Social Aspects of Amputee Management" at a symposium in Rungsted, Denmark, sponsored by the International Committee on Prosthetics and Orthotics on "Trends in Prosthetics and Orthotics."

* * * *

In response to an invitation from the recently organized North Carolina Society of Orthotists and Prosthetists, Ivan A. Dillee, Instructor in Prosthetics and Orthotics, New York University Post-Graduate Medical School, spoke at the group's first meeting, which was held on December 11 and 12, 1970, at the Bowman-Gray Medical College of Wake Forest University, Winston-Salem, North Carolina.

On December 11, Mr. Dillee's topic was "New York University Prosthetics and Orthotics in Portugal—Three Years of Cooperation," in which he described the teaching program at the Centro de Medicina de Reabilitacao, Alcoitao-Estoril, Portugal, the leading rehabilitation facility of the country.

On December 12, Mr. Dillee spoke on "Preparation for Professionalism in Prosthetics," in which he traced the evolution of college- and university-level educational programs, the expanding need for prosthetic and orthotic services, and the development of schools above the high-school level in which health-related curricula are stressed. He placed great emphasis on the importance of education on a professional level, both as student and as teacher, and the continuing responsibility to one's peers to instruct and to learn.

Committee on Prosthetic-Orthotic Education

Meeting of the Subcommittee on Publications and Educational Materials

The Subcommittee on Publications and Educational Materials, CPOE, met in Miami Beach, Florida, on December 3,

1970. Publications currently used in prosthetics and orthotics schools, new publications, and educational materials now being developed were reviewed by committee members. The subcommittee agreed that CPOE should continue to survey and identify needs in prosthetic-orthotic teaching literature and recommend priorities for publication of instructional manuals.

Dr. Miles Anderson reported that the publication date for the manual "Lower Extremity Orthoses" was set for late 1971 and noted that future plans include publication of additional prosthetic and orthotic textbooks under the sponsorship of the U.S. Office of Education.

The possibility of the consolidation of current prosthetic and orthotic journals was considered at length, and the chairman, Dr. Augusto Sarmiento, appointed an ad hoc committee consisting of himself, Mr. William Bernstock, Mr. Herbert Warburton, Miss Audrey Calomino, and Mr. A. Bennett Wilson, Jr., to meet and further explore the proposal.

The subcommittee approved a project in which a CPOE ad hoc committee will compile a list of prosthetic and orthotic terms for inclusion in an information-retrieval system being developed by the Subcommittee on Orthopedic Literature Information Services of the Committee on the Skeletal System, National Research Council, working with the National Library of Medicine. Mr. Warren Springer is chairman of the ad hoc group. Mr. James Foort described the information-retrieval system developed by the staff at the Manitoba Rehabilitation Hospital in Winnipeg.

Mrs. Joan Edelstein was appointed to explore the potential use of modern educational methods, including video tape, closed-circuit television, and sound slides, for use in the fields of prosthetics and orthotics.

Present at the meeting were Augusto Sarmiento, M.D., chairman; Miles H. Anderson, Ed.D.; William M. Bernstock; Joan E. Edelstein; Bella J. May, Ph.D.; Frederick L. Hampton, C.P.; Clark L. Sabine; Warren P. Springer; A. Bennett Wilson, Jr.; Hector W. Kay; Charlotte L.

Cranmore; and Barbara R. Friz, executive secretary of CPOE.

Meeting of the Subcommittee on Special Educational Projects in Prosthetics and Orthotics

A meeting of the Subcommittee on Special Educational Projects in Prosthetics and Orthotics, CPOE, was held on December 4, 1970, in Miami Beach, Florida. The modern concept of the amputee clinic and the problems currently associated with the conduct of amputee clinics were discussed. Upon recommendation of the subcommittee, the chairman, Dr. J. Warren Perry, appointed the following persons to study the structure and composition of amputee clinics and the methods of delivery of prosthetic services: Herbert E. Pedersen, M.D., chairman; William M. Bernstock; Alvin L. Muilenburg, C.P.O.; Walter A. L. Thompson, M.D.; Bella J. May, Ph.D.; Sidney Fishman, Ph.D.; and Harlan C. Amstutz, M.D.

The subcommittee members concurred with Mr. Warburton's proposal that the essentials of an approved prosthetic and orthotic school, as developed at the CPOE-sponsored workshop last June and approved by AOPA Board of Directors, be considered a standard for such schools and distributed to institutions contemplating development of prosthetic and orthotic educational programs. Establishment of an accrediting body is being considered; however, as Dr. Perry explained, this action should be delayed until completion of a study on accreditation now being undertaken by a recently established Commission on the Study of Accreditation in the Health Fields. Dr. Perry strongly recommended that AOPA representatives establish liaison with such groups as the AMA Council on Medical Education, the National Commission on Accreditation, and the Association of Schools of Allied Health Professions. It was noted that evaluation of manpower requirements as related to school capabilities is indicated and that, rather than a recruiting effort, a public-re-

lations-type campaign should be planned to acquaint the public with the role and function of prosthetists and orthotists in the health field. Such a project is under consideration.

Those present at the meeting were: J. Warren Perry, Ph.D., chairman; William M. Bernstock; Sidney Fishman, Ph.D., Alvin L. Muilenburg, C.P.O.; Herbert B. Warburton; and Herbert E. Pedersen, M.D. Present as guests were: Walter A. L. Thompson, M.D.; Charles Fryer; and Cameron B. Hall, M.D.

Subcommittee on Orthotics Meeting

The Subcommittee on Orthotics, CPOE, held a meeting at O'Hare Inn, Chicago, Illinois, on October 21, 1970, with Dr. Jacquelin Perry presiding. Educational needs in orthotics were discussed for the purpose of identifying gaps in efficiency that deter, directly or indirectly, the delivery of quality orthotic services to orthopedically handicapped persons.

A priority activity of the subcommittee will be the compilation of a mailing list of physicians who prescribe orthotic devices for patients. Information concerning reading materials, bibliographies, and announcements of courses, perhaps in the form of a bulletin, will be distributed periodically to those on the list. An attempt will also be made to have presentations of orthotic materials at instructional courses of various medical societies and associations.

Upon the request of the American Orthotic and Prosthetic Association, the members will participate in a general review of orthotic terminology and will coordinate efforts to compile a universally acceptable standard list.

Members attending the meeting were: Jacquelin Perry, M.D., chairman; Norman Berger; John E. Eschen; Arthur W. Guilford; Paul R. Meyer, Jr., M.D.; Clyde L. Nash, Jr., M.D.; Bradd Rosenquist; and Daniel G. Rowe. Representing the National Research Council was Mrs. Barbara R. Friz.

Prosthetic-Orthotic Terms in MEDLARS

On October 23, 1970, the Subcommittee on Orthopedic Literature Information Services of the Committee on the Skeletal System, National Research Council (NRC), agreed to a proposal from the Subcommittee on Publications and Educational Materials, CPOE, to include prosthetic-orthotic terms in the microthesaurus which they are preparing for use in MEDLARS (Medical Literature Analysis and Retrieval System) at the National Library of Medicine.

Warren D. Springer, chairman; Joseph M. Cestaro, C.P.O.; Dr. Newton C. McCullough, and Mr. Basil Peters, C.P.O., were named as members of the CPOE Ad Hoc Committee on Information Retrieval, charged with the task of preparing a termi-

nology list for the field of prosthetics and orthotics.

The first meeting was held at Georgetown University, Washington, D.C., on November 6, 1970. Dr. George Hyatt, chairman of the Subcommittee on Orthopedic Information Services; Dr. Walter F. Abendschein, Jr., Division of Orthopedic Surgery, Georgetown University Medical Center; and Mrs. Barbara Kelner, Orthopedic Information Specialist at the National Library of Medicine, presented general guidelines for the project.

A second meeting of the group, held on December 3, 1970, in Miami Beach, Florida, was devoted to development of a list of prosthetic terms to be included in the microthesaurus. Mr. James Foort, technical director of the Prosthetic Research and Development Unit in Winnipeg, Canada,



Among the registrants at the Engineering Foundation Research Conference "Introduction to Prosthetic and Sensory Aids" at the Proctor Academy in Andover, N.H., were *left to right top row*: C. W. Radcliffe, Harold deSouza, Paul Newell, Richard Simpson, David Grosvenor, Russell Hynes, Ralph Storrs, Elwyn Saunders, J. E. Traub, John Glancy, Charles Fryer; *second row*: Lonnie von Renner, C. G. Warren, David Sonstegard, Augustus White, Donald Kettelkamp, Frank Clippinger, James Schuster, Abraham Jacob, James Cockrell, Cairbre McCann; *third row*: William Fortune, Wen Ko, S. N. Banerjee, Arthur MacNeill, I. M. Neou, Howard Freiburger, Ronald Blecher, L. K. Irwin, Richard Olson; *bottom row*: C. M. Godfrey, Wilfred Holsberg, Eugene Murphy, A. Bennett Wilson, Jr., Philip Deffer, and J. T. Mortimer.



Approximately 300 individuals attended the week-long observance of the twenty-fifth anniversaries of PSAS and CPRD, which was highlighted by a reception and banquet on Thursday, October 15, 1970, in the ballroom of the Mayflower Hotel, Washington, D.C.



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At the final session of the twenty-fifth anniversary program, the presentations demonstrated the progress that has been made during the past 25 years in prosthetics, orthotics, and sensory aids.



Twenty-Fifth Anniversary Program

October 12-16, 1970

Mayflower Hotel, Washington, D.C.

Monday, October 12

- | | |
|-------------------------------------|---------------------|
| I. The Role and Function of CPRD | Colin A. McLaurin |
| II. Recommendations for Future Work | |
| A. Fundamental Studies | Victor H. Frankel |
| B. Design and Development | Anthony Staros |
| C. Evaluation | Frank W. Clippinger |

Tuesday, October 13

- | | |
|--|-------------------|
| D. Child Prosthetics | George T. Aitken |
| III. Recommendations for Establishment and Operation of Rehabilitation Engineering Centers | Colin A. McLaurin |
| IV. General Discussion and Determination of Priorities | |

Wednesday, October 14

- | | |
|--|---|
| I. Introductory Remarks | Robert E. Stewart
M. J. Musser |
| II. Twenty-Five Years of Progress | Eugene F. Murphy
A. Bennett Wilson, Jr.
William H. Talley
Anthony Staros |
| III. Panel on Below-Knee Prosthetics | |
| IV. Panel on Amputation Surgery, Early Fitting, and Immediate Postsurgical Fitting | Richard Warren |
| V. Panel on Upper-Extremity Prosthetics | Edward Peizer |

Thursday, October 15

- | | |
|---|----------------------|
| VI. Panel on Above-Knee Prosthetics | Charles W. Radcliffe |
| VII. Panel on Orthotics and Orthopedic Aids | Frank W. Clippinger |
| VIII. Prosthetics and Orthotics Abroad | Eugene F. Murphy |
| 6:30 P.M. Reception | |
| 8 P.M. Banquet | |

Friday, October 16

- | | |
|---|--|
| Opening Remarks | Donald E. Johnson |
| Spinal Orthotics | Norman Berger |
| Lower-Extremity Orthotics | Verne T. Inman |
| Upper-Extremity Orthotics | Anthony Staros |
| Upper-Extremity Prosthetics | James B. Reswick
James Allen
Colin A. McLaurin
Ivan Dillee
Dominick Casella
Leon M. Kruger
James C. Bliss
Thomas E. Whitesides, Jr.
Charles W. Radcliffe
George T. Aitken
James F. Garrett |
| Child Prosthetics and Orthotics | |
| Sensory Aids for the Blind | |
| Lower-Extremity Prosthetics | |
| Education, Clinical Application, and the Future | |
| Closing Remarks | Assistant Administrator, Office of Research and Demonstrations
Social and Rehabilitation Service, Department of Health, Education, and Welfare |

was present and discussed the retrieval system developed at that institution.

Mrs. Barbara R. Friz and Miss Charlotte L. Cranmore, National Research Council, attended both meetings.

Prosthetics-Orthotics Exhibit

"Prosthetics and Orthotics in North America," an exhibit which depicts research, development, education, and clinical application of prosthetics and orthotics, was shown at the 11th World Congress of the International Society for Rehabilitation of the Disabled in Dublin, Ireland, in September 1969; at the Annual Scientific Assembly of AOPA, Miami Beach, Florida, in October 1969; and at the American Physical Therapy Association Convention, Washington, D.C., in June 1970, where it was awarded the First Prize in Research and Education. The display was prepared cooperatively with the American Orthotic and Prosthetic Association, the Prosthetic and Sensory Aids Service of the Veterans Administration, and the Social and Rehabilitation Service of the Department of Health, Education, and Welfare.

Engineering Foundation Research Conference

The Committee on Prosthetics Research and Development, as part of the Engineering Foundation Research Conferences, sponsored a conference on August 17-21, 1970, in Andover, New Hampshire, entitled "An Introduction to Limb Prosthetics and Sensory Aids." The conference, chaired jointly by Eugene F. Murphy and A. Bennett Wilson, Jr., was designed to give to research and development groups who were considering entering the field a background in limb prosthetics, orthotics, and sensory aids. Forty-eight physicians, engineers, and prosthetists attended.

Areas covered included demographic and economic data; history of research and development in prosthetics, orthotics, and sensory aids; present status of the field; and needs for further research and development.

Anniversary Observance

A quarter century of progress in prosthetics, orthotics, and sensory aids was

commemorated when the twenty-fifth anniversaries of the Prosthetic and Sensory Aids Service, Veterans Administration, and of the Committee on Prosthetics Research and Development, National Research Council—National Academy of Sciences, were celebrated at the Mayflower Hotel, Washington, D.C., the week of October 12-16, 1970.

The working sessions were attended by approximately 300 individuals associated with prosthetics and orthotics in Canada, England, Australia, West Germany, Israel, Ceylon, Puerto Rico, and the United States, among them many of the men who were active during the formative years of the two programs.

On October 12 and 13, in sessions moderated by Colin A. McLaurin, chairman of CPRD, recommendations for future work in fundamental studies, design and development, evaluation, and children's prosthetics and orthotics were presented.

The PSAS program on October 14 and 15 included panel presentations on: above and below-knee prosthetics; amputation surgery, early fitting, and immediate post-surgical fitting; upper-extremity prosthetics; orthotics and orthopedic aids; and prosthetics and orthotics abroad.

At the reception and banquet on October 15, the concept was formal but the ceremonies were marked by informality and humor. Five former chairmen of the Committee on Prosthetics Research and Development were among the honored guests: Paul E. Klopsteg, Gen. Frederick S. Strong, Howard D. Eberhart, Herbert Elftman, and George T. Aitken. The Veterans Administration presented Distinguished Service Awards to Walter Bura and Augustus Thorndike, and a Meritorius Service Award to Robert E. Stewart.

On October 16, presentations and demonstrations with the assistance of patients reviewed the progress that has been made in prosthetics, orthotics, and sensory aids during the past 25 years. Implicit in this, the closing session, was the portent of even greater accomplishments—given the same recognition of, and dedication to, mutual goals in the future.

Committee on Prosthetics Research and Development

Subcommittee on Fundamental Studies

The subcommittee, with the chairman, Victor H. Frankel, M.D., presiding, met in Cleveland, Ohio, on October 5, 1970, to consider what fundamental research is needed for improvement of the orthotic and prosthetic treatment of patients.

Plans for 1971 include a Workshop on Soft-Tissue Response to Local Force—Donald B. Kettelkamp, M.D., Chairman; a Workshop on Biomechanics of the Foot and Ankle—James M. Morris, M.D., Chairman; and a Workshop on Materials—chairman to be named.

In addition, the following panels were formed to consider fundamental research in specific areas: Panel on Neuromuscular Control—Joseph P. Van der Meulen, M.D., Chairman; Panel on Locomotion—Albert H. Burstein, Ph.D., Chairman; Panel on Studies of the Spine—chairman to be named; and Panel on Materials—chairman to be named.

Subcommittee on Evaluation

The subcommittee, with the chairman, Frank W. Clippinger, M.D., presiding, met on September 11, 1970, in Annapolis, Maryland, and on November 9, 1970, in Durham, North Carolina. The status of the items under evaluation is as follows:

1. Externally powered prosthetic elbows

The AMBRL, Boston, and Rancho powered elbows were fitted for trial wear on amputee subjects in various clinics throughout the United States. Results indicate that these elbows are not yet indicated for routine patient application. The amputees commented that all the units were heavy, noisy, slow, and uncosmetic, and had inadvertent operation. Standards for future development of powered elbows have been recommended.

2. Lower-extremity orthoses

Four lower-extremity orthoses—the UCBL dual-axis ankle brace, the UCBL shoe insert, the NYU insert brace, and the VAPC single-bar brace—are being fitted on patients for trial wear at various clinics

throughout the United States. Results are expected by mid-1971.

3. Below-knee orthoses

A biomechanical analysis and comparative study will be done at Moss Rehabilitation Hospital on the following below-knee orthoses: the AMBRL posterior-bar drop-foot brace, AMBRL two-rod drop-foot brace, IRM spiral BK brace, NYU insert brace, Rancho polypropylene drop-foot brace, Teufel Ortholen (TM) drop-foot brace, TIRR BK brace, UCBL dual-axis ankle brace, and the VAPC drop-foot brace.

The objective is to more clearly determine the functional characteristics, prescription criteria, and relative merits of each brace. Results are expected by early 1972.

Subcommittee on Sensory Aids

The fourth meeting of the Subcommittee on Sensory Aids was held in Boston, Massachusetts, on September 14-15, 1970. Visits were made to the American Center for Research in Blindness and Rehabilitation; the Sensory Aids Evaluation and Development Center, the Department of Mechanical Engineering, Massachusetts Institute of Technology; the Sensory Measurement Group of the Research Laboratory for Electronics, MIT; and the Low-Vision Clinic, Boston College.

At the formal meeting, a Panel on Mobility Aids was formed with Patrick Nye, Ph.D., as chairman. The initial responsibility of the panel will be to provide assistance in the evaluation of the laser Typhlocane that has been developed by Bionic Instruments, Inc., Bala Cynwyd, Pennsylvania, under contracts with the Veterans Administration. In addition, it was decided that a conference should be held to discuss experience and present practices in reference to presently available laser canes, with the thought that the results of such a conference will provide a useful point of departure for the development of procedures for the evaluation of mobility devices.

The fifth meeting of the subcommittee was held in Washington, D.C., on Decern-

ber 12, 1970. It was decided that a Conference on the Typhlocane would be held in Washington, D.C., on March 26-27, 1971 (later postponed), to be followed by a meeting of the Panel on Mobility. Consideration was given to development of an evaluation program for reading aids, and long-range plans.

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Richard E. Hoover, M.D.

Richard E. Hoover, M.D., chairman of the Subcommittee on Sensory Aids, CPRD, was a recipient of the 1970 Migel Medal, which is awarded annually for outstanding service in work for the blind.

Presented to Dr. Hoover for his work on the voluntary level, the award was made by the American Foundation for the Blind in ceremonies on October 22, 1970, in New York City. The medal is named for the late M. C. Migel, the foundation's first president.

Dr. Hoover, chief of ophthalmology at the Greater Baltimore Medical Center, is the creator of the long-cane travel technique and has served the cause of blindness as an advisor to many organizations.

Establishment of the International Society on Prosthetics and Orthotics

After a series of meetings in Rungsted, Denmark, during the week of November 8, 1970, the Steering Committee of the International Committee on Prosthetics and Orthotics set out the objectives and laid down guidelines for the establishment of the *International Society on Prosthetics*

and Orthotics (ISPO). The founding statement signed by ten members of the steering committee at 11 A.M. on Sunday, November 15, 1970, described the new organization as:

... an individual body which, under the laws of Denmark, will serve as an international impartial and non-political coordinating, correlating, and advisory body on prosthetics and orthotics and other technical matters related to the neuromuscular and skeletal system in close collaboration with the national and international bodies involved in international prosthetics-orthotics programs, offering appropriate guidance and advice to these bodies to avoid unwitting duplication of effort and to encourage maximum use of resources.

The Society will be open to all individuals or groups of such individuals, whether legal entities or not, with a bona fide interest in prosthetics and orthotics and related professions as well as an interest in supporting the Society's objectives.

It is hoped that those associations or societies already organized to achieve similar objectives in prosthetics and orthotics will become affiliated with the International Society. All members of ISPO will be entitled to a number of benefits. These will include the receipt of *Prosthetics International*, the journal of the society, initially on a basis of two issues per year for two years and thereafter on a quarterly basis. Members will also receive other planned publications and the use of the society's Information Service. Participation in seminars and courses will also be a membership privilege. It is considered that membership in ISPO will carry a significant status because of the stringent membership requirements.

A committee consisting of J0rgen Kjolbye of Denmark, George Murdoch of Scotland, and Anthony Staros of the United States has been assigned the responsibility of drafting the society's by-laws for presentation, debate, and acceptance at a steering committee meeting to be held in Dundee, Scotland, in June 1971. The by-laws will describe the proposed government of the International Society and specify privileges of members of those societies which are to be encouraged to affiliate. In all countries, especially those that do not have organized societies or associations which can now affiliate, mem-

bers of ISPO will be organized to form National Member Societies of ISPO.

The International Committee of ISPO, consisting of representatives from national groups, will be charged with the responsibility for government of the society. Each country's membership will be entitled to appoint either one or two representatives to the International Committee, depending on national ISPO membership. This means that large countries with large numbers of members will have no greater control over the International Committee than will smaller countries with fewer members.

The International Committee will elect the officers and executive board of the society. The president of the society will select committee chairmen for the seven standing committees: Membership, Finance, Resource, Research, Evaluation, Education, and Publications.

These committees, within their specified areas of concern, will have responsibilities for worldwide coordination of activities related to the society's objectives. Thus, the responsibilities of the members of those standing committees, representing as they do all parts of the world, will include the establishment of standards for devices and techniques; the planning of symposia and other meetings, policies for publications, and the like; and the implementation of relevant fiscal policies.

The membership committee now has an immediate and primary responsibility to establish criteria for membership in the society. These criteria will be based on the concept of a society of individual members who are professionals actively engaged in prosthetics-orthotics rehabilitation, including research, education, clinical practice, and other significant aspects of the technology.

Clearly, there are other individuals who may not qualify for full membership in ISPO, and indeed may not wish the full privileges of full membership, yet wish to be associated with the society and are willing to participate in sponsoring the society's objectives. An associate membership is being offered for such persons.

During the period from the founding of

the society until the occasion of the First World Congress in September 1972, there will be many actions taken to recruit interest in the society's program.

Dr. Knud Jansen of Denmark, who was chairman of the International Committee on Prosthetics and Orthotics, has been elected by the Steering Committee to serve as president until the First World Congress of ISPO. For the same period, three vice-presidents to assist Dr. Jansen have been elected to represent the society's interests. Their selection reflects both different geographical areas and the several professions involved in the field. Dr. Jansen has already selected interim chairmen of the standing committees so that they can begin to exercise their functions. It is anticipated that these standing committees will now formulate plans for worldwide coordination in their specific fields of interest to prosecute the objectives of the society.

At the First World Congress of ISPO, to be held in Sydney, Australia, in September 1972, the International Committee will be elected, representing those countries which at that time fulfill membership requirements. The International Committee in turn will elect the executive board to oversee the society's operations from 1972 to 1975.

As stated above, the membership committee has already begun its work, and members will be elected after application to that committee. It is clearly important that the membership increase rapidly in number and demonstrate wide representation in a geographical and disciplinary sense if the International Committee is to be truly representative. Readers who would like to join the ISPO should contact the chairman of the membership committee: Dr. D. S. McKenzie, Director, Biomechanical Research and Development Unit, Department of Health and Social Security, Roehampton, London SW 15, England.

Symposium on "Trends in Prosthetics and Orthotics"

From November 9-14, 1970, the International Committee on Prosthetics and Orthotics of the International Society for



The International Committee on Prosthetics and Orthotics of ISRD sponsored a conference on "Trends in Prosthetics and Orthotics" in Rungsted, Denmark, on November 9-14, 1970. The participants numbered approximately 100.

Rehabilitation of the Disabled (Rehabilitation International) sponsored in Rungsted, Denmark, a symposium entitled "Trends in Prosthetics and Orthotics." The number of participants was limited to approximately 100, which is the capacity of the new conference center, Rungstedgaard. Topics covered included "The Engineer in the Clinic Team," "Amputation Techniques and Levels," "Modular Prostheses," "Management of Congenital Deficiencies of the Lower Extremity," and "Rehabilitation of Patients with Spinal Cord Injuries." The education and training of clinic team members was also discussed.

The faculty were:

Dr. Bede J. Alcock, London, England
 Prof. Erling Asmussen, Hellerup, Denmark
 Mr. David N. Condie, Dundee, Scotland
 Dr. Bent Ebskov, Hellerup, Denmark
 Dr. Bodil Eskesen, Hornbaek, Denmark
 Dr. Sidney Fishman, New York, N.Y.
 Dr. Donald W. Grieve, London, England
 Mr. John Hughes, Glasgow, Scotland
 Mr. Knud Jansen, Hellerup, Denmark
 Prof. R. M. Kenedi, Glasgow, Scotland
 Mr. Jorgen Kjolbye, Copenhagen, Denmark
 Mr. Bo Klasson, Stockholm, Sweden
 Mr. Wilfred Kragstrup, Copenhagen, Denmark
 Prof. Gotz Gerd Kuhn, Munster, Germany
 Mr. Erik Lyquist, Copenhagen, Denmark
 Dr. D. S. McKenzie, London, England
 Mr. Colin A. McLaurin, Toronto, Canada
 Mr. Sven Molbech, Hellerup, Denmark
 Mr. George Murdoch, Dundee, Scotland
 Mrs. Katja Popplow, Heidelberg, Germany
 Dr. Robin G. Redhead, London, England

Mr. Anthony Staros, New York, N.Y.
 Mr. Joseph E. Traub, Washington, D.C.
 Mr. A. Bennett Wilson, Jr., Washington, D.C.

Postgraduate Course in Lower-Extremity Prosthetics and Orthotics

The University of Miami School of Medicine, the Veterans Administration Prosthetic and Sensory Aids Service, and the Committee on Prosthetics Research and Development conducted on December 4-6, 1970, in Miami Beach, Florida, a postgraduate course in lower-extremity prosthetics and orthotics. Over 300 physicians, prosthetists, and therapists attended the three-day session, which was designed to keep clinical personnel abreast of the latest developments in procedures for management of amputees and other patients with orthopedic impairments. Virtually every type of disability of the lower limb was discussed by a distinguished faculty drawn from the research, evaluation, and education programs in the United States and Canada. Problems of both adults and children were covered. Of special interest were the new concepts advanced recently by the Ontario Crippled Children's Centre of Toronto for bracing of patients with paraplegia resulting from spina bifida and cerebral palsy.

The faculty were:

Dieter Bochmann, C.P.O., Toronto, Canada
 Paul W. Brand, F.R.C.S., Carville, La.

Clinton L. Compere, M.D., Chicago, Ill.
 David N. Dupree, C.P., Miami, Fla.
 Joan E. Edelstein, New York, N.Y.
 Thorkild J. Engen, CO., Houston, Tex.
 Charles H. Epps, Jr., M.D., Washington, D.C.
 James Foort, C.P., Winnipeg, Canada
 Victor H. Frankel, M.D., Cleveland, Ohio
 Charles M. Fryer, M.A., Chicago, Ill.
 Cameron B. Hall, M.D., Los Angeles, Calif.
 John E. Hall, M. D., Toronto, Canada
 Frederick L. Hampton, C. P., Chicago, Ill.
 Verne T. Inman, M.D., San Francisco, Calif.
 Robert P. Reiser, M.D., Miami, Fla.
 Richard E. King, M.D., Atlanta, Ga.
 H. R. Lehneis, C.P.O., New York, N.Y.
 Earl A. Lewis, R.P.T., New York, N.Y.
 Bella J. May, R.P.T., Miami, Fla.
 Newton C. McCollough III, M.D., Miami, Fla.
 Walter Motloch, CO., Toronto, Canada
 Robert Nitschke, C.P., Rochester, N.Y.
 Edward Peizer, Ph.D., New York, N.Y.
 Carol Ross, R.P.T., New York, N.Y.
 Augusto Sarmiento, M.D., Miami, Fla.
 Mark E. Schultz, C.P., Miami, Fla.
 J. Darrell Shea, M.D., Miami, Fla.
 William F. Sinclair, C.P.O., Miami, Fla.
 Anthony Staros, New York, N.Y.
 A. Bennett Wilson, Jr., Washington, D.C.
 C. L. Wilson, M.D., Miami, Fla.

A similar course is planned for December 1971. Details may be obtained by writing to Dr. Augusto Sarmiento, Professor of Orthopaedics and Rehabilitation, University of Miami School of Medicine, P.O. Box 875, Miami, Fla. 33152.

AAOS Postgraduate Courses

The American Academy of Orthopaedic Surgeons will sponsor a three-day postgraduate course on the upper extremity on May 6-8, 1971, at the Holiday Inn Vanderbilt, Nashville, Tennessee.

Invited to attend are orthopaedic surgeons, general surgeons, physiatrists, and interested physicians and rehabilitation personnel. The course will be held in cooperation with the Continuing Education Department of Vanderbilt University School of Medicine and will deal with current concepts in the management of difficult reconstructive problems of the upper limb.

The faculty of 26 physicians includes members of the school's staff and guest lecturers from other universities. Faculty

members include Dr. Sydney Sunderland, Professor of Experimental Neurology, University of Melbourne, Australia, and author of the text *Nerves and Nerve Injuries*.

The first day of the course will be devoted to basic physiology and management of arterial, tendon and nerve injuries. The second and third days will concentrate on a variety of reconstructive problems of the hand, elbow and shoulder, ranging from finger amputations to brachial plexus injuries.

Director of the three-day course of lectures and panel discussions is Dr. John Connolly, Assistant Professor of Orthopedic Surgery, Vanderbilt University School of Medicine.

For information contact John Connolly, M.D., Orthopedic Surgery Department, Vanderbilt University Hospital, Nashville, Tennessee 37203.

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The American Academy of Orthopaedic Surgeons will sponsor a postgraduate course on reconstructive surgery of the arthritic patient on May 12-14, 1971, in Philadelphia, Pennsylvania.

The three-day course of lectures and panel discussions will be held at the Sheraton Hotel and is offered by the Academy's Committee on Arthritis in cooperation with the Department of Orthopaedic Surgery, University of Pennsylvania.

The course for orthopaedic surgeons, rheumatologists, and other interested *physicians* will be devoted to medical and orthopaedic problems in the rheumatoid patient. The course will be a comprehensive presentation of the current status of reconstructive surgery. Indications for surgery, preoperative evaluation, surgical technique, and postoperative management will be discussed in detail. The twenty-seven member faculty includes lecturers representing eighteen medical centers across the country.

For application forms and further information, contact Dr. John L. Sbarbaro, 133 South 36th Street, Philadelphia, Pennsylvania 19104, or the American Academy of Orthopaedic Surgeons, 430 North Michigan Avenue, Chicago, Illinois 60611.

Other courses scheduled in 1971 under the Continuing Education Program of the **American Academy of Orthopaedic Surgeons** are:

COURSE	DATE-CITY	PRODUCING COMMITTEE	COURSE CHAIRMAN
CHILDRENS' HIP PROBLEMS	May 24-26 Atlanta	Committee on the Handicapped Child	Wood W. Lovell, MD 340 Boulevard, NE 30312
ADULT SPINE	June 2-4 Cleveland	Committee on Injuries	George E. Spencer, MD 2065 Adelbert Rd. 44106
SHOULDER IN SPORTS	July 26-28 San Francisco	Committee on Sports Medicine	Fred L. Behling, MD 300 Homer Avenue 94301
KNEE IN SPORTS	Sept. 13 15 New York	Committee on Sports Medicine	James A. Nicholas, MD 150 East 77th St. 10021
FOOT DISORDERS IN CHILDREN	Sept. 19-21 San Francisco	Committee on the Handicapped Child	Robert L. Samilson, MD 3580 California St. 94118
FOOT AND ANKLE	Sept. 29-Oct. 2 San Antonio	Committee on Injuries	Charles A. Rockwood, MD 7703 Floyd Curl Dr. 78229
MEDICO-LEGAL PROBLEMS	Oct. 16-18 Winston-Salem	Committee on Adult Orthopaedics	John T. Hayes, MD Bowman Gray School of Med. 27103
BIOMECHANICS	Nov. 8-12 Cleveland	Committee on Basic Science	Victor H. Frankel, MD 2109 Adelbert Road 44106
MODERN CONCEPTS OF FRACTURE TREATMENT	Nov. 15-18 Boston	Committee on Injuries	William R. MacAusland, Jr., MD 412 Beacon St. 02115
LOWER EXTREMITY FRACTURES	Dec. 1-3 Downey, Calif.	Committee on Injuries	Vert Mooney, MD 7847 E. Florence 90241
THE ADULT HIP	Dec. 13-16 Miami	Committee on Injuries	Augusto Sarmiento, MD P.O. Box 875, Biscayne Annex 33152

The courses are designed for orthopaedic surgeons, but they are open to other interested physicians and allied health personnel. Registration limits will be set by the course chairman to avoid overcrowding of course facilities. For further information, contact the Coordinator of Continuing Education, American Academy of Orthopaedic Surgeons, 430 N. Michigan Ave., Chicago, Ill. 60611.

Orthotics Conference

A Conference on the Advance in Orthotics will be held at the University of Dundee, Scotland, on June 21-25, 1971. Sponsored by the Eastern Regional Hospital Board, and in association with the Scottish Home and Health Department and the University of Dundee, the conference will outline and review the various

locomotor and functional disabilities which may require the prescription of orthotic devices.

Emphasis will be placed on the assessment and description of functional incapacity, prescription techniques, a realistic appreciation of the functional advantages and disadvantages of the presently accepted apparatus, description and demonstration of new and advanced designs, and the formulation of guidelines for research, development, and design for the future. Also, the place of orthotic management vis-a-vis surgical treatment in certain specified conditions and in relation to the growth period will be explored. An international team of experts representing all relevant disciplines has been assembled to insure comprehensive discussion.

The proceedings will be conducted under the following subjects:

Biomechanical Matching	Cerebral Palsy
Rationale of Prescription	Spina Bifida
Upper-Extremity Orthotics	First Aid
Lower-Extremity Orthotics	Rheumatoid Arthritis
Spinal Bracing	Orthotics and the
Wheelchairs	Elderly
Fracture Bracing	Paraplegia
Administration, Supply, and the Clinic Team	Club Foot

The conference is multidisciplinary and is intended for general and orthopedic surgeons, physical medicine specialists, prosthetists, orthotists or orthopedic tech-

nicians, therapists and remedial gymnasts, biomedical engineers, and others with a stated interest in the field.

It is anticipated that the consolidated registration fee, including board and accommodation, will be approximately £35 (\$84.00 U.S.).

Details may be obtained from the Dundee Limb Fitting Centre, 133 Queen Street, Broughty Ferry, Dundee, Scotland.

12th SICOT Congress

The Societe Internationale de Chirurgie Orthopedique et de Traumatologie (SICOT) has announced that the 12th SICOT Congress will be held in Israel on October 9-13, 1972.

In conjunction with the congress, the Israel section of SICOT and the Orthopedic Association of Israel are offering 15 travel fellowships which include free air travel and seven days full board in Israel during the meeting. This "12th SICOT Congress Fellowship" is a scientific competition for the best original papers on an orthopedic subject or any basic subject connected with the society's field of interest. The competition is open to every surgeon and/or scientist up to 40 years of age.

The final date for submission of papers is January 31, 1972. Address: Societe Internationale de Chirurgie Orthopedique et de Traumatologie, Secretariat, 43 rue des Champs-Elysees, Brussels 5, Belgium.

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

THE NATIONAL ACADEMY OF SCIENCES is a private, honorary organization of more than 700 scientist and engineers elected on the basis of outstanding contributions to knowledge. Established by a Congressional Act of Incorporation signed by Abraham Lincoln on March 3, 1863, and supported by private and public funds, the Academy works to further science and its use for the general welfare by bringing together the most qualified individuals to deal with scientific and technological problems of broad significance.

Under the terms of its Congressional charter, the Academy is also called upon to act as an official—yet independent—adviser to the Federal Government in any matter of science and technology. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a governmental agency and its activities are not limited to those on behalf of the Government.

THE NATIONAL ACADEMY OF ENGINEERING was established on December 5, 1964. On that date the Council of the National Academy of Sciences, under the authority of its Act of Incorporation, adopted Articles of Organization bringing the National Academy of Engineering into being, independent and autonomous in its organization and the election of its members, and closely coordinated with the National Academy of Sciences in its advisory activities. The two Academies join in the furtherance of science and engineering and share the responsibility of advising the Federal Government, upon request, on any subject of science or technology.

THE NATIONAL RESEARCH COUNCIL was organized as an agency of the National Academy of Sciences in 1916, at the request of President Wilson, to enable the broad community of U. S. scientists and engineers to associate their efforts with the limited membership of the Academy in service to science and the nation. Its members, who receive their appointments from the President of the National Academy of Sciences, are drawn from academic, industrial, and government organizations throughout the country. The National Research Council serves both Academies in the discharge of their responsibilities.

Supported by private and public contributions, grants, and contracts, and voluntary contributions of time and effort by several thousand of the nation's leading scientists and engineers, the Academies and their Research Council thus work to serve the national interest, to foster the sound development of science and engineering, and to promote their effective application for the benefit of society.

COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT COMMITTEE ON PROSTHETIC-ORTHOTIC EDUCATION

The *Committee on Prosthetics Research and Development* and the *Committee on Prosthetic-Orthotic Education*, units of the Division of Engineering and the Division of Medical Sciences, respectively, undertake activities serving research and education in the fields of prosthetics and orthotics, when such activities are accepted by the Academy as a part of its functions. Activities of the Committees are presently supported by the Department of Health, Education, and Welfare and the Veterans Administration. Information or reports developed by activities of the Committees are officially transmitted and published through the National Academy of Sciences.