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Orthotics and Prosthetics

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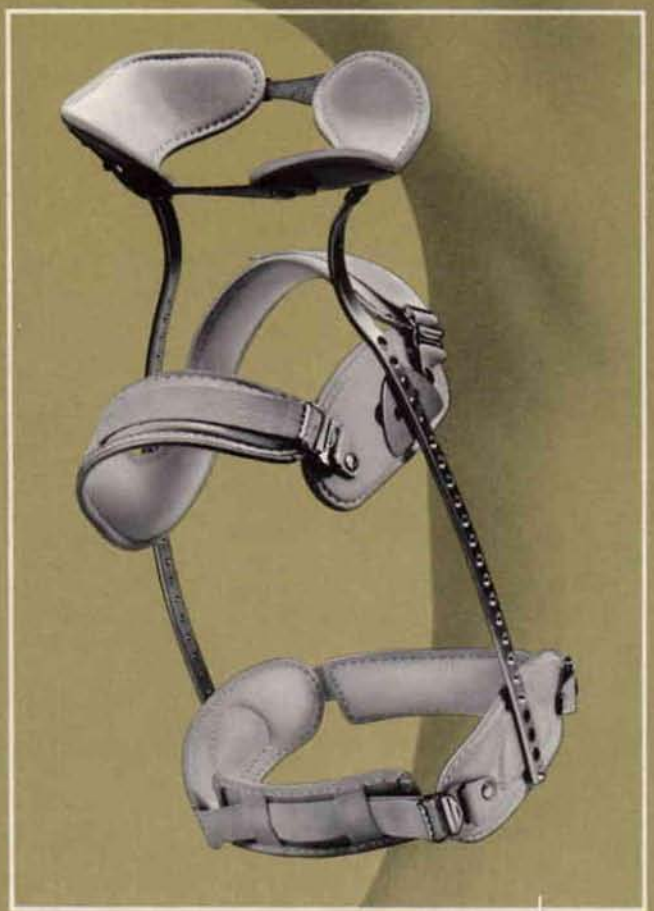

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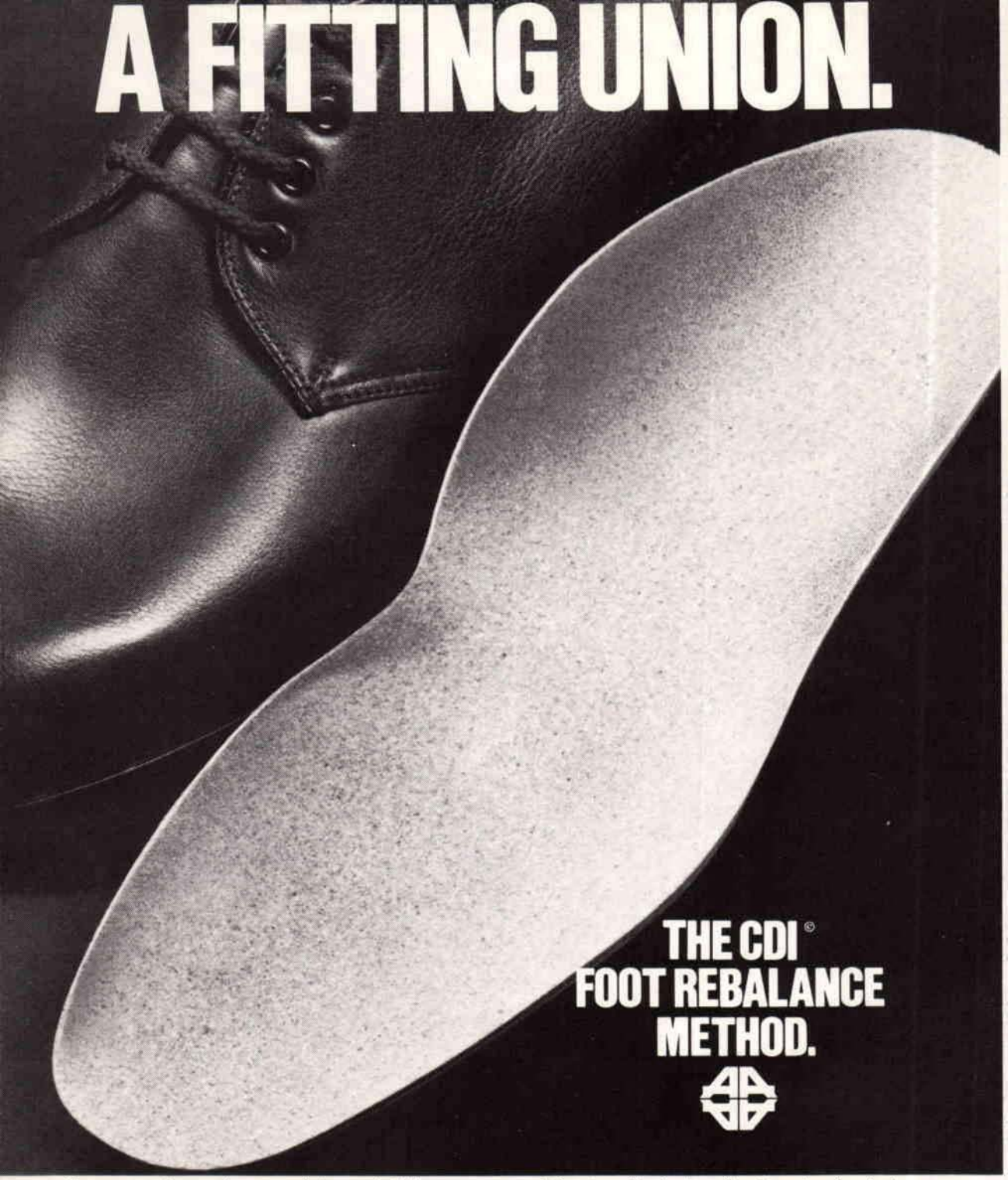

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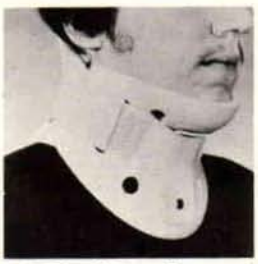

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Orthotics and Prosthetics, Vol. 30, No. 2, pp. 1–2, June 1976

PROFESSIONAL COOPERATION — THE PRESENT DAY CHALLENGE TO US

The pace at which our modern industrial community is developing is truly breath-taking. The stable structure of the past century has changed to a dynamic one. From day to day it becomes increasingly specialized and complex.

The population has not only increased at an explosive rate during the last 100 years, but its form has changed to such an extent that a completely new structure of society has developed. According to Germacher approximately 80% of the working population was employed in agriculture in the year 1800. In 1960 it was only about 20% in the industrial countries.

In keeping with this rapid change is the ever increasing amount of scientific knowledge available to us. In his book "Education-Future-Safety" Heinz Schwalbe gives us the following information: In the year 1700 there were 10 scientific publications registered. By about 1800 the number was 100, by 1850 already 1000 and in the year 1900 it was as many as 10,000. By 1950 it had risen to 100,000 and in 1968, solely in the field of psychology, 12,000 publications could be counted. Specialists estimate that the amount of scientific information available doubles about every 15 years.

According to I. I. Cervan Schrieber's book "The American Challenge", in the year 3000 B.C. Egyptian soldiers moved about with a speed of around 5 km. per hour. In the Middle Ages, 4000 years later, the crusading armies moved at the same speed. Columbus achieved an average speed of 8 km. per hour and then ultimately Napoleon's carriage brought it up to 16 km. per hour. Thus it took man nearly 5000 years merely to treble his speed of moving forward.

In the last one and one-half centuries, however, this has increased enormously. The moon rocket, with Armstrong and Aldrin on board, shot itself out of the moon's orbit towards the earth with a speed of 9100 km. an hour. These figures speak for themselves.

Now back to industry. Heinz Schwalbe tells us that the period of time from scientific discovery to industrial application was 112 years for photography, 50 years for the telephone, 35 years for radio, 15 years for radar, 12 years for television, 6 years for the atom bomb, and 5 years for transistors. From this we can see that, not only is our environment changing, but also that the tempo of dynamics is continuously accelerating.

We do not know if we are in a position to meet this challenge successfully, but we can be sure that only with considerable knowledge and ability will we be able to master it. If we review industrial development over the past 50 years we see that professions come and go. Not only has industrial progress made many professions obsolete, but also the actual change which has taken place within most is quite incredible. It would fill columns to list all the occupations whose internal structure has been completely remodelled.

What is the position in our profession? Do you really think that everything will stay as before? That no new guidelines are necessary?

May I remind you that only a few decades ago we produced practically all elements of our orthopaedic technology ourselves in our own workshops. Today we are supplied by industries especially equipped for carrying out this work, and, thereby, the basic handicraft skills have been forced into a secondary position. Let us take, for example, the tubular skeleton prostheses for arms and legs which leave

practically nothing to be completed by hand. This spotlights how the might of knowledge and know-how gets ever stronger and greater.

Looking back at the past we see that the professional training methods in the USA have taken quite a different path from those in Europe. Whereas in Europe the educational framework of orthopaedic technology is still based largely on manual skills, and further education is necessary if one is to keep up with the developments, rather the opposite situation is to be observed in the USA, where good basic training through research and technology is given priority.

Despite these differences in tradition, or even more appropriately because of these differences, a wonderful opportunity presents itself for both sides to profit from the differing experience of the other. When one studies the position existing on the two continents with respect to orthopaedic technology one is truly amazed at the extent to which the experience of the one complements that of the other. We should not allow this opportunity of cooperating together to slip away.

Within the scope of INTERBOR, to which 15 countries belong, such a cooperation has already been partially realized. We should, however, not forget that precisely in such an international organization the efforts of all members are necessary. Only by closely cooperating together in all sections of orthopaedic technology can we expect to shape and influence the future of our profession. National frontiers, differing languages, and dissimilar conditions and opinions must not hinder our mutual efforts.

The joint AOPA-INTERBOR Congress in Miami Beach, Florida, presents itself as an ideal opportunity to get to know each other better and to work out together successful plans for the future. I assure you that we are really happy about this meeting and place great hopes on it.

Andre Bahler
President
INTERBOR

Orthotics and Prosthetics, Vol. 30, No. 2, pp. 3–11, June 1976

FABRICATION AND FITTING OF THE CARS-UBC KNEE ORTHOSIS

R. Wassen[1], R. Hannah[1],
J. Foort[1], and S. Cousins[1]

The CARS-UBC Knee Orthosis (Fig. 1) which was described in the December 1975 issue of Orthotics and Prosthetics (*1*) is specifically designed to hold a medially or laterally unstable knee from moving into a painful position of deformity while the knee is in extension, and bearing weight. This paper covers fabrication and fitting procedures.

In the early phase of development, a plaster cast of the affected limb was made with the knee in a nearly corrected position. A positive model of the limb was made, and plastic laminate cuffs were made over it. Since then, we have developed prefabricated kits (Fig. 2). The cuffs are preformed of polyvinylchloride, a transparent thermoplastic with reasonable impact resistance and sufficient rigidity, and are fitted individually after being heated slightly.

The joint system (Fig. 3) includes the polypropylene joint head and the nylon bolt which serves as a pivot. The nylon is locked onto the PVC cuffs with a thin nylon nut which has been countersunk to fit approximately the shape of the underside of the flat head nylon bolt. The PVC, countersunk in the molding process, is clamped between the head of the bolt and the thin nut. When the hinge, which is threaded to mate the bolt, is screwed on, excess bolt is cut off to finish the joint system.

The telescopic beam plugs into the polypropylene joint head. The telescopic feature permits unrestrained flexion of the knee. The fit of the steel tubes permits the units to slide freely with respect to each other without rattle. One end of the knee sling is anchored to this beam so that the required pull toward the beam is achieved. The other ends of the knee cuff are fastened to the PVC cuffs (Figs. 4 and 5).

[1]Division of Orthopaedics, Department of Surgery, Faculty of Medicine, University of British Columbia, Vancouver 9, B.C., Canada.

The knee sling (Fig. 6) is made of leather. It is triangular in shape so that one corner can be anchored to each cuff and one to the telescopic beam in such a way that the three forces on the knee sling balance out the displacing force within the knee. The knee sling, the straps which hold it to the rest of the orthosis, and the straps that hold the orthosis on are the most handcrafted parts of the orthosis. Most of the fitting required involves adjusting the straps to achieve the required balance between the three parts of the orthosis: the thigh cuff, the shank cuff, and the knee sling. Included in these adjustments is adjustment of the waist band suspension system which holds the orthosis in place vertically, and adjustment of the straps which hold the shank and thigh cuffs in position when the whole system relaxes with flexion of the knee and hip.

FABRICATION

THE TELESCOPIC BEAM

Table 1 provides specifications for the seamless, mechanical steel tubing, (Standard Tube, Canada Ltd.) used to fabricate the telescopic beam (Fig. 3). The tubing is cut into seven-inch lengths using a standard type of tubecutter. These lengths will be cut shorter later if necessary to permit sufficient telescoping as the patient sits. An additional piece of 3/8-in. tubing 1-in. long is cut to insert into the 7/16-in. tubing so that 3/8-in. protrudes to plug the 7/16-in. part onto the polypropylene hinge. The 1-in. piece is attached to the 7/16-in. tube by a pop rivet through a hole approximately 3/16-in. from the end of the 7/16-in. tubing. The cut ends of the 7/16-in. tubing are deburred, and the telescopic beam assembly is nickle plated. The completed telescopic beam is shown in Figure 3.

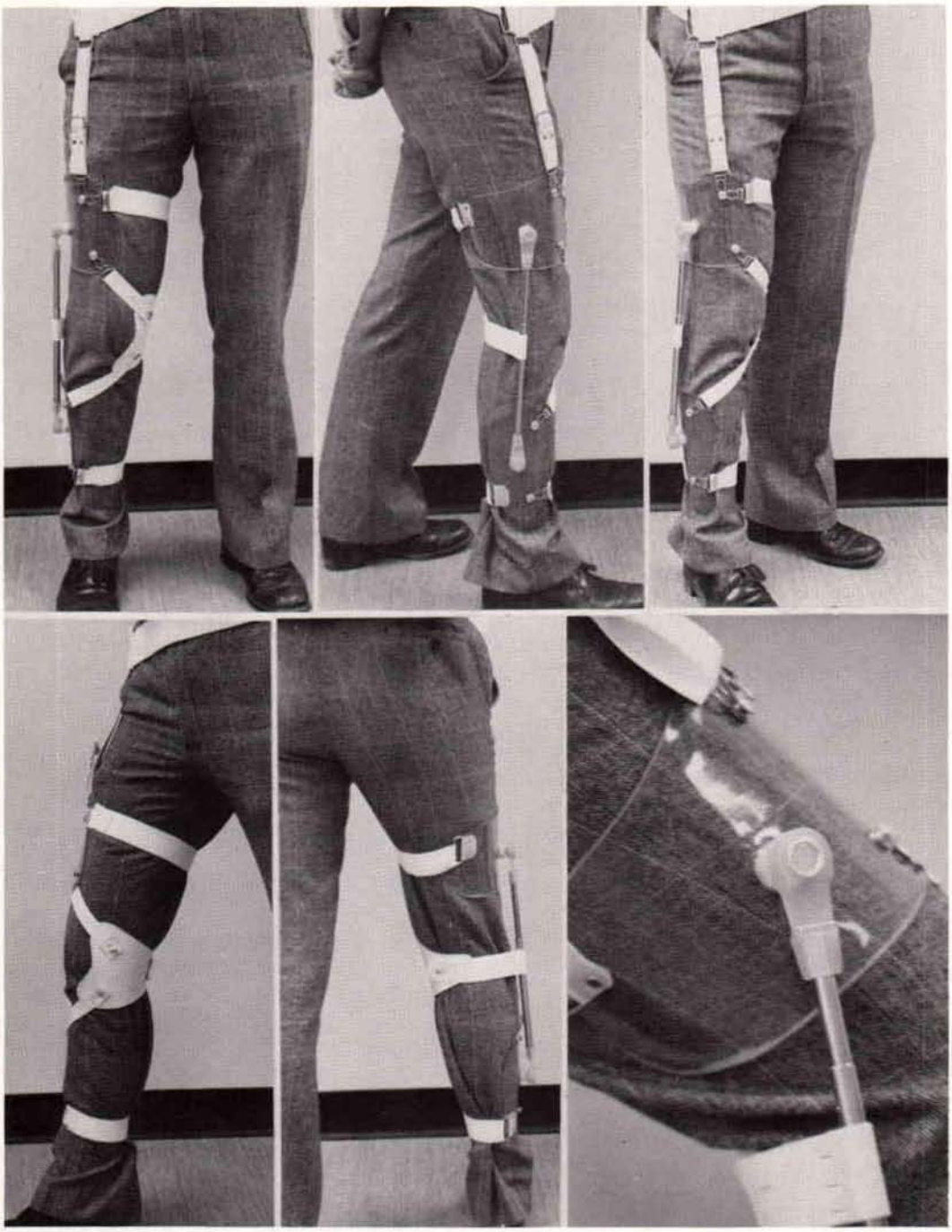

Fig. 1. Various views of the CARS-UBC knee orthosis for arthritis. These views show the orthosis fitted to provide for lateral instability. It can be fitted just as easily with the telescoping bar on the medial side of the knee to provide for medial instability. Although shown here being worn on the outside of trousers the orthosis may be worn next to the skin or simply with a stockinet over the knee.

TABLE 1. SPECIFICATIONS ON THE SEAMLESS MECHANICAL TUBING

O.D.	Wall Thickness Gauge	Dec.	I.D.	Length	Yield Str.	Finish	Type
3/8 in.	17	0.058	0.259	7 in.	60,000 min.	Nickel	4130
7/16 in.	22	0.028	0.318	7 in.	60,000 min.	Nickel	4130

THE JOINT-PIVOT SYSTEM:

Dimensions of the polypropylene joint head, which is injection molded by a local fabricator, are shown in Figure 3. An aluminum insert at the bearing area is provided to eliminate the effects of shrinkage of the polypropylene after molding. The insert is made of 5/8-in. aluminum round stock drilled and tapped for a 1/2-in. N.C. thread. The outer surface is knurled to key it to the polypropylene.

Attachment of the nylon bolt to the PVC cuff is shown also in Figure 3. The head of the bolt

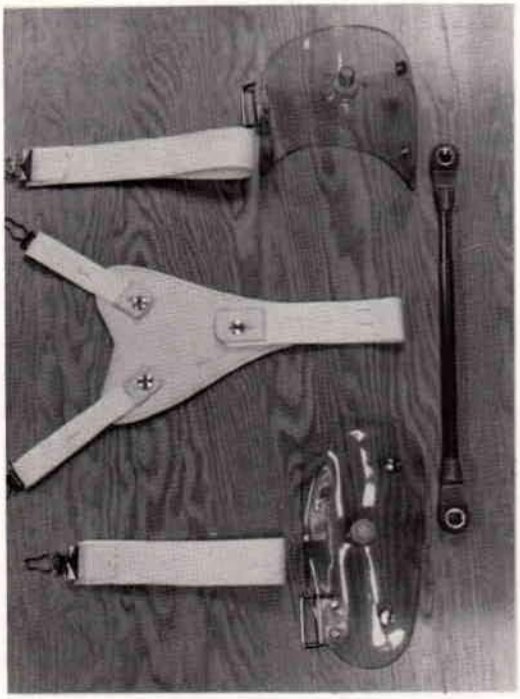

Fig. 2. The parts of the kit for the CARS-UBC knee orthosis.

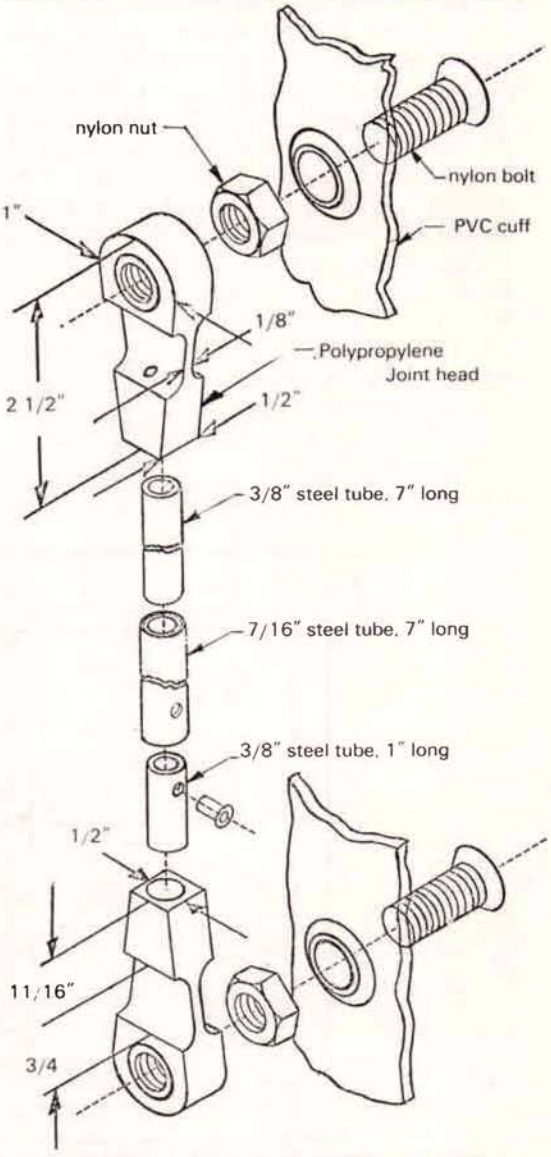

Fig. 3. The components of the telescoping joint system.

is shaved off to remove the screw driver slot, and a nylon nut, which is used to clamp it to the PVC, is thinned to approximately 1/4-in. and countersunk on the side which fits against the PVC. The nylon flat head bolt has 1/2-in. N.C. threads. The polypropylene joint head is screwed onto the nylon bolt to the required position. The advantages gained by using a threaded pivot-bearing system include the ability to position the joint head closer or further from the body for optimizing comfort and cosmesis, and keying of the joint head to the pivot in a direct and simple way.

Assembled, the joint system provides more than adequate pivoting action without significant joint head shift because the degree of pivoting required is only about 45 deg. The thin section of the joint head is designed to provide a flexing hinge which acts at right angles to the pivot. The flexing hinge can allow shifts of about 30 deg. off the axis of the telescopic beam in either direction. If it should flex beyond the yield point, it will not break, but continue to function as a springless hinge. Since the forces act inward against the PVC cuffs, all tendencies favor the system. Furthermore, because the telescopic beam allows relative rotation between the 3/8-in. and 7/16-in. tubing, it is virtually impossible to load the whole system adversely.

THE PVC CUFFS

When it was recognized that prefabricated cuffs were practical, plaster molds (Fig. 7) were established for the thigh cuff and the shank cuff. Each cuff is a mirror image of it's mate and so these are not really left and right cuffs, but varus and valgus cuffs. Thus, the shape of the valgus right is the shape for the varus left. The surface of the mold is shaped to give a flare to the edge of the cuff and to produce a conical elevation for the screw to recess into.

The cuffs are made of 1/16-in. PVC. The material is water clear, and therefore allows direct inspection of fit against the body. When adjustments are required, they can be made with a heat gun. The dimensions for the thigh and shank cuff bands are shown in Figures 4 and 5.

Molding and Finishing Procedures.

1. Soften the PVC pieces in an oven at approximately 400° F for at least 30 sec.
2. Prewarm the molds sufficiently to allow the needed working time.
3. With gloved hands, remove the PVC piece from the oven and work it down against the mold until it mates. Vacuum forming of course can be used.

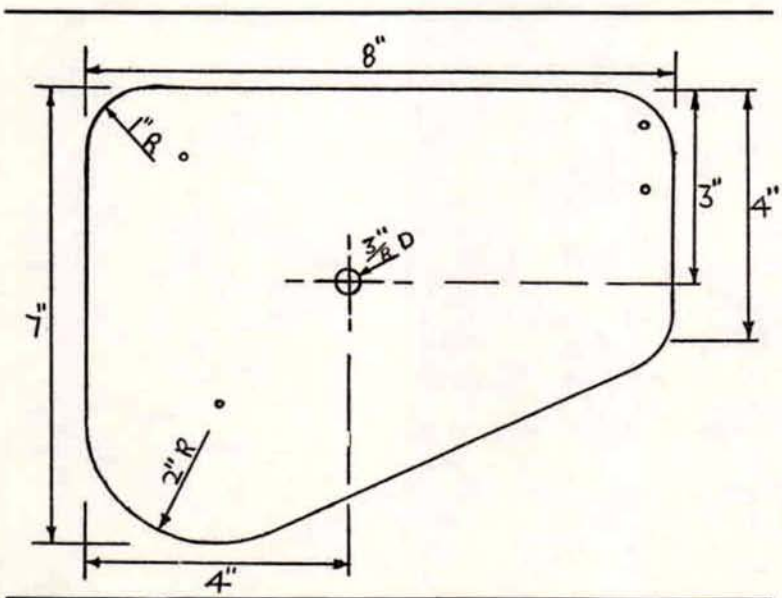

Fig. 4. Outline of the thigh cuff band. Transparent polyvinylchloride has proven to be a satisfactory material for the cuffs.

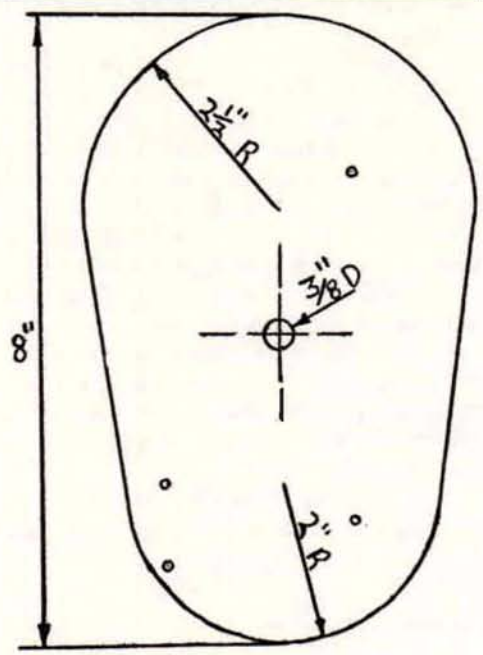

Fig. 5. Outline of the shank cuff blank. Transparent polyvinylchloride has proven to be a satisfactory material for the cuffs.

4. Remove the cooled part. Grind the edges with a disc sander and polish the edges with a felt buffer. Avoid fumes during all operations.

5. Using the disc sander, grind the tip off the conical elevation until a hole is made large enough to receive snugly the 1/2-in. nylon bolt.

6. Drill holes for straps and buttons as indicated on the template sketch using a No. 8 drill (Figs. 4 and 5).

STRAPS AND FASTENING

Because there is no attachment to the shoe, and the whole apparatus is so loosely interlinked within itself, a waist band suspension system is required. Figure 8 shows the 1 5/8-in. belt end, made of leather, to which two shapes and the 1 1/2-in. cotton webbing waist band are attached. The steps involved in making the straps are:

1. Make a leather belt end for attaching the metal shapes and waist strap per the pattern in Figure 8.

2. Use Velcro, attached at the time of fitting, for securing the belt.

3. Make the 1-in. Dacron webbing loop as indicated in Figure 9. The clip fastens to the

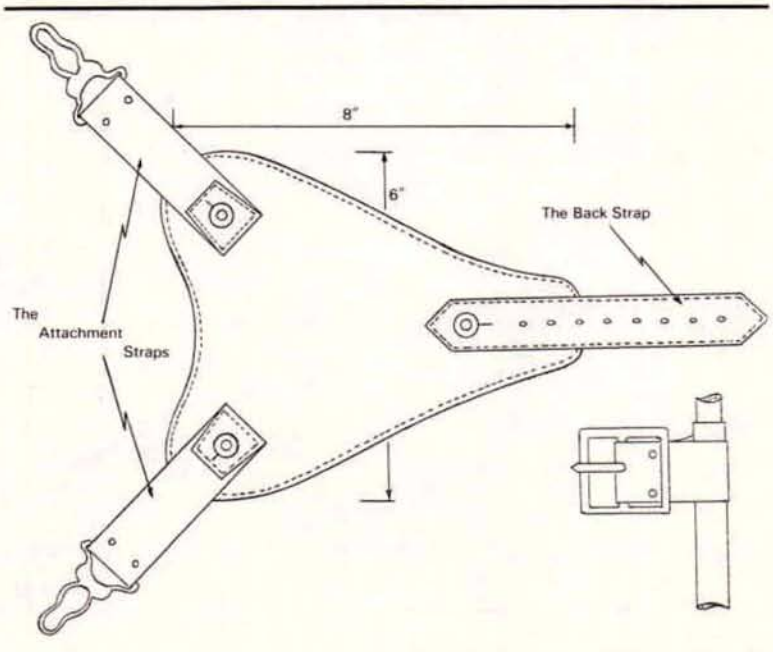

Fig. 6. Basic dimensions of the leather knee sling.

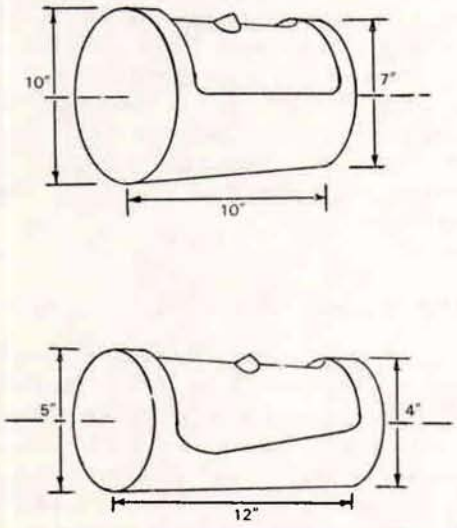

Fig. 7. The molds for the cuffs. The upper figure is for the thigh cuff mold, and the lower for the shank cuff mold. Only one mold for each level is required to provide left and right, varus and valgus because each cuff is a mirror image of its mate and because of the material used it can be reversed.

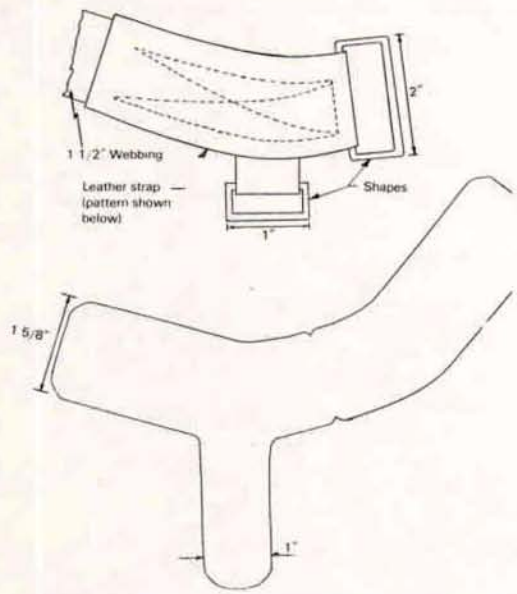

Fig. 8. Upper figure shows the end of the suspension belt. The lower figure is the pattern for the leather portion of the belt end.

button that is attached to the top-front end of the thigh cuff.

4. Make two 1 1/2-in. cotton webbing straps per Figure 10. These are attached to the thigh and shank cuffs and looped around the limb to stabilize the cuffs. The thigh cuff attachment strap is at the top edge, and fits onto the same button as the suspension strap, but goes on second to prevent disconnection of the suspension loop when there is no tension in the system. The shank attachment strap fastens to the lower edge of the shank cuff in the same way.

5. The knee sling is made according to the pattern shown in Figure 6. Attachment points for the three buttons are indicated and these are pop-riveted to the sling. Small copper washers are used for reinforcement.

6. Webbing attachment straps for the knee are shown also in Figure 6. Like other straps they are

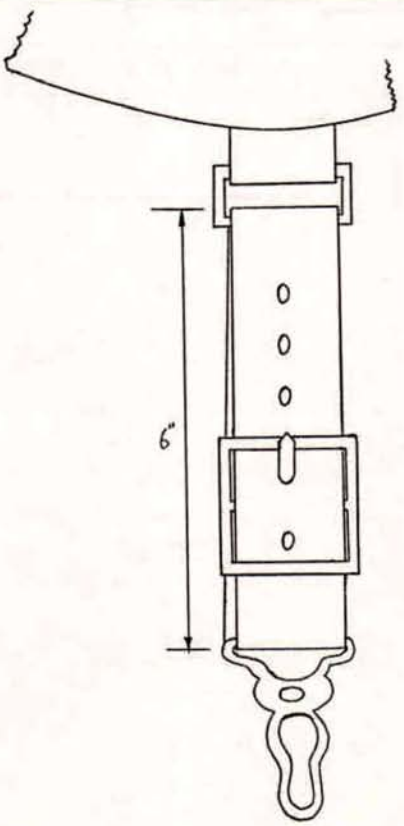

Fig. 9. The suspension strap.

made overlength and cut to the required length after trials on the patient.

7. The posterior knee strap is shown also in Figure 6.

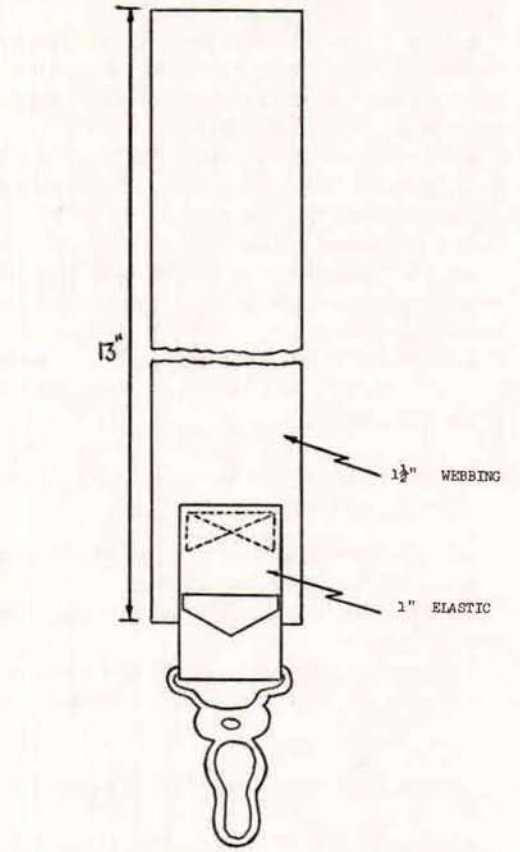

Fig. 10. The cuff strap. Two are required.

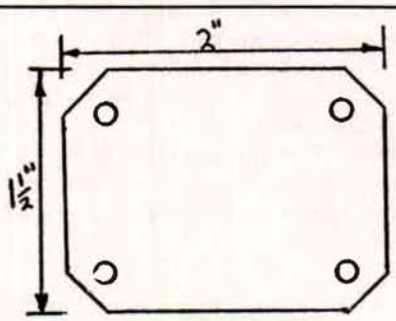

Fig. 11. The Polyethylene Link.

8. Straps are connected to the PVC cuffs by 1 1/2-in. shapes. These are attached by means of polyethylene links (Fig. 8) to the PVC cuffs.

9. Rayon elastic cord, 1/8-in. in diameter is fitted inside the tubing, extending through the polyethylene joints through 1/8-in. holes drilled into the joints along the axis of the tubing as indicated in Figure 3.

FITTING PROCEDURE

With the patient seated and the knee flexed the following steps are carried out:

STEP 1: THE WAIST BELT

- Apply the waist belt so that the suspension strap hangs down the anterior midline of the affected limb.
- Adjust the belt for comfort and sew Velcro on to fasten the belt.

STEP 2: THE THIGH CUFF

- Position the cuff at mid-thigh; on the lateral side for correcting a valgus deformity; on the medial side for correcting a varus deformity.
- For a snug fit, warm the cuff lightly with a heat gun or over a hot plate, and gently bend it to fit the leg. (Practice with a strip of scrap PVC is recommended.)
- Fit the thigh cuff securing strap by adjusting it through the ring on the cuff. It should pass around the leg to fasten onto the top button on the front of the cuff. This strap should hold the cuff securely in place but not restrict circulation. Sew or rivet the strap to the ring and trim off the excess.

STEP 3: THE SHANK CUFF

- A good fit is also important for the shank cuff.
- Fit it mid-way between the knee and the ankle on the medial or lateral side as was the case with the thigh cuff.
- Shape the cuff by warming it and flare the lower edge, if necessary, by pressing the warmed edge against a bench.
- Adjust the securing strap so that it fastens onto the bottom button on the cuff and holds the cuff securely in position.

- Check that the strap is not restricting the circulation, and rivet, or set it, to length.

STEP 4: THE TELESCOPIC TUBE

- Remove the cuffs from the leg and screw the plastic screws into the joint heads of the telescopic tube.
- The narrow tube should be at the top.
- The screw should not protrude from the joint head and the joint should rotate freely.
- Replace the cuffs, now connected by the telescopic tube, on the leg.

STEP 5: THE SUSPENSION STRAP

- Fasten the suspension strap clip (hanging from the belt) to the top button on the front of the thigh cuff.
- Fasten the thigh cuff securing strap back on *top* of the suspension strap clip on the top button.
- Have the patient stand. Adjust the length of the strap, with the patient standing, so that it supports the thigh cuff but does not pull the waist belt down uncomfortably on the hips. Have the patient sit and the suspension strap will go slack.
- Squeeze the suspension strap clip, only, permanently in place on the button with pliers.

STEP 6: THE KNEE SLING

This is the most important part of the fitting procedure because it is the knee sling that pulls the knee into a comfortable position.

- With the knee flexed, fasten one clip on the knee sling to the lower button on the thigh cuff and fasten the other clip to the top button on the shank cuff.
- Adjust the straps through these clips until the knee sling is positioned snugly on the side of the knee, but not restricting the patella.
- Pass the posterior leather strap of the knee sling behind the buckle of the telescopic tube.
- Extend the knee with the patient sitting. The knee sling should pull firmly against the side of the knee. If the anterior straps are pulling the cuffs out of position, they are too short. If adjustment on the posterior strap is insufficient the anterior straps are too long.

STEP 7: HAVE THE PATIENT WALK

- If the thigh cuff is rotating anteriorly, loosen the strap connecting the knee sling to the thigh cuff and tighten the posterior strap of the knee sling.
- Do the same to the shank cuff if it is also slipping anteriorly.
- When the best length of the two straps linking the knee sling to the cuffs has been determined, rivet or sew the straps and squeeze the clips permanently to the buttons with pliers.
- Have the patient take off the orthosis and put it on again a number of times to ensure independence. Establish that the patient can follow the written instructions given him.
- If the telescopic tube is too long, (i.e. restricting flexion), it may be shortened using a tube cutter or hacksaw.
- If the skin is in good condition the orthosis may be worn next to the skin, otherwise a stockinette may be worn.

Points which indicate that the fitting of the brace is successful are:

- the patient feels less pain in the affected knee
- the speed of walking is increased
- there is increased stability and mobility in the stance phase
- the patient feels more secure and confident
- there is less dependence on any walking aid

INSTRUCTIONS FOR THE PATIENT

- The orthosis is most easily put on when the patient is sitting with the knee flexed.
- Put the waist belt on with the buckle just in front of the hip.
- Position the cuffs on the side of the leg.
- Fasten the top cuff on by clipping the strap to the top button of the cuff.
- Fasten the bottom cuff on by clipping the strap to the bottom button.
- Now that the cuffs are fastened to the leg, fasten the knee sling. Do this by pulling the strap around and behind the knee and fasten it to the buckle on the tube.

Check:

1. When standing, the knee sling should give firm support at the side of the knee.
2. *If it is too tight* sit down and slacken the buckle on the tube.
3. *If it is too slack* sit down and tighten the buckle on the tube.

To take the orthosis off:

1. Unfasten the strap behind the knee.
2. Undo the strap at the bottom.
3. Undo the strap at the top.
4. Take off the waist belt.

LITERATURE CITED

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THE SHOE AS A COMPONENT OF THE ORTHOSIS[1]

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A specific shoe prescription must be evolved on an individual basis for each type of lower-limb orthosis prescribed[6]. The shoe and the rest of the orthosis cannot be considered as separate entities, but must be evaluated as a total orthotic system since the shoe modifications needed in each individual case are dependent upon the pathologic problem and the manner in which the total system will function.

The pathology to be braced, the condition of the local tissues and foot, the characteristics of all parts of the orthosis, the gait characteristics, the cosmesis of the device, and the patient's wishes must all be considered when the prescription is developed by the Clinic Team. This presupposes that all of the members of the team, including the representative of the Shoe Laboratory are professionals. The shoe orthotist should be a specialist in last design as well as in shoe construction and shoe modifications, and not solely a "shoemaker" whose expertise does not extend beyond the ability to apply heels and soles to shoes. He should be able to work in close association with other orthotics services and be familiar with the needs of users of orthoses.

Nevertheless, it is possible to generalize within fairly narrow limits and designate the proper shoes, or shoe modifications, usually required as part of each orthotic system, and it is the purpose of this paper to do so. Discussion will be limited to the orthoses most often used at the VAPC, the shoes or shoe modifications which should be employed with such devices, and the reasons for each specific shoe prescription. Since the shoes and shoe modifications required for ankle-foot orthoses (AFO's) do not differ from those required for hip-knee-ankle-foot orthoses (HKA FO's) and knee-ankle-foot orthoses (KAFO's) under similiar circumstances, the discussion will center primarily on AFO orthotic systems to avoid unnecessary repetition.

Two types of commercially available shoes with special features will be referred to frequently throughout this presentation. It is therefore important to describe the pertinent special features of each. The Wilbur Coon Shoe[7] has a stiff ("hard") counter and 3/16-in. thick removable inlay of foam rubber covered by calf leather. The Ortho-Inlay, or Formo-Ped shoe[8], has a relatively flexible ("soft") counter, and an inlay which is 5/8-in. thick at the heel, 3/8-in. thick at the ball, and 1/4-in. at the toe. The inlay is fabricated of cork covered by kid leather with 1/8-in. thickness of Impresol sandwiched between the superior covering of leather and the cork. Both of these are technically "depth" shoes. For purposes of simplification, these shoes are referred to by their commercial names whenever it is convenient to do so; otherwise they are referred to as the depth shoe with thin inlay (Wilbur Coon), or the depth shoe with thick inlay (Ortho-Inlay).

SHOE CLASP ORTHOSIS (Fig. 1)

Modification: The shoe must have a stiff ("hard") counter (*1*). This combination of shoe

[1]The authors are all permanent members of the Veterans Administration Prosthetics Center Special Clinic Team. The team has been designated as "Special" since its primary function is to evaluate and prescribe for problem cases referred from elsewhere in the Veterans Administration. Other specialist members, such as clinical engineers, are called upon as needed.

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[6]Other than the KO's which do not extend to the shoe. The subject of FO's has been adequately covered elsewhere(1). Although varying somewhat in design and material used, FO's are basically arch supports. An exception is the long steel spring and rocker bar used for hallux rigidus which should be technically classified as an FO.

[7]Available from P. W. Minor and Son, Inc., Batavia, NY 14024.

[8]Available from Scholl, Inc., 213 W. Schiller St., Chicago, Ill. 60610.

Fig. 1. VAPC shoe clasp ankle-foot orthosis.

and the rest of the orthosis exemplifies the importance of the shoe as a component of the orthosis. It is not simply an extension of the shoe clasp device, but an essential part of it. A well constructed Blucher-type shoe with leather sole, strong shank, stiff ("hard") counter, and rubber heel should be employed. Under ordinary circumstances, in the absence of the need for a special last, a stock shoe will be adequate if it includes these characteristics.

Reason for Modification: The area of attachment of the shoe clasp to the counter is subject to continuous pressure. A flexible ("soft") counter will break down, become readily deformed, produce irritation of the posterior heel, and even cause blisters. It may occasionally be necessary to use a shoe which is one-half size larger than the shoe usually worn to provide adequate freedom from the possibility of posterior heel pressure. It is our custom to use the Wilbur Coon shoe and retain the inlay under these circumstances.

TEUFEL ORTHOLENE AFO

Modification: The material of the Teufel Ortholene AFO (Fig. 2) is thick, and when fitted unilaterally to ordinary commercial shoes can cause a cosmetic problem, since two significantly different shoe sizes are required. At the VAPC, we solve that problem by using the Ortho-Inlay shoe fabricated with a removable cork inlay (Fig. 3).

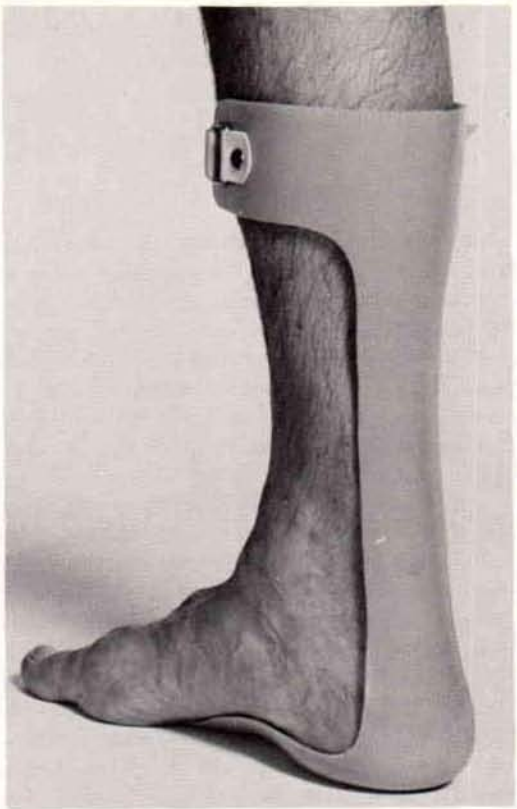

Fig. 2. Teufel Ortholene ankle-foot orthosis.

Fig. 3. The Ortho-Inlay shoe with a removable cork inlay.

Reason for Modification: This arrangement enables the orthotist to remove the inlay on the involved side only and replace it with the orthosis. As indicated earlier, the removable cork inlay of the Ortho-Inlay shoe is 5/8-in. thick at the heel, 3/8-in. thick at the ball and 1/4-in. thick at the toe.

POLYPROPYLENE AFO WHEN FABRICATED AS A POSTERIOR LEAF SPRING ORTHOSIS

Modification: At the VAPC we use a depth shoe, the Wilbur Coon, and remove the relatively thin innersole (3/16-in.) on the involved side (Fig. 4).

Reason for Modification: This arrangement permits a cosmetic fit (Fig. 5), since the space occupied by the 1/8-in. thick polypropylene is an adequate replacement for the innersole. When the patient has plantar foot problems requiring a modified innersole, the Ortho-Inlay shoe is used, and the innersole is placed over the plantar segment of the polypropylene orthosis. Plastazote may also be used to replace the inlay in this shoe. If necessary, a special shoe may be constructed to accommodate for special pathological conditions (Fig. 6). As indicated above and illustrated by Figure 5, the shoe corrections employed for a KAFO will not differ from those used for an AFO under similar circumstances.

POLYPROPYLENE AFO WHEN FABRICATED AS A SOLID ANKLE ORTHOSIS

Modification: The shoes should be modified so as to include a SACH type heel (Fig. 7), long steel spring (Fig. 8), and rocker bar (Fig. 9).

Fig. 4. The depth (Wilbur Coon) shoe with a thin insert.

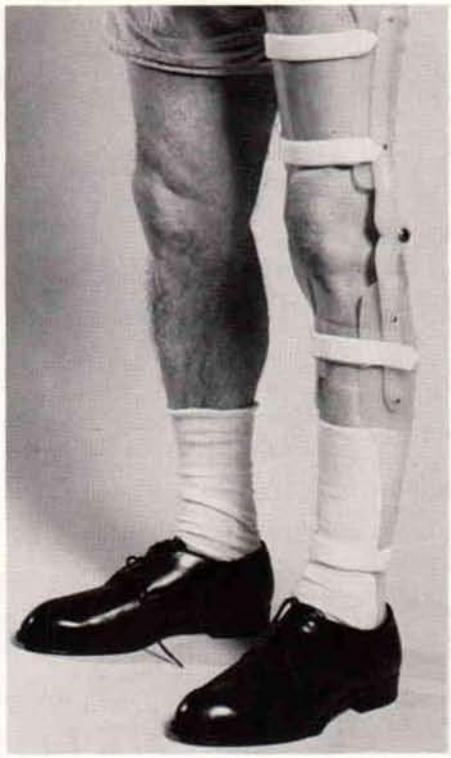

Fig. 5. Knee-ankle-foot orthosis molded of polypropylene over a positive model of the patient's limb. Because the polypropylene is quite thin the depth shoe shown in Figure 4 is used. Removal of the thin insert compensates for the thickness of the polypropylene in the foot section.

Fig. 6. A special insert and shoe designed to meet the needs of a special pathological condition.

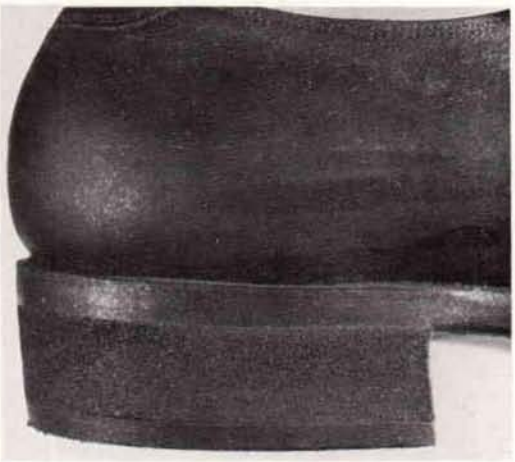

Fig. 7. "SACH-Type" cushion heel.

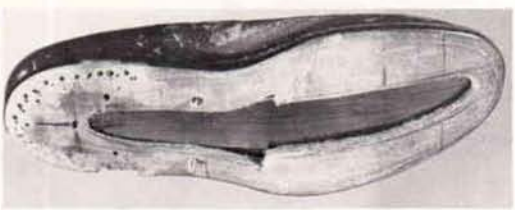

Fig. 8. Cut-away view of shoe showing addition of a longitudinal steel spring to provide additional strength and to provide some push-off.

Fig. 9. Rocker bar added to sole of shoe to permit roll-over and thereby make walking easier.

Reason for Modification: Because ankle motion is absent, the SACH heel is needed to permit a limited but relative equinus on heel strike; the rocker bar aids roll-over; and, because the limited ankle motion interferes with push-off, the long steel spring is introduced to assist that function and prevent deformation of the shoe at the distal border of the shank.

FUNCTIONAL ELECTRICAL STIMULATION (FES)

No shoe modification is required unless plantar foot problems necessitate a modified inlay, and then the Ortho-Inlay shoe is used with corrections included. The special very thin (switch) inlay of the FES may be placed on the inlay of the Ortho-Inlay shoe if necessary (Figs. 10 and 11).

Fig. 10. A functional electrical stimulator for correction of a drop-foot condition. Shoe modification is seldom required to accomodate this modern system.

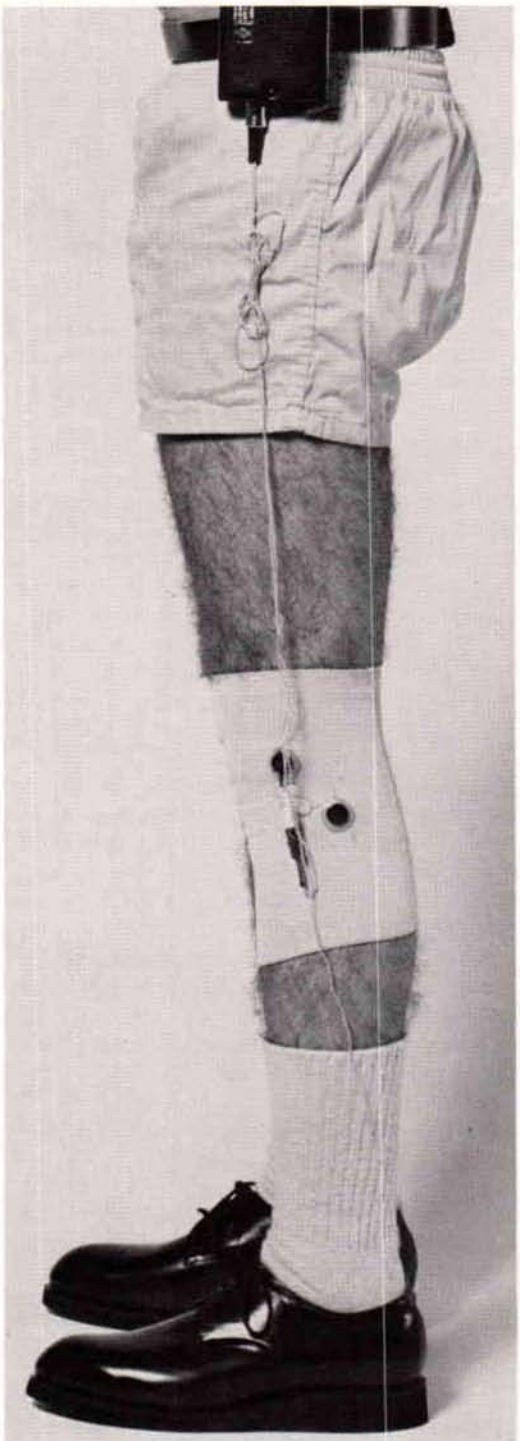

Fig. 11. Another view of the functional electrical stimulation system shown in Figure 10. The control unit and battery are carried on a waist belt.

VAPC PTB ORTHOSIS

The PTB orthosis (Fig. 12), as advocated by the designers, should be fabricated to permit no or very limited ankle motion to provide a high degree of unweighting. If, for example, the pathology has produced ankle pain on motion, a solid ankle should be used. If the pathology is at a higher level, then limited motion may be employed to lessen component stress. Some of the stresses will be dissipated by the limited motion, minimizing breakage. The forces transmitted from the floor to the cuff are greater with limited or absent motion (*2*).

Modification: The shoe should include a SACH heel, rocker bar, and long steel spring.

Reason for Modification: As previously indicated, with absent or limited ankle motion, substitution for plantarflexion is obtained by the use of a SACH-type heel. The rocker bar aids roll-over and the long steel spring assists push-off and prevents breakdown of the shoe at the distal section.

Fig. 12. The VAPC Patellar-Tendon-Bearing orthosis.

SINGLE- OR DOUBLE-BAR ORTHOSES WITH FREE MOTION ANKLE AND ALSO DORSIFLEXION ASSIST ORTHOSES

Modification: The only modification required for the conventional single- or double-bar orthosis is the attachment of a shoe stirrup (Figs. 13 and 14). The shoe should be a well constructed Blucher-type shoe with a leather sole, a rubber heel, and a strong shank.

Reason for Modification: This attachment makes the shoe a part of the orthosis. The strong shank is necessary because of the stresses placed on this area with the attachment of a shoe stirrup. The Blucher shoe permits easier entry of the foot and also more efficient adjustability of the vamp closure.

SINGLE- OR DOUBLE-BAR ORTHOSES WITH LIMITED OR ABSENT MOTION ("SOLID") ANKLE

Modification: SACH-type heel, rocker bar, and long steel spring are required.

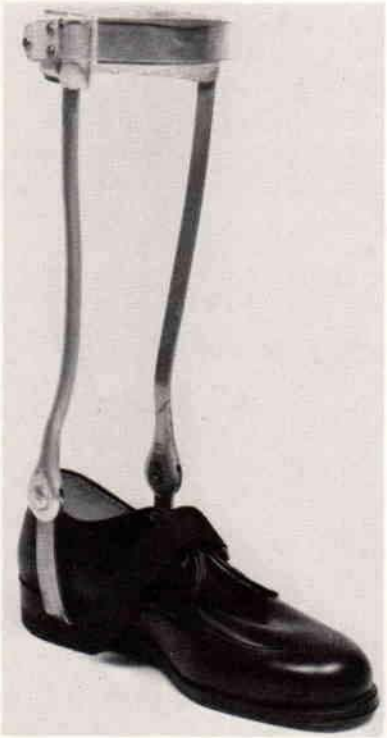

Fig. 13. Conventional double-bar ankle-foot orthosis.

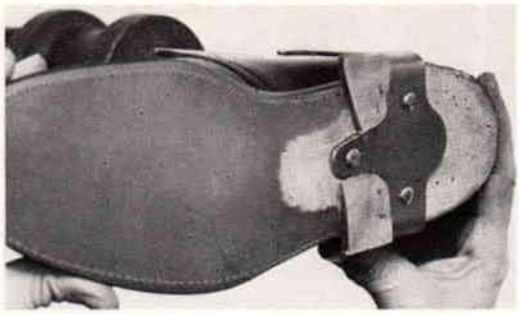

Fig. 14. View showing some details of installation of the stirrup necessary for proper function of the conventional double-bar ankle-foot orthosis (Fig. 13).

Reason for Modification: To reiterate: the SACH-type heel provides a substitute for plantarflexion, the rocker bar aids roll-over, and the long steel spring assists push-off and prevents breakdown of the distal portion of the shoe.

SINGLE- OR DOUBLE-BAR ORTHOSES WITH ANKLE JOINT WITH 90 DEG. PLANTARFLEXION STOP

Modification: This orthosis will usually be prescribed for patients with spasticity who do not have a normal stride. When a 90 deg. stop is prescribed for the patient who does have a nearly normal heel-and-toe gait, a SACH heel should be employed.

Reason for Modification: The SACH-type heel allows for limited relative plantarflexion of the shoe in relation to the floor. By eliminating this motion at the ankle the tendency toward triggering the spasticity is decreased.

SINGLE- OR DOUBLE-BAR ORTHOSES WITH DORSIFLEXION STOP

Modification: Rocker bar and long steel spring are required.

Reason for Modification: The rocker bar aids roll-over and the long steel spring assists push-off.

KNEE STABILIZING ANKLE-FOOT ORTHOSIS (Fig. 15) (*3*)

Modification: The shoe should be a depth shoe with inlay removed, and it should be modified to include a rocker bar and long steel spring (Fig. 15).

Reason for Modification: The rocker bar aids roll-over, and the long steel spring produces a long lever to aid knee extension.

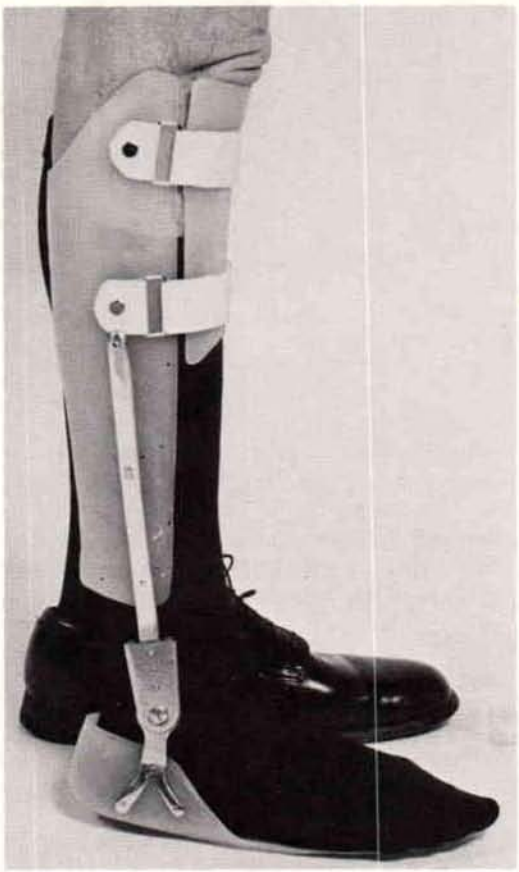

Fig. 15. A knee-stabilizing ankle-foot-orthosis developed at the Veterans Administration Prosthetics Center (*3*).

THE EQUINO-VARUS CORRECTION ANKLE-FOOT ORTHOSIS (DORSIFLEXION ASSIST PLUS SPRING-LOADED VARUS CORRECTION)

Modification: A posterior flat-caliper box (Fig. 16) should be used in the heel of a Blucher shoe. A removable transfixion pin placed through the caliper box from the upper aspect of the heel will hold the orthosis fixed. The heel should incorporate an outflare.

Reason for Modification: The caliper box with transfixion pin will prevent slippage and the outflare heel will act in conjunction with the spring-loaded varus control to correct a flexible varus deformation.

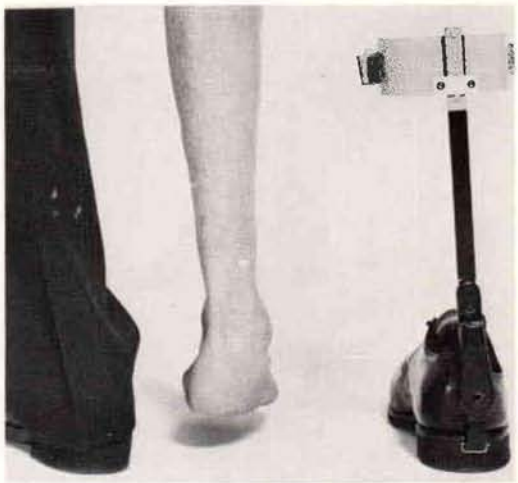

Fig. 16. The equino-varus correction ankle-foot-orthosis.

POLYPROPYLENE SHOE INSERT ORTHOSIS FOR SPASTIC FOOT (Figs. 17 and 18)

Modification: A special shoe with a vamp and tongue which can be laid back to expose the entire innersole is now available commercially.

Reason for Modification: It should be noted that the ability to lay open the entire upper of the shoe permits the patient to grasp the orthosis in one hand and place his foot into the orthosis and the shoe as a unit without making the effort of forcing his toes through the smaller opening of the throat of the shoe. This avoids the stimulus which will frequently result in increased spasticity and clawing of the toes. When spastic toe clawing occurs, entry of the foot into the shoe is made difficult. Because Velcro is used on both the shoe and the orthosis, closure can be carried out easily by use of the uninvolved hand. This type of shoe has been custom made by the VAPC Shoe Laboratory in the past, but they are now available from P. W. Minor[7].

The polypropylene shoe insert orthosis can be separated readily from the shoe (Fig. 19), thus enabling the patient to change shoes as desired. The orthosis is held firmly in the shoe by Velcro.

Fig. 17. A special shoe available and recommended for use with a molded polypropylene ankle-foot orthosis designed especially for patients with a spastic foot.

Fig. 18. Spastic foot being placed in the orthotic system consisting of a molded polypropylene ankle-foot orthosis and a shoe with a special tongue.

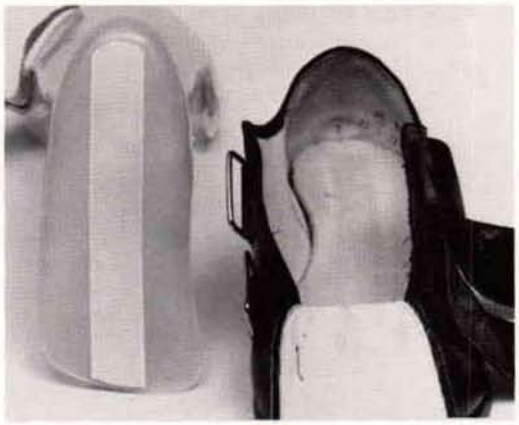

Fig. 19. The use of Velcro to stabilize the molded ankle-foot orthosis in the shoe.

Velfoam padding is glued to the innersole of the shoe and loop fabric Velcro is laminated to the Velfoam. Hook fabric Velcro is glued to the undersurface of the orthosis so that, when mated, these firmly attach the orthotic device to the innersole of the shoe, and yet permit removal as with any Velcro arrangement.

DOUBLE OR SINGLE BAR ORTHOSIS FOR SPASTIC FOOT

Modification: A shoe stirrup can be attached to the special Flap-Open shoe shown in Figures 17 and 18.

Reason for Modification: This patient can be independent, apply his shoe and orthosis without assistance and avoid the difficulties encountered when he attempts to push a spastic foot into a commercial shoe. Entry into the shoe-orthosis unit may be assisted by the use of a posterior opening calf cuff if this is necessary.

HIGH TOP SHOE WITH REINFORCING VERTICAL METAL STRUTS (Fig. 20)

Modification: Vertical reinforcing struts are incorporated into the medial or lateral aspects of the quarter of the shoe extending from the heel level to the top of the high quarter.

Reason for Modification: Occasionally a patient with a drop-foot deformity may have extensive scarring and tenderness at the level of the calf to such a degree that he cannot tolerate the pressure of a calf cuff. The orthotic system shown

Fig. 20. High-top shoe with reinforcing vertical metal struts.

here offers a solution to this problem. Although not as efficient as the usually prescribed dorsiflexion assist AFO, it is the most useful under the circumstances. This system may also be used where there are similar calf problems in the case of the patient who has ankle instability owing to lax or torn lateral ligaments.

DISCUSSION

Although the AFO total orthotic system has been the principle subject of this review, the HKAFO and KAFO total orthotic systems have similar features and should be considered in parallel fashion since they have the same type of shoe attachment as do the AFO's. This is true not only of such devices as the shoe insert orthosis (Fig. 5) and the double bar orthosis (Fig. 13), but also of the shoe clasp with polypropylene knee cage (Fig. 21).

Certain aspects of the shoe modifications will be determined by the patient's gait. A patient, for example, who has had a solid ankle orthosis prescribed, but does not have a heel-and-toe gait will not benefit from a SACH-type heel, rocker bar, and long steel spring. A basic outline of the VAPC approach to shoe prescriptions are related to AFO's is summarized in Table 1. When coupled with Table 2 (*4*), a more complete picture of the VAPC Clinic Team procedures is obtained. It should be emphasized, as pointed out initially, that each patient has an individual problem, and the chart can only present a basic approach to the solution of the problem. This may have to be varied when the requirements for the solution of the problem point to the necessity for such variations.

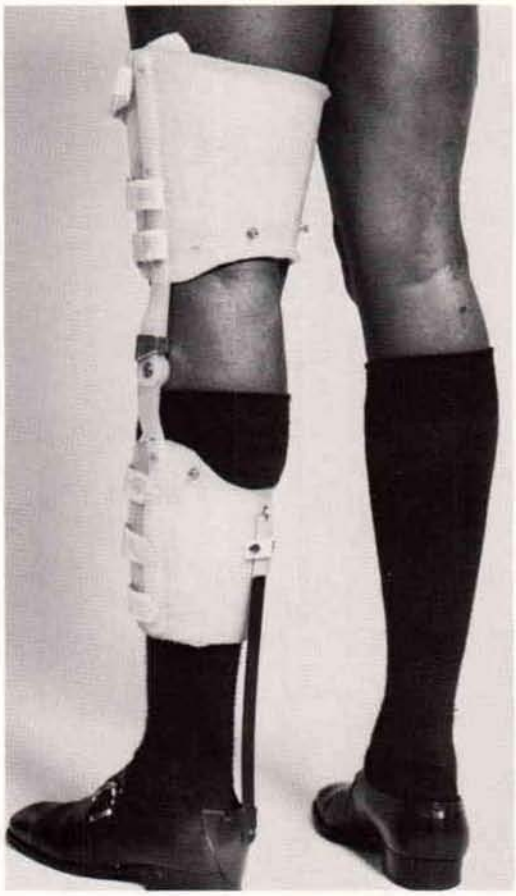

Fig. 21. The shoe clasp can be used to maintain a knee orthosis in proper position.

The authors wish to reiterate that this presentation is based on VAPC Clinic Team procedures, and for this reason ankle-foot orthoses in use elsewhere have not been included. There are many such orthoses that have been used only on occasion at our clinic. They fit into the broad grouping of either shoe insert or shoe attachment orthoses. Examples of these are the IRM Spiral AFO, the NYU Double Bar Shoe Insert AFO, the AMBRL Two-Rod Drop-Foot Brace and the AMBRL Posterior Bar Drop-Foot Brace (*5*).

The simple and effective wire drop-foot orthosis is still sometimes prescribed, invariably as a renewal of a similar orthosis for an older wearer who resists change.

TABLE I. LOWER LIMB SYSTEM

THE ANKLE-LEG COMPONENT		THE FOOT COMPONENT*
Type	AFO Designation	Shoe Modifications
Dorsiflexion Assist AFO	1- Shoe Clasp →	1- Hard counter; Blucher shoe*
	2- Polypropylene Posterior Leaf Spring →	2- Depth shoe** with thin inlay
	3- Ortholene Posterior Leaf Spring →	3- Depth shoe** with thick inlay
	4- Conventional →	4- Solid stirrup or caliper stirrup footplate and a very strong shank; Blucher shoe*
Dorsiflexion Assist plus spring-loaded varus control	Posterior Leaf Spring Orthosis with spring-loaded varus correction →	Posterior caliper stirrup footplate with Blucher shoe* and outflare heel
AFO with plantarflexion stop***	1- Polypropylene →	1- Depth shoe with thin inlay
	2- Conventional Double Bar →	2- Solid stirrup or caliper stirrup footplate; strong shank; Blucher shoe*
	3- Single Bar →	3- Solid stirrup or caliper stirrup footplate; strong shank; Blucher shoe*
AFO with dorsiflexion stop	Conventional Double Bar →	Solid stirrup or caliper stirrup footplate; rocker bar; long steel spring; Blucher shoe**
AFO with limited motion ankle	1- Conventional Double Bar →	1- Solid stirrup or caliper stirrup footplate, SACH heel; rocker bar long steel spring; Blucher shoe*
	2- PTB Orthosis →	2- Solid stirrup; SACH heel; rocker bar; long steel spring; Blucher shoe*

TABLE 1. (Continued)

AFO with absent motion ankle (solid ankle)	1- Conventional Double Bar →	1- Solid stirrup or caliper stirrup footplate, SACH heel; rocker bar; long steel spring; Blucher shoe*
	2- Solid Ankle Polypropylene →	2- Depth shoe with thick inlay (1/4" polypropylene used); SACH heel; rocker bar; long steel spring
	3- PTB Orthosis →	3- Solid stirrup; SACH heel; rocker bar; long steel spring; Blucher shoe*
AFO with dorsiflexion stop and adjustable equinus position	Knee Stabilizing AFO →	Depth shoe with thick inlay; rocker bar; long steel spring
Shoe-Orthosis with flap-open vamp for spastic foot	1- Shoe clasp (mild spasticity) →	1- Hard counter shoe with flap-open vamp; velcro closure
	2- Conventional Double Bar →	2- Stirrup or caliper stirrup footplate attachment; special shoe with flap-open vamp and velcro closure
	3- Single Bar →	3- As above
	4- Polypropylene Shoe Insert →	4- Depth shoe with either thin or thick inlay and with velcro closure
Shoe-orthosis for sensitive calf	Shoe-Strut AFO →	High top shoe incorporating vertical metal struts (See text)

* The preferred basic shoe should be the Blucher type with leather sole and rubber heel. If special needs are dictated by foot pathology, then indicated modifications should be made. FES does not require special shoe modifications. When depth shoes are prescribed for shoe insert orthoses, the inlay is removed on the side of the orthosis to provide room for insertion of the foot segment of the device. 1/8" thickness of polypropylene can be satisfactorily inserted into a Wilbur Coon shoe, and 1/4" thickness should be inserted into an Ortho Inlay shoe.

** The depth shoes should also be of the Blucher type, unless specifically indicated, as in the case of the shoes with flap-open vamp. The depth shoe with thin inlay is used for a 1/8" polypropylene shoe insert orthosis and the depth shoe with thick inlay for 1/4" polypropylene shoe insert orthosis.

*** If patients in this category demonstrate a heel and toe gait with near normal stride length, then a SACH heel should be added.

TABLE 2. LOWER LIMB SYSTEM

PRESCRIPTION PROCEDURES FOR AFO's

	ETIOLOGY	PATHOLOGY	MODIFYING FACTORS	DESIRED CONTROL	PRESCRIPTION
1	LOWER MOTOR NEURON DEFECT (PERONEAL N.)	FLACCID PES EQUINUS	STABLE*	Assist dorsiflexion of foot at ankle	SHOE CLASP (VAPC) AFO
			UNSTABLE* — MILD	Assist dorsiflexion and resist varus-valgus	POLYETHYLENE (TEUFEL)
			UNSTABLE* — MOD	Assist dorsiflexion and resist varus-valgus	POLYPROPYLENE
2	LOWER MOTOR NEURON DEFECT (SCIATIC N.)	FLACCID PES EQUINUS (WITH CALF MUSCLE CONTRACTURE**)	STABLE*	Assist dorsiflexion of foot at ankle	SHOE CLASP
			UNSTABLE* — MILD	Assist dorsiflexion and resist varus-valgus	POLYETHYLENE
			UNSTABLE* — MOD	Assist dorsiflexion and resist varus-valgus	POLYPROPYLENE
		FLACCID PES EQUINO-CALCANEUS (WITHOUT CALF MUSCLE CONTRACTURE)	STABILITY NOT A FACTOR SINCE CHOICE IS LIMITED TO STABLE ORTHOSES	Resist dorsiflexion and resist plantar flexion	SPIRAL ORTHOSIS (IRM). BUT IF BILATERAL INVOLVEMENT. THEN POLYETHELENE OR POLYPROPYLENE FABRICATED TO RESIST DORSIFLEXION AND PLANTAR-FLEXION
3	UPPER MOTOR NEURON DEFECT	SPASTIC PES EQUINUS	MILD***	Assist dorsiflexion	SHOE CLASP FES
			MOD***	Assist dorsiflexion and resist plantar flexion	POLYETHYLENE. IF NOT ADEQUATE.
			MOD***	Assist dorsiflexion and stop plantar flexion	THEN - POLYPROPYLENE
			SEVERE***	Stop dorsiflexion and plantar flexion	POLYPROPYLENE - IF NOT ADEQUATE. THEN -
			SEVERE***	(If foot deforms in brace)	DOUBLE BAR (SHOE ATTACHMENT) AFO
4	ANY OF THE ABOVE	ANY OF THE ABOVE	EDEMA OF FOOT-ANKLE AND OR IMPAIRED SENSATION**** AND OR VARUS OR VALGUS (REQUIRING T-STRAP)	Any of the above controls PLUS — Allow limited subtalar motion	SINGLE BAR (ROTATION) ORTHOSIS (VAPC) FOR FLACCID OR SINGLE BAR (NO ROTATION) FOR SPASTIC
				Any of the above controls PLUS — Hold subtalar motion	OR DOUBLE BAR AFO IF SUBJECT IS OVERWEIGHT OR VERY ACTIVE
5	PAINFUL DESTRUCTIVE DISEASE OF ANKLE	ARTHRITIS (POST-TRAUMATIC, INFECTIOUS, INFLAMMATORY, ETC.)	PAIN ON AP OR ML STRESS BUT NO PAIN ON WEIGHT-BEARING	Stop plantar-flexion, dorsiflexion, varus and valgus	POLYPROPYLENE ORTHOSIS MODIFIED TO RESTRICT DORSI-FLEXION AND PLANTAR FLEXION
6	a) STRUCTURAL IN-ADEQUACY DISTAL TO THE KNEE	a) NON-UNION OR DELAYED UNION OF TIBIA, CHARCOT'S DISEASE OF ANKLE/FOOT, ETC.	TISSUE BENEATH THE CUFF AREA MUST BE CAPABLE OF TOLER-ATING THE PRESSURES OF PARTIAL UNWEIGHTING. FOR EXAMPLE, SENSATION MUST BE INTACT	Partially unweight the leg, ankle, or foot	PTB WEIGHT-BEARING AFO
	b) PAIN DISTAL TO KNEE ON WEIGHT BEARING	b) DESTRUCTIVE DISEASE OF ANKLE, ETC.			

*Stability is: a. evaluated during trial of a stock brace (VAPC shoe clasp, Teufel, Polypropylene) on the patient by the Clinic Team, or, b. can be assumed by the nature of the terrain the subject may walk upon (fields, golf courses, etc.).

**Many patients with sciatic nerve injuries develop calf contractures sufficient to stabilize the ankle at about 90°, in the weight bearing position. These patients need only a correction for the flaccid pes equinus.

***During the clinic team evaluation of orthoses, the degree of spasticity is related to the "triggering" of spastic equinus (or equino-varus) by the stock braces tested directly on the patient as part of the evaluation procedure. For example, if the stock shoe clasp triggers the foot into spastic equinus, one must try the stock Teufel, or finally, the stock Polypropylene. If the foot deforms within the Polypropylene, external (shoe) attachment bracing is required. Very severe spasticity cannot be controlled by a brace.

****Most such patients will tolerate a properly fitted shoe insert brace, or a shoe clasp. Those who develop areas of irritation should be changed to external bracing with individualized shoe modifications, if indicated.

SUMMARY

The authors have outlined the shoe modifications customarily employed for the various lower-limb orthoses most frequently used in their facility. The shoe and the orthosis cannot be considered as casually related. The shoe modifications required for each orthosis are dependent upon the characteristics of the orthosis employed, the pathology to be treated, the condition of the local tissues and foot, the individual patient's gait pattern, and the response of the patient himself.

A basic approach to prescription of a total orthotic system for the lower limb has been presented, but each patient is an individual and the basic approach may have to be varied at times to solve unusual individual problems. That is the reason for the existence of the Clinic Team.

ACKNOWLEDGEMENT

The authors wish to extend their appreciation to Mr. Robert Towner, Clinic Team Coordinator, for his valuable assistance.

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Orthotics and Prosthetics, Vol. 30, No. 2, pp. 27–28, June 1976

THE OHC KNEE-DISARTICULATION PROSTHESIS

Erik Lyquist[1]

Because the length and bulging shape of the distal part of the stump of the knee-disarticulation case have made it difficult to provide a functional prosthesis that is reliable and cosmetically acceptable, surgeons have been discouraged for carrying out disarticulation at the knee.

However, amputation by disarticulation at the knee results in a stump with many obvious advantages over amputation at a higher level:

1. The stump is end-bearing, i.e. the major part of body weight can be transmitted through the distal stump surface.
2. The long stump makes possible effective medio-lateral stability in the socket at minimum unit pressure.
3. The stump musculature is well preserved and the extension moment produced in the hip joint will, under normal conditions, be sufficient to secure stability of a prosthetic knee in the stance phase of walking.
4. The bulgy distal part of the stump may be used for suspension of the prosthesis. It also provides good resistance to rotation about the long axis of the thigh.
5. Proprioception is probably better than when the amputation is at a higher level.

While knee mechanisms with built-in friction brakes (extension stabilizing) are not required in the majority of cases, swing-phase control is desirable because of the possibilities of the high and varying walking speeds that are normally possible.

To make the most of the advantages and at the same time reduce or eliminate the disadvantages, the Prosthetics-Orthotics Research Department of the Orthopaedic Hospital in Copenhagen has developed a polycentric knee unit of the four-bar-linkage type with a built-in hydraulic swing control unit (Figs. 1–3).

The knee unit has been designated the OHC

Fig. 1. The OHC knee-disarticulation prosthesis in extended position but without cosmetic cover. Note the polycentric hinge arrangement that makes it possible to place all mechanisms distal to the end of the stump and at the same time allow for installation of a fluid-type swing-phase control unit. The piston rod can be seen between the two vertical links of the four-bar polycentric system.

[1]The Orthopadeic Hospital, 3 Hans Knudsins Plads, 2100 Copenhagen Ø, Denmark.

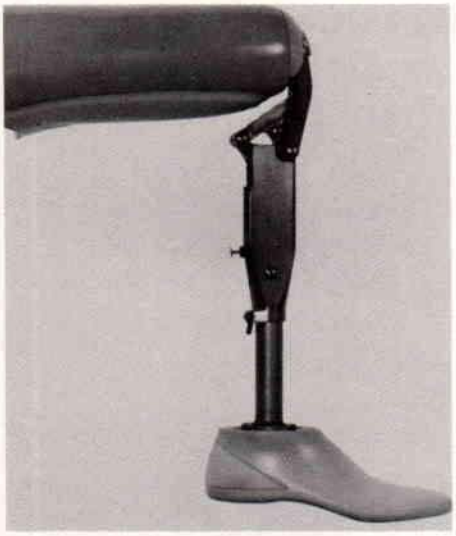

Fig. 2. The OHC knee-disarticulation prosthesis in flexion. Flexion is limited to about 100 deg. but this seldom presents a problem to most lower-limb amputees.

UNIT which, of course, is an abbreviation for the Orthopaedic Hospital, Copenhagen.

Use of a polycentric knee unit has made it possible to locate the knee mechanism immediately below the socket and thus obtain cosmetic advantages acceptable even to young female amputees. This arrangement also permits incorporation of a fluid-control type of swing-phase control. The OHC unit can also be used on above-knee amputees.

Knee flexion is limited to about 100 deg. but this seldom presents a problem to most lower-limb amputees.

The OHC unit is available commercially and the manufacturer[2] furnishes a comprehensive manual covering application and use of the device.

[2]United States Manufacturing Company, 623 South Central Avenue, Glendale, California 91209.

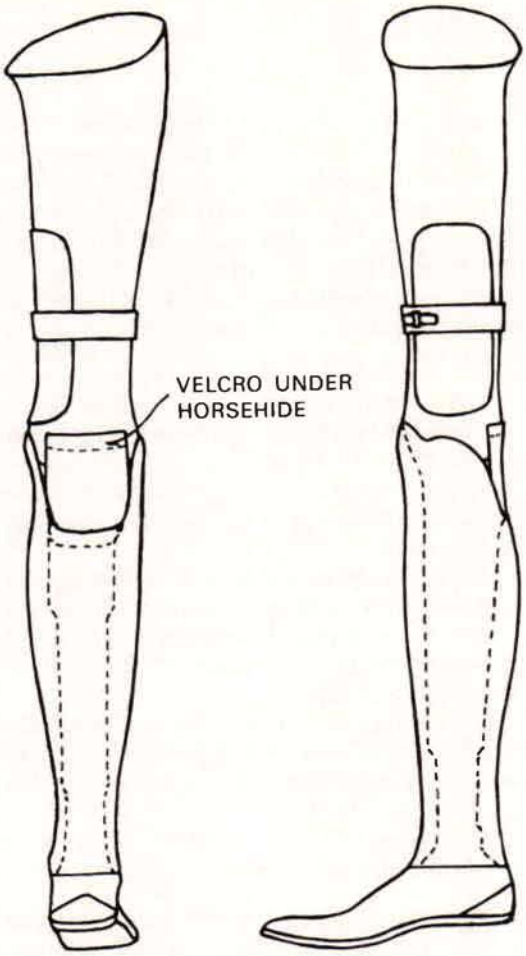

Fig. 3. Line drawing showing the OHC knee-disarticulation prosthesis with cosmetic cover in place.

Orthotics and Prosthetics, Vol. 30, No. 2, pp. 29, June 1976

SOME CLINICAL EXPERIENCE WITH THE O.H.C. KNEE-DISARTICULATION PROSTHESIS

Bert Goralnik, C.P.[1]

The O.H.C. Knee-Disarticulation Prosthesis is being used routinely at the Veterans Administration Prosthetics Center. A brief report of experiences with six cases is given here.

Patient #1—This patient is a 57-year-old male, right above-knee amputee. The patient's residual limb is 12 in. long, and the cause of amputation was an automobile accident. The patient is not active, but enjoys working in his garden. After switching from a conventional knee-bearing prosthesis, the patient as well as the clinic team feels that his gait is much smoother with the O.H.C. unit. Furthermore, his major criteria of ample stability has been met.

Patient #2—This patient is a 48-year-old male, left, above-knee amputee. His residual limb is 11 in. long. The patient is moderately active, particularly in his home, (painting, masonry, etc.). In the past, the patient has not been pleased with the Henschke-Mauch SNS unit, because he feels that it offers too much resistance during the swing phase of walking. After wearing the O.H.C. unit for approximately nine months, the patient is very pleased overall with his gait.

Patient #3—This patient is a 42-year-old male, bilateral, above-knee amputee. The left side has been fitted with the O.H.C. knee-disarticulation prosthesis, due to the length of the residual limb (11 1/4 in.). The patient is overweight, his level of activity is minimal, and he has always had problems because of scar tissue in the distal part of the stump. The patient complained that he had trouble "breaking" the O.H.C. knee unit when he attempted to sit. He also felt that his gait was not smooth. Overall, the patient was not satisfied with the O.H.C., and reverted to the prosthesis with the Dupaco unit, a system that features a yoke that is fixed to each outside knee joint in order to make the swing phase unit useful.

Patient #4—This patient is a 31-year-old male, right, above-knee amputee. The cause of amputation was vascular insufficiency. The patient is very active and previously had had more than fifteen malfunctions with the Dupaco yoke system. His major activities include fishing and gardening. After eleven months of wearing the O.H.C. unit, the patient is very satisfied. He feels that his gait is quite smooth, and has had no need for repairs or adjustments.

Patient #5—This patient is a 29-year-old male, with a transcondylar amputation of the left femur. The patient has always had a problem of irritation in the distal part of the stump. The patient plays basketball daily, and therefore his level of activity is obvious. In the past, the patient has had numerous mechanical problems with the SNS hydraulic system. After wearing the O.H.C. for a period of sixteen months, the patient has not had a breakdown. His gait is smooth, and he is very satisfied.

Patient #6—This patient is a 44-year-old, left, above-knee amputee, with residual limb of 11 1/2 in. In the past, the patient has always been a knee-bearing wearer. His case is unusual in the sense that the patella is retained anteriorly, but not attached. The patient is very active, his major hobby being golf. Although he has additional mobility, he does feel that the stability is not as evident with the O.H.C. Otherwise, the patient is quite satisfied with the prosthesis.

[1]Technical Assistant to the Director, Veterans Administration Prosthetics Center.

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ASSESSMENT OF AMPUTEE REHABILITATION USING A TEXT-GENERATING DATA PROCESSING SYSTEM

Peter H. Stern, M.D.

In 1974, The Burke Rehabilitation Center began a major effort to computerize its medical record system in an endeavor to simplify the ever increasing demands for documentation in health care. Previous experience with a terminal-oriented, time-sharing computer system called APL *(1)* convinced us of the practicality of using computer-generated English-text discharge summaries for major disease categories that can be described in a relatively finite number of variables. In a previous publication *(2)* the procedures required for stroke rehabilitation discharge summaries were described.

This paper is concerned with discharge summaries for lower-limb amputees that were referred to the Burke Rehabilitation Center during the period between 1/1/74 and 9/20/75 and with the concurrent establishment and analysis of a data base accumulated during this period.

METHOD

The computer system, APL (A Programming Language), consists of a terminal connected by telephone equipment to a remotely located central IBM-370 computer (Fig. 1). It is a time sharing system; that is, many terminals are connected simultaneously. A new general purpose program, APG (A Program Generator), is added for our purposes. The APL/APG system is highly interactive, user oriented, and does not require any special knowledge in computer sciences or mathematics. At the Burke Rehabilitation Center medical, nursing, and clerical personnel are able to operate the terminals with very little instruction.

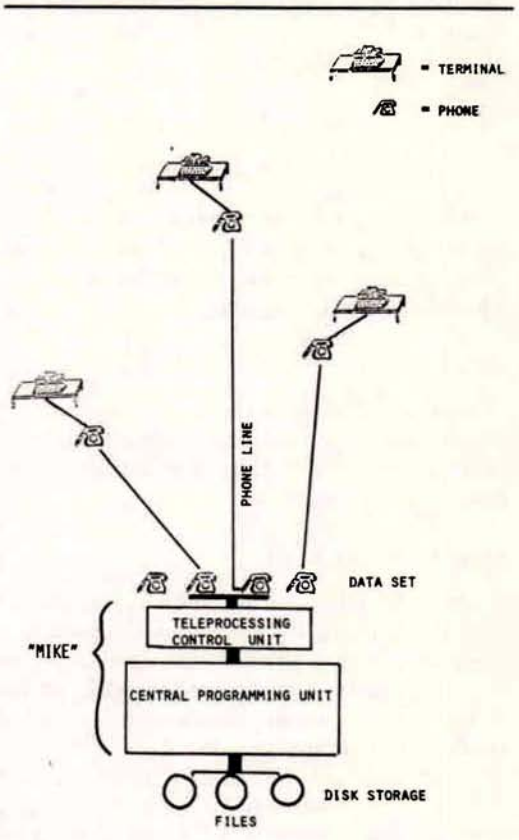

Fig. 1. Schematic of the text generating data processing system. MIKE is the name assigned to the program reported here.

Preprogramming

The user, in this case the physician in charge of the Amputee Service, constructs a questionnaire type discharge summary work sheet as shown in Appendix A. The encircled numbers are used to generate the English text discharge summary. The programmer is provided with a sample prose; upper and lower bounds for queries such as laboratory values for the inclusion of validity checks, and a general idea of the data that might be subject to calculations, correlations, or tabulations.

Operation

In order to generate a discharge summary the attending physician simply encircles the appropriate answers to the prepared series of queries and if necessary completes the free text provisions which are of fixed character length. The data is then entered by a terminal operator or the physician himself. It is retrieved either as an English text discharge summary (Fig. 2) or as part of a statistical report, the format of which are predetermined in the preprogramming and programming phases (Table 1).

RESULTS

During the period between January 1, 1974 and September 20, 1975, 127 amputee patients were discharged from the Burke Rehabilitation Center. The tabulated results follow.

Age, Sex

Equal sex distribution and an average of 65 years (range 17–90) shows that the elderly "vascular" amputee is the major public health problem in amputee rehabilitation.

Length of Stay (L.O.S.)

The mean L.O.S. of the entire group was 45 days (median 39). If bilateral and asymmetrical amputees are separated out, the mean length of stay dropped to 35.8 days. The L.O.S. of the bilateral below-knee amputees was 56 days and of the asymmetrical amputees 96.4 days.

The median L.O.S. of 39 days on the Amputee Service of a rehabilitation hospital compares favorably with national P.S.R.O. standards. Our data was influenced by a long-term (284 days) stay of a bilateral traumatic amputee. The mode of 28 days signifies a trend towards shorter L.O.S.

Functional Outcome

The achievement scale of Russek *(3)* was selected to assess outcome. The results appear gratifying since 13 bilateral and 5 asymmetrical amputees are included. The majority (more than 90%) of the patients were discharged with a temporary prosthesis with a plaster-of-Paris socket (Figs. 3 & 4), applied almost immediately following admission. These devices are worn for an average of 6–8 weeks. It can be assumed that most patients will achieve a higher rating once supplied with the permanent device. Only about half of the bilateral below-knee amputees achieved a classification III rating. The rest remained Class IV. Of the asymmetrical amputees only two achieved Classification III.

Employment Status

The results, not encouraging, are attributable to the retirement age of most male patients and the presence of a variety of associated medical conditions which are listed in section II(*3*).

Level of Amputation

The classification recommended by the task force on standardization of prosthetic-orthotic terminology was used *(4)*. Over two-thirds of the patients had either short or standard length below-knee (B/K) amputations as opposed to above knee (A/K).

This signifies a laudable trend for surgeons to carry out B/K amputations in preference to A/K amputations, which only 15 years ago was the preferred operative site if popliteal pulses were absent. Knee disarticulation, thought to be a suitable alternative to long A/K or a very short B/K amputation, was encountered only once.

Description of Amputation

The slightly higher incidence of right versus left amputation is probably statistically insignificant. There were 11 bilateral B/K amputees, 5 asymmetrical, but only 2 bilateral A/K amputees. The admission of this category of patients is generally discouraged as successful prosthetic application is usually not possible for older persons.

Interval of Amputation to Walking

It takes about two months after amputation before patients can walk again with a prosthesis. The mode of 48 days indicates a trend towards a much shorter interval.

Reason for Amputation

As expected, diabetic arteriosclerosis obliterans (ASO) is the most frequently encountered reason

THE BURKE REHABILITATION HOSPITAL SUMMARY

[redacted]

43242

Admitted: 07/08/75 Discharged: 08/21/75
Length of stay: 44 days Date of amputation: 06/25/75 (LL)

PRIMARY DIAGNOSIS: Amputation left upper tibia secondary to vascular disease

ASSOCIATED CONDITIONS: heart disease, hypertension, and diabetes mellitus

COMPLICATION: stump injury, wound resutured

CONDITION ON DISCHARGE: improved

ABILITY TO USE LOWER LIMB PROSTHESIS: Class III Fair functional outcome; job modification required.

DISCHARGE NOTE:

1. Reason for entering hospital: This 66 year old black male was admitted for amputee rehabilitation because of a left upper tibia amputation secondary to vascular disease as a result of diabetic ASO. Associated with this was heart disease, hypertension, and diabetes mellitus.

2. Pertinent Past History: The amputation was performed on 06/25/75 for the lower left limb at NYH. Complications because of blood-loss anemia were encountered.

3. Pertinent Physical, X-ray and Lab Findings on Admission: BP was 150/100; PR was 80; temp. was 37.0 C.; weight was 63 Kg. General condition was fair. The lower left stump condition was bulbous, not healed, and edematous. The remaining limbs showed impaired circulation, and weakness. Sensory findings were: normal. Tests: HCT 37.0; WBC 6500.0; FBS 129.0; BUN 28.0; Creatinine 1.1; Uric acid 7.6; K+ 4.0. Chest X-ray was not done. ECG showed CAD.

4. Course in Hospital: This patient was on a program of amputee rehabilitation including preprosthetic activities, stump shaping, wound healing, functional training, and self-care training. A left B/K plaster of paris pylon was issued on 07/29/75. He first walked on 07/30/75. Lower left surgical treatment included stump care, and debridement. Medications: antihypertensives, diuretics, and analgesics. Complications because of stump injury, wound resutured were reported.

DISCHARGE DISPOSITION: home, and OPD
EMPLOYMENT STATUS: retired

DISCHARGE ORDERS:

1. Hydrodiuril 50mg QD
2. Phenobarb 15mg TID
3. Diet: 2000C diabetic

Physician: Peter H. Stern M.D.

RETURN TO OPD ON 09/04/75 AT NYH-K7
HOME CARE COORDINATOR: Mary Ellen Gibson, R.N. TELEPHONE: (212) 472-5907

Fig. 2. A typical English-text discharge summary provided by the APL/APG system.

TABLE I. BURKE REHABILITATION HOSPITAL
AMPUTEE REHABILITATION REPORT (LOWER LIMB)
DISCHARGES DURING THE PERIOD 01/01/74 THROUGH 09/20/75

	PATIENTS DISCHARGED (all diagnoses)				127
	Male				65
	Female				62
	AGE (127 patients):				
1.	Maximum				90
	Minimum				17
	Mean				65
	Median				67
	Mode				75
	LENGTH OF STAY (127 patients):				
2.	Maximum				284
	Minimum				6
	Mean				45
	Median				39
	Mode				28
	ABILITY TO USE LOWER LIMB PROSTHESIS				
3.	Class I	Excellent functional outcome; not handicapped			1
	Class II	Good functional outcome; some restriction			19
	Class III	Fair functional outcome; job modification required			52
	Class IV	Walking with assistance and for short distances only			38
	Class V	No significant improvement of mobility			11
	Class VI	Rejection of prosthesis			5
	EMPLOYMENT STATUS				
4.	Retired				71
	Full time, usual work				2
	Part time, usual work				9
	Job modification or retraining				10
	Unable to work				34
	LEVEL OF AMPUTATION		RIGHT	LEFT	TOTAL
5.	Pelvic, complete		2	0	2
	Hip, complete		1	0	1
	Thigh, upper		2	6	8
	Thigh, middle		23	13	36
	Thigh, lower		1	1	2
	Knee disarticulation		1	0	1
	Below knee, upper		13	12	25
	Below knee, middle		33	33	66
	Below knee, lower		1	0	1
	Foot, complete		2	1	3
	Foot, partial		0	0	0
	Other		0	0	0
	DESCRIPTION OF AMPUTATION				
6.	Right				61
	Left				48
	Bilateral, below the knee				11
	Bilateral, above the knee				2
	Assymetrical				5

TABLE I. (Continued)

	INTERVAL—AMPUTATION TO WALKING (114 patients):			
	Maximum			360
7.	Minimum			12
	Mean			69
	Median			49
	Mode			48
	REASON FOR AMPUTATION			
8.	TRAUMATIC			
	Industrial			1
	Traffic			2
	Gunshot			1
	Recreational			0
	Other			0
	VASCULAR			
	Diabetic ASO			71
	ASO			34
	TAO			2
	Thrombo-embolism			6
	Other			6
	CONGENITAL			
	All			0
	TUMOR			
	All			4
	PRECEDING SURGICAL PROCEDURES			
9.	Sympathectomy			20
	Embolectomy			13
	By-pass			30
	Previous amputation			27
	Other			0
	COMPLICATIONS AT ACUTE HOSPITAL			
10.	None			41
	Blood-loss anemia			47
	Pulmonary embolism			6
	Infection			30
	All			4
	Pneumonia			2
	Other			33
	STUMP CONDITION	RIGHT	LEFT	TOTAL
11.	Good	14	22	36
	Bulbous	27	20	47
	Not healed	33	21	54
	Edematous	42	28	70
	Infected	17	7	24
	Other	13	7	20
	ASSOCIATED CONDITIONS			
12.	None			10
	Dementia			27
	Parkinsonism			2

TABLE I. (Continued)

	Stroke	1
	Heart disease	65
	Hypertension	17
	Pulmonary disease	12
	Renal disease	9
	GI disease	10
	Diabetes mellitus	61
	GU disease	11
	Fractures	3
	Depression	12
	Eye disease	20
	Peripheral neuropathy	4
	Other	43
	INTERVAL—AMPUTATION TO ADMISSION (127 patients):	
13.	Maximum	306
	Minimum	<18
	Mean	58
	Median	38
	Mode	21

for amputation, followed by other vascular conditions.

Preceding Surgical Procedures

The data show a trend in surgery away from the once popular sympathectomies towards vascular surgical efforts such as by-pass procedures or embolectomies to restore failing circulation. Twenty-seven patients had previous amputations such as partial foot, conversions or amputations on the other side.

Complications at Acute Hospital

Reported complications which occurred at the referring hospital were frequent and ranged from mild (blood loss anemia) to pulmonary or myocardial infarctions. Only 41 patients had no complications. Wound infections occurred in 24 patients.

Stump Conditions

Only 36 patients had optimal stump conditions. Bulbous (47), not healed (54), edematous (70), or infected (24) stumps were noted. These significantly affected L.O.S. data.

Associated Conditions

This tabulation shows that practically all patients have one or more significant associated disorders, including 27 patients who had mild to moderate dementia.

Interval of Amputation to Admission

Mean and median values show that this interval is between 6–8 weeks with a trend towards a shorter interval (mode 21 days). Some of the reasons for delay in transfer to a rehabilitation hospital can be explained by the data presented in Sections 8, 9, 10, and 11.

DISCUSSION

The utilization of the described APG/APL application is not only time-saving and convenient for the physician, but has a direct, beneficial effect on health care delivery.

The patient's summary is available at the time of discharge and contains vital information concerning his medication schedule and appointment place and time for outpatient re-evaluation.

The interactive questionnaire type program

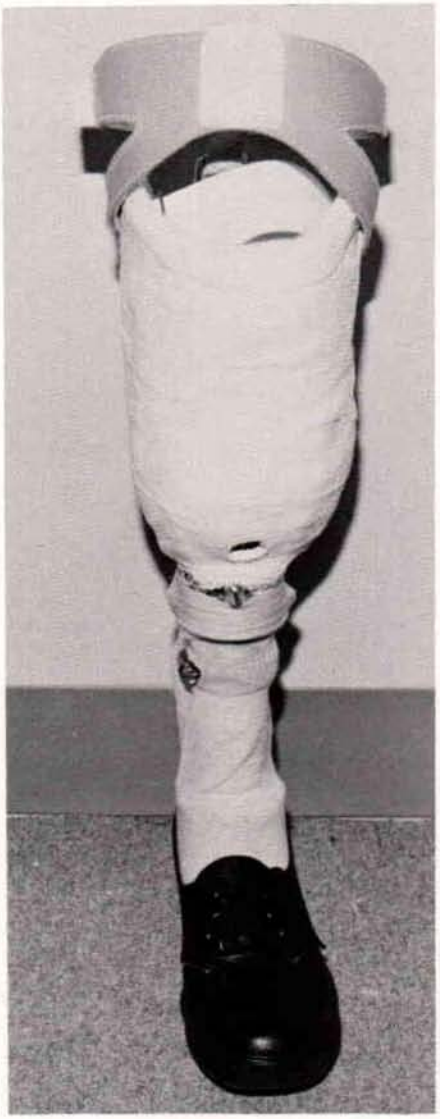

Fig. 3 A typical temporary prosthesis provided below-knee amputees. A Sach foot, an adjustable "pylon," and a plaster-of-Paris socket are used.

Fig. 4. A typical temporary prosthesis provided above-knee amputees. A Sach foot, an adjustable AK "pylon" with manual knee lock, and a plaster-of-Paris socket are used.

will remind the physician and allied health personnel of possible omissions in record keeping or care.

The periodic exploration of a cumulative data base allows not only the detection of trends but the constant monitoring of the amputee service activities for the purposes of quality control.

SUMMARY

This is a description of an APL/APG system oriented towards use by medical personnel essentially unskilled in computer sciences. An interactive questionnaire type input allows the generation of English-text summaries of patients

discharged from The Burke Rehabilitation Center. Variables contained in the summary are stored to form a data base for concurrent statistical analysis.

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APPENDIX A

THE BURKE REHABILITATION HOSPITAL [1] UNIT NUMBER: 43242

AMPUTEE DISCHARGE SUMMARY WORKSHEET [2] NAME:

LOWER LIMB(S)

---

[3] TRANSFERRED FROM:

(1) NYH, (2) NYC Hospital, (3) Local Hospital, (4) Other Hospital, (5) Home

(6) Other:_____ 20 ch.

[4] ADMITTED ON: 7 / 8 / 75 . [5] DATE OF DISCHARGE: 8 / 21 / 75 . [6] DAYS AWAY: 0

[7] AGE 66 , [8] SEX: ETHNIC ORIGIN: (1) Male, (2) Female, (3) White, (4) Black (5) PR

(6) Oriental, (7) Other:_____ 15 ch.

[9] UPPER LIMB: (0) NOT UPPER LIMB

---

[13] LOWER LIMB: (1) Right, (2) Left, (3) Bilateral B/K, (4) Bilateral A/K, (5) Asymetrical

[14] ETIOLOGY: (1) Vascular, (2) Traumatic, (3) Congenital, (4) Tumor,

(5) Other:_____ 30 ch.

SIDE, RIGHT:

[15] LOWER RIGHT LEVEL
(1) PELVIC, COMPLETE
(2) HIP, COMPLETE
THIGH
(3) Upper
(4) Middle
(5) Lower
(6) KNEE DISARTICULATION
BELOW KNEE
(7) Upper
(8) Middle
(9) Lower
(10) FOOT, COMPLETE
(11) FOOT, PARTIAL
(12) Other:_____ 30 ch

SIDE, LEFT:

[16] LOWER LEFT LEVEL
(1) PELVIC, COMPLETE
(2) HIP, COMPLETE
THIGH
(3) Upper
(4) Middle
(5) Lower
(6) KNEE DISARTICULATION
BELOW KNEE
(7) Upper
(8) Middle
(9) Lower
(10) FOOT, COMPLETE
(11) FOOT, PARTIAL
(12) Other:_____ 30 ch

---

[17] ASSOCIATED CONDITIONS:

(0) None
(1) Dementia
(2) Parkinsonism
(3) Stroke
(4) Heart disease
(5) Hypertension
(6) Pulmonary disease
(7) Renal desease
(8) GI disease
(9) Diabetes mellitus
(10) GU disease
(11) Fractures
(12) Depression
(13) Eye disease
(14) Peripheral neuropathy
(15) Other:_____ 30 ch

HISTORY OF PRESENT ILLNESS:

DATE OF AMPUTATION(S): [20] LOWER RIGHT / / . [21] LOWER LEFT: 6/25/75

[22] REASON FOR AMPUTATION(S)

TRAUMATIC:
(1) Industrial
(2) Traffic
(3) Gunshot
(4) Recreational
(5) Other:_____ 30 ch

VASCULAR:
(6) Diabetic ASO
(7) ASO
(8) TAO
(9) Thrombo-embolism

[23] Vascular, other:_____ 30 ch [24] CONGENITAL_____ 30 ch

[25] TUMOR Dg:_____ 50 ch

AMPUTEE DISCHARGE WORKSHEET *Continued, Page 2*

[26] PRECEDING SURGICAL PROCEDURE(S):
(0) None
(1) Sympathectomy
(2) Embolectomy
(3) By-pass
(4) Other _____ 30 ch

[27] Previous amputation(s) _____ 30 ch

[28] COMPLICATION(S):
(0) None
(1) Blood-loss anemia
(2) Pulmonary embolism
(3) Infection
(4) MI
(5) Pneumonia
(6) Other _____ 50 ch

PERTINENT PHYSICAL, LAB. AND X-RAY FINDINGS ON ADMISSION:

[29] BP 150/100, [30] PR 80, [31] TEMP. 98.6, [33] WEIGHT 139 lbs.

[34] GENERAL CONDITION: (1) Good, (2) Fair, (3) Poor, (4) Other: _____ 30 ch

[37] STUMP CONDITION, LOWER RIGHT:
(1) Good
(2) Bulbous
(3) Not healed
(4) Edematous
(5) Infected
(6) Other: _____ 30 ch

[38] LOWER LEFT:
(1) Good
(2) Bulbous
(3) Not healed
(4) Edematous
(5) Infected
(6) Other: _____ 30 ch

[39] REMAINING LIMB(S): (1) Normal, (2) Impaired circulation, (3) Contractures, (4) Weakness, (5) Other: _____ 30 ch

[40] SENSORY FINDINGS: (1) Normal, (2) Impaired vision, (3) Impaired hearing, (4) Impaired proprioception, (5) Other: _____ 30 ch

[41] HCT 37; WBC 6500; FBS 129; BUN 28; Creatinine 1.1
Uric Acid 7.6; K+ 4.0;

[42] OTHER TESTS: U 50 ch

[43] X-RAY, CHEST:
(0) Not done
(1) Normal
(2) Acute inflam.
(3) Chronic inflam.
(4) Infarction
(5) Emphysema
(6) Malignancy
(7) Other: _____ 30 ch

[44] X-RAY, OTHER: U 30 ch

[45] ECG: (0) Not done, (1) Normal, (2) AF, (3) CAD, (4) BBB, (5) PVC's, (6) MI, (7) LVH, (8) RVH, (9) Other: _____ 50 ch

[46] COURSE IN HOSPITAL; REHABILITATION:
(1) Preprosthetic activities
(2) Stump shaping
(3) Wound healing
(4) Functional training
(5) Self-care training
(6) Other _____ 30 ch

LOWER LIMB(S), PREPARATORY

[69] RIGHT B/K:
(0) None
(1) B/K plaster of paris
(2) Other 30 ch

[70] LEFT B/K:
(0) None
(1) B/K plaster of paris
(2) Other _____ 30 ch

[71] RIGHT A/K:
(0) None
(1) A/K plaster of paris
(2) Other: 30 ch

[72] LEFT A/K:
(0)
(1) A/K plaster of paris
(2) Other: _____ 30 ch

[73] DATE RIGHT ISSUED: / /

[74] DATE LEFT ISSUED: 7/29/75

AMPUTEE DISCHARGE WORKSHEET, *Continued, Page 3*

LOWER LIMB(S), FINAL:

U

[75] DATE RIGHT ISSUED: ____/__/____

[77] DATE LEFT ISSUED: ____/__/____

[80] RIGHT COMPONENTS:
(1) B/K PTB, hard socket
(2) PTB, soft insert
(3) PTB, thigh lacer
(4) Conventional
(5) PTS
(6) Symes
(7) Other_____ 30 ch

[81] LEFT COMPONENTS:
(1) B/K PTB, hard socket
(2) PTB, soft insert
(3) PTB, thigh lacer
(4) Conventional
(5) PTS
(6) Symes
(7) Other_____ 30 ch

[82] A/K SOCKETS, RIGHT
(1) Quadrilateral, wood
(2) Total contact, laminated
(3) Molded plastic, sockets (Canadian)
(4) Hemi-pelvectomy, molded socket
(5) Other_____ 30 ch

[83] A/K SOCKETS, LEFT:
(1) Quadrilateral, wood
(2) Total contact, laminated
(3) Molded plastic, sockets (Canadian
(4) Hemi-pelvectomy, molded socket
(5) Other_____ 30 ch

[84] A/K KNEES, RIGHT:
(1) Knee lock
(2) Single axis
(3) Hydraulic
(4) Variable friction
(5) Other:_____ 30 ch

[85] A/K KNEES, LEFT:
(1) Knee lock
(2) Single axis
(3) Hydraulic
(4) Variable friction
(5) Other:_____ 30 ch

[86] FEET, RIGHT:
(1) Wood foot w. toe break
(2) SACH
(3) Single axis, SACH
(4) Other:_____ 30 ch

[87] FEET, LEFT:
(1) Wood foot w. toe break
(2) SACH
(3) Single axis, SACH
(4) Other:_____ 30 ch

[88] SUSPENSION, RIGHT:
(1) Semi-rigid pelvic belt
(2) Silesian belt
(3) Other:_____ 30 ch

[89] SUSPENSION, LEFT:
(1) Semi-rigid pelvic belt
(2) Silesian belt
(3) Other:_____ 30 ch

[90] DATE PATIENT FIRST WALKED: 7/30/75.

SURGICAL TREATMENT:

[101] LOWER RIGHT:
(0) None
(1) Stump care
(2) Debridement
(3) Stump revision date ____/____/____.

[102] LOWER LEFT:
(0) None
(1) Stump care
(2) Debridement
(3) Stump revision date ____/____/____

[107] MEDICAL TREATMENT:
(0) None
(1) Antihypertensives
(2) Cardiac
(3) Anticoagulants
(4) Diuretics
(5) Antihyperglycemics
(6) Antibiotics
(7) Psychotropics
(8) Analgesics
(9) Other:_____ 25 ch

[108] COMPLICATIONS:
(0) None
(1) Osteomyelitis
(2) Infection (stump)
(3) Contractures
(4) PVD
(5) Pulm. infarct
(6) Pneumonia
(7) URI
(8) GU infection
(9) BPH
(10) MI
(11) CHF
(12) Arrhythmia
(13) Hip fx.
(14) Stroke
(15) GI disease
(16) Renal disease
(17) Other: STUMP INJURY: WOUND RESUTURED
_____ 50 ch

AMPUTEE DISCHARGE WORKSHEET, *Continued, Page 4*

[109] CONDITION ON DISCHARGE: (1) Improved, (2) Unchanged, (3) Worse, (4) Deceased

[111] ABILITY TO USE LOWER LIMB PROSTHES(ES):

(1) Class I	Excellent functional outcome; not handicapped by disability.
(2) Class II	Good functional outcome; some restriction of activities.
(3) Class III	Fair functional outcome; job modification required.
(4) Class IV	Walking with assistance and for short distances only.
(5) Class V	No significant improvement of mobility.
(6) Class VI	Rejection of prosthesis.

[112] DISCHARGE DISPOSITION: (1) Home, (2) Nursing Home, (3) Hospital, (4) Home Health, (5) OPD, (6) Other: _____ 20 ch

EMPLOYMENT STATUS: (7) Retired, (8) Full time, usual work, (9) Part-time, usual work, (10) Job modification or retraining, (11) Unable to work

[113] DISCHARGE ORDERS:

MEDICATIONS: (0) None	DOSAGE	SCHEDULE	AMOUNT:
(1) HYDRODIURIL	50 mg	QD	
(2) PHENOBARBITAL	15 mg	TID	
(3) DIET: 2000C DIABETIC			
(4)			
(5)			

[119] RETURN TO OPD: DATE: 9/4/75

[120] LOCATION: (1) Burke, (2) NYH-K7, (3) Other _____ 25 ch

HOME CARE COORDINATOR: [121] NAME MARY ELLEN GIBSON, R.N.

[122] TELEPHONE: (212) 472-5907

[123] PHYSICIAN: PETER H. STERN M.D.

Orthotics and Prosthetics, Vol. 30, No. 2, pp. 43-55, June 1976

VACUUM-FORMED ORTHOSES FOR FRACTURE OF THE TIBIA[1]

Melvin Stills, C.O.[2]

The routine management of fractures of the long bones of the lower limb infers immobilization by use of plaster casts extending above and below the fracture site. A research team at the University of Miami has shown that the rigid walls of a plaster cast about a limb with a fracture oppose those forces created by vertical loads that otherwise would tend to displace the fracture. An understanding of the mechanical forces required to stabilize and support fractures led to the development of the below-knee functional orthosis described by Sarmiento, et al (*1*).

The rigidity of plaster-of-Paris casts can be duplicated easily with several thermoplastic materials. The experience at the Krusen Research Center with vacuum forming materials such as polyethylene and polypropylene led us to believe that a fracture orthosis using these techniques and materials would be an improvement over previously reported methods.

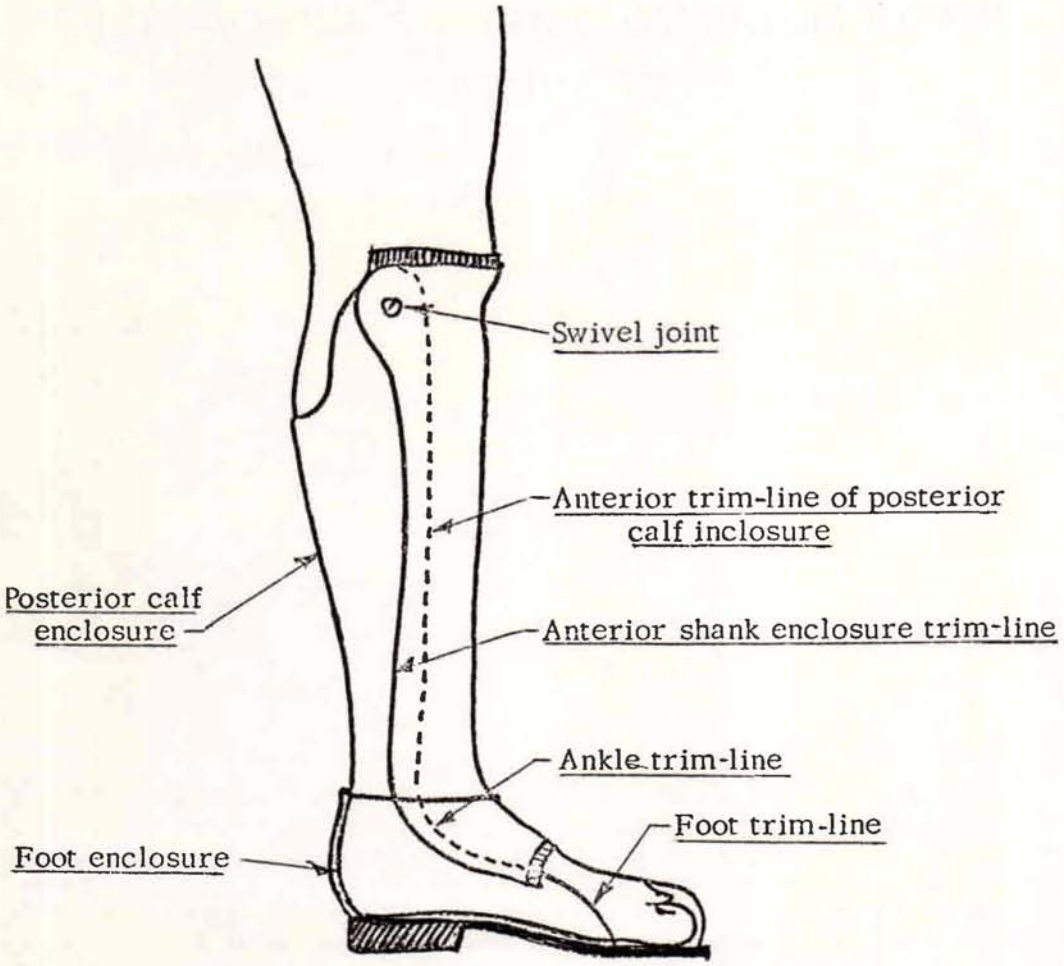
It is the intent of this paper to describe a technique that has proven useful in the management of lower-limb fractures.

MOLDED ORTHOSES FOR LOWER-LIMB FRACTURES

The molded lower-limb fracture orthosis is thermoformed from two pieces of standard grade polypropylene. Polypropylene was used because of its resistance to fatigue, low cost, light weight, and ease of working. The orthosis is formed over a plaster model of the body part to be braced. It is a two-piece unit having three basic components: the posterior calf enclosure, foot enclosure, and an anterior shank enclosure.

[1]This work was carried out with the partial support of the Rehabilitation Services Administration, Department of Health, Education, and Welfare under Grant #23P-55518.

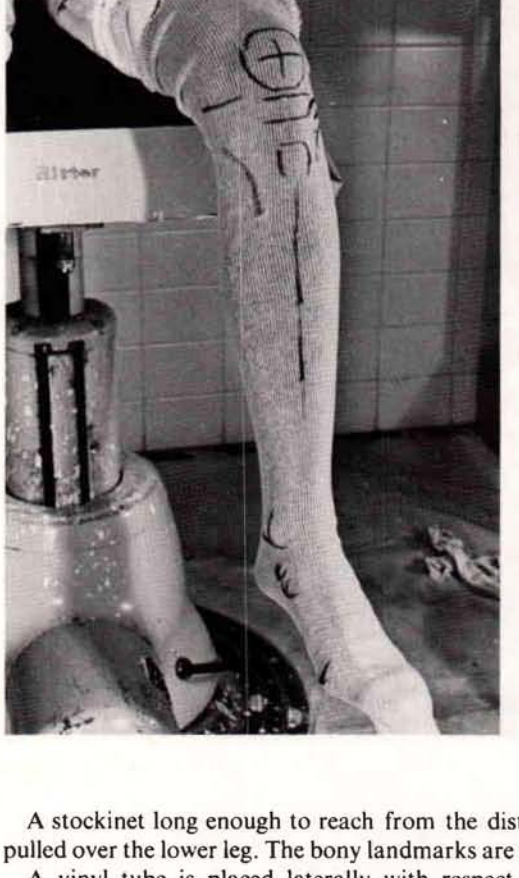
[2]Director of Orthotics, Krusen Center for Research and Engineering, Moss Rehabilitation Hospital, 12th Street and Tabor Road, Philadelphia, Pennsylvania 19141

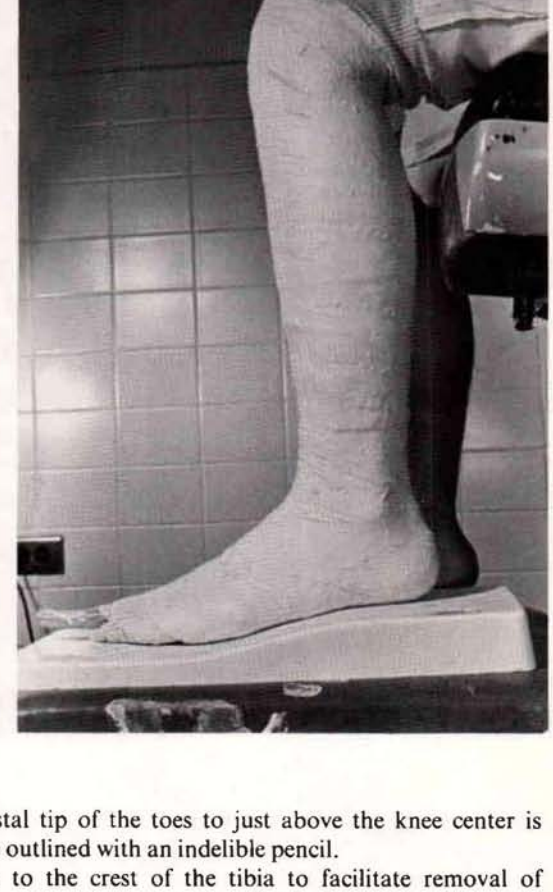


The nomenclature describing the orthosis is basically the same as that suggested for the molded ankle-foot orthosis (*2*), but the anterior shank enclosure part is added.

The function of the orthosis is the same as that intended of a plaster-of-Paris cast. The orthosis provides complete control circumferentially of the shank from the knee center to about the mid-foot point. The overall height of the system depends upon the site of the fracture. The amount of motion permitted at the ankle can be varied from total rigidity to total freedom at the discretion of the prescribing physician. Rigidity is controlled by the location of the ankle trim-lines and how far distally the anterior shank portion is extended. Locomotion studies at the Krusen Center have shown that motion about the ankle can be restricted to as little as two to three degrees with this design. The ankle angle is routinely maintained at 90 deg. so that minimal forces will be exerted on the knee and the fracture site.

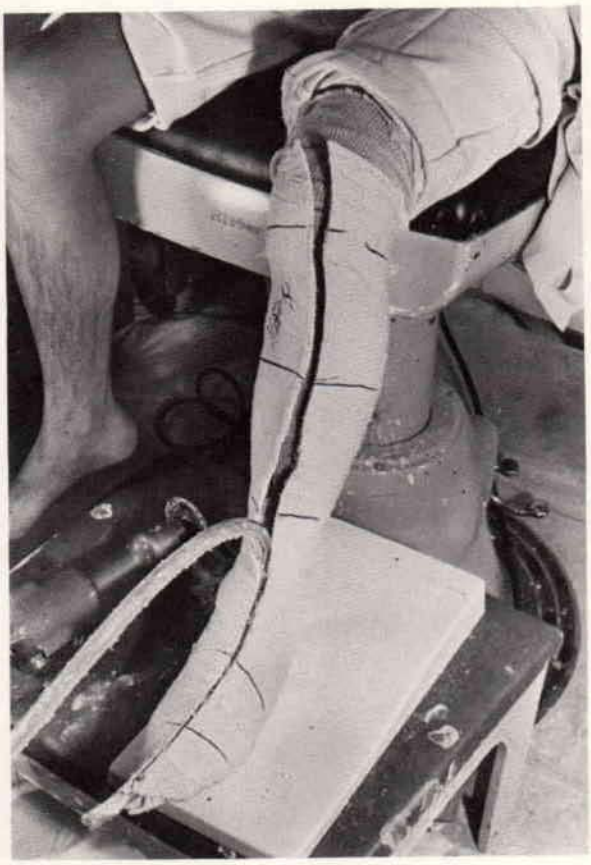
FABRICATION



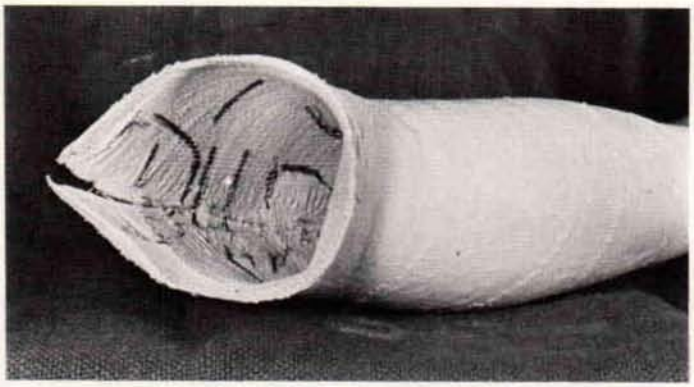


A stockinet long enough to reach from the distal tip of the toes to just above the knee center is pulled over the lower leg. The bony landmarks are outlined with an indelible pencil.

A vinyl tube is placed laterally with respect to the crest of the tibia to facilitate removal of the plaster cast. One layer of elastic plaster bandage is applied first, followed by two layers of standard plaster bandage. The foot is placed on a standard foot board in order to position the ankle properly and to give the desired shape to the plantar surface. The cast is allowed to set approximately ten minutes.

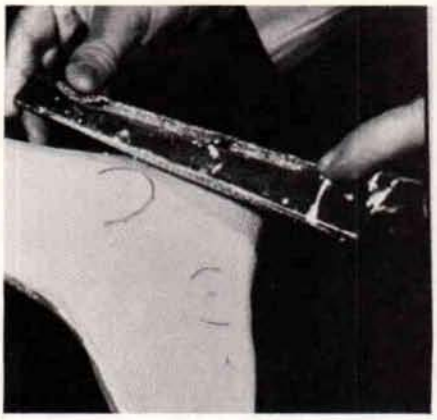


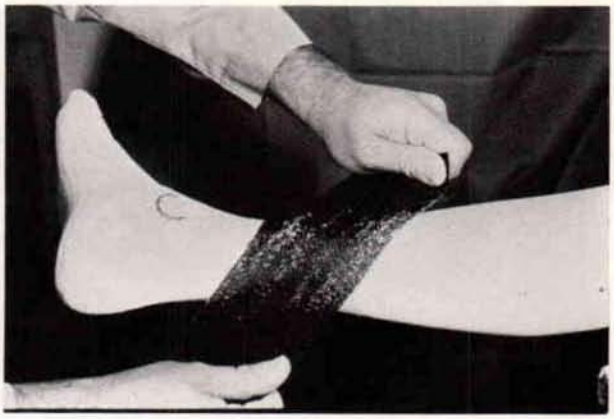
A cast cutter is used to cut the cast. The vinyl tube is removed and the stockinet is split with bandage scissors.



The cast is resecured along the cut seam with tape or staples, and plaster strips are applied along the seam to avoid leakage of the plaster slurry when the positive model is formed. The indelible pencil mark will have been transferred to the negative cast. They can be reinforced if needed, of course.

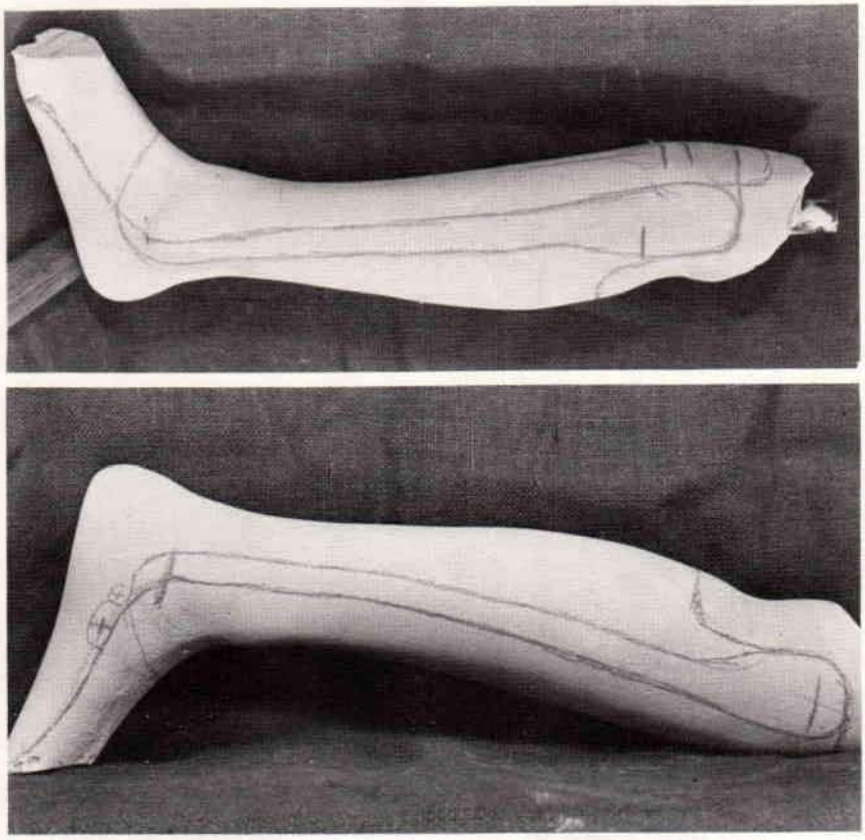
The cast after being slushed with a soap solution to act as a parting agent is filled with plaster-of-Paris slurry. A 1/2-in. water pipe is inserted to coincide approximately with the long axis of the shank. While the plaster is setting, the water pipe is turned slowly to facilitate removal later. The negative wrap is removed and all indelible pencil marks are reinforced if necessary.





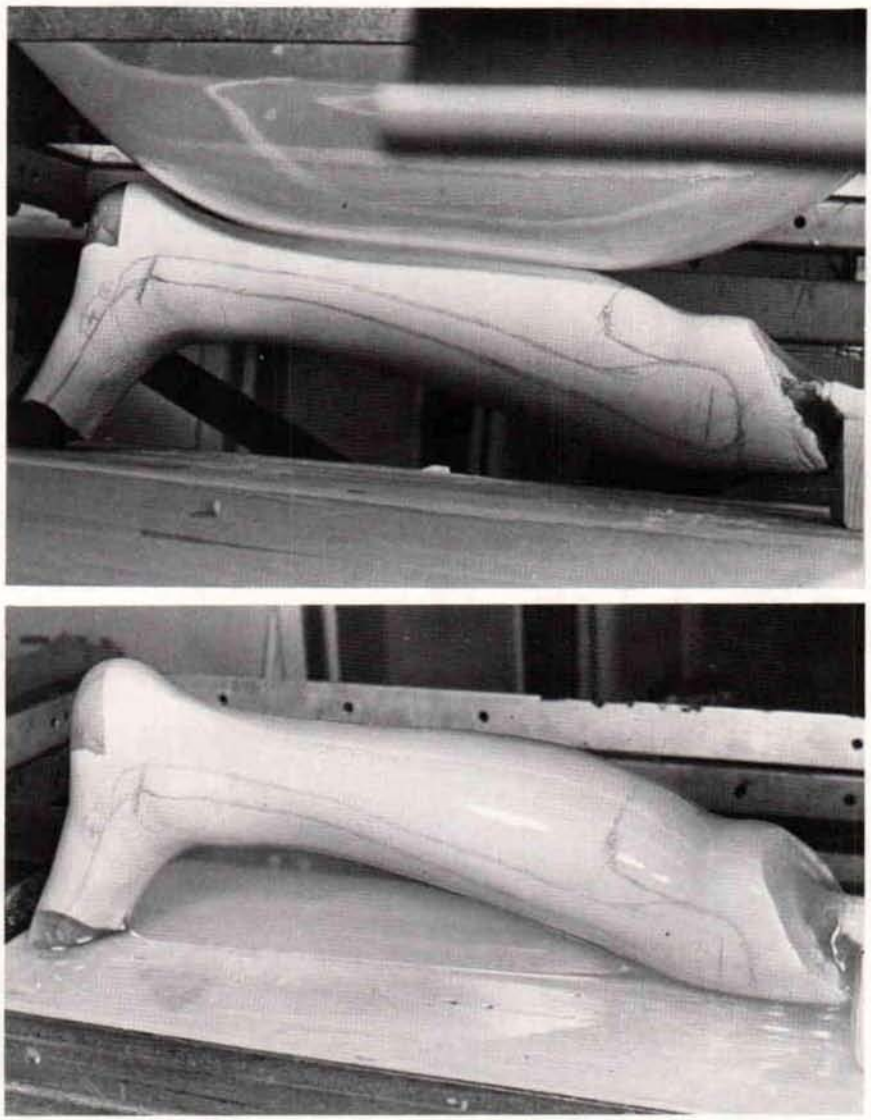
Basically, the modification of the model that is required is removal of the stockinet marks and smoothing the surface. Material may be removed from the area of the calcaneus in order to insure purchase and control when considered necessary.

Plaster may be removed from around the gastrocnemius and lateral to the crest of the tibia to increase the pressure supplied by the soft tissue on the fracture site. The amount of plaster to be removed depends on the original cast, and only through experience can one determine what is appropriate.

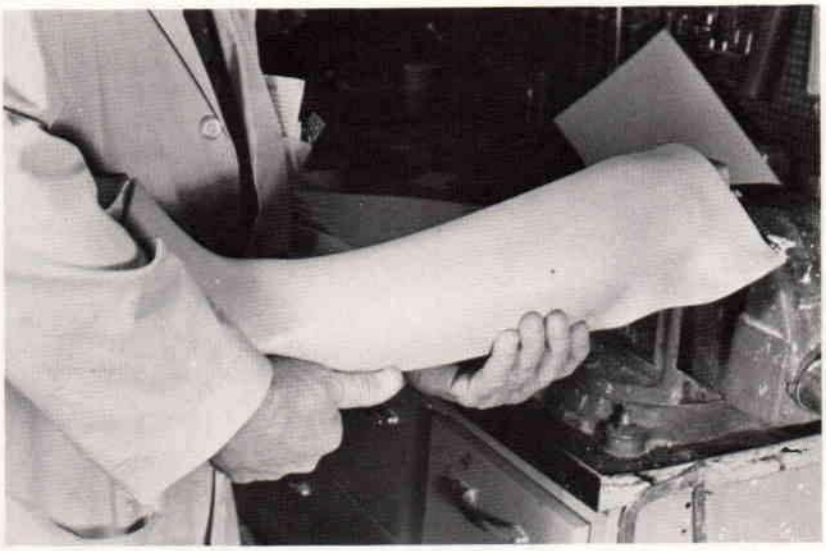


The peripheries of the parts of the orthosis should be outlined on the model. The anterior trim line of the posterior section should be anterior to the mid-line of the leg at the knee and should pass through the mid-line of the medial and lateral malleoli. The trim-line at the ankle is dependent on the amount of rigidity required. The more flexibility required, the further posterior the trim-lines at the ankle. The posterior proximal trim-line is such that the knee can be flexed freely.

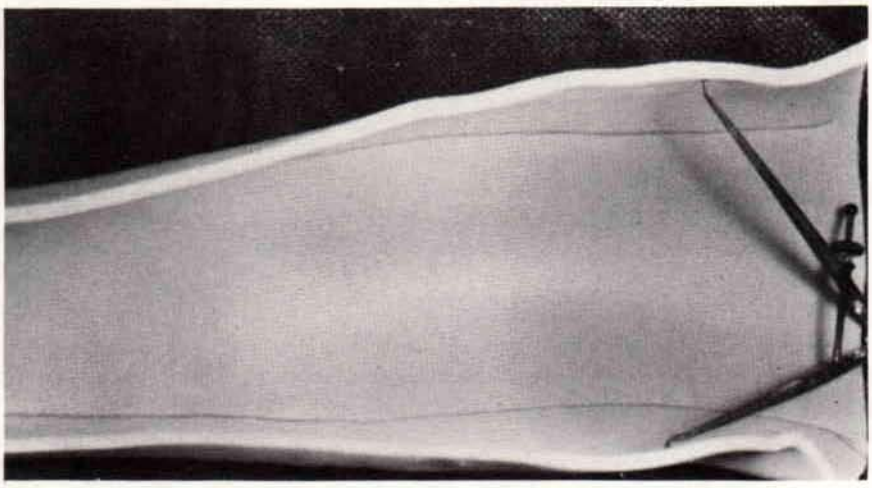
The anterior section must overlap the posterior section by at least 1/2-in. and is brought down over the dorsum of the foot depending upon the amount of dorsiflexion desired. The toe of the model is cut off so that it will rest in a stable position on the platen.



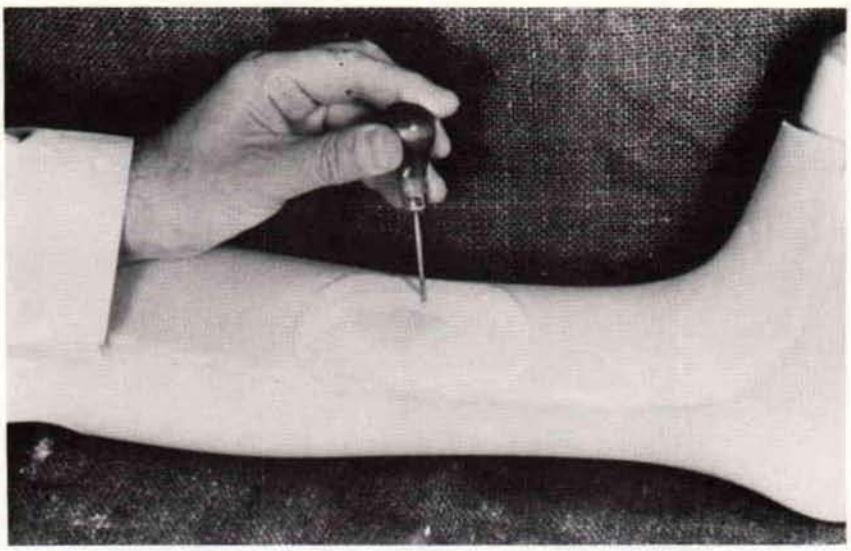
A nylon stocking is pulled over the plaster model and the proximal end is raised off the platen so that the material may pull around the anterior section. Standard 3/16-in. or 1/4-in. thick polypropylene is formed over the model using the vacuum method. The thickness of the material used depends upon the size of the model and the amount of rigidity required. The posterior section is then cut out following the trim-lines indicated on the model. The perimeter of the orthosis is then finished following the technique described earlier (*2*).



The posterior section is placed back on the model, and 1/4-in. thick, polyethylene foam (Plastizote), after being heated until it is pliable, is applied to the anterior surface to insure firm contact with the crest of the tibia and to allow for any irregularities in surface contour due to the fracture and formation of new bone.

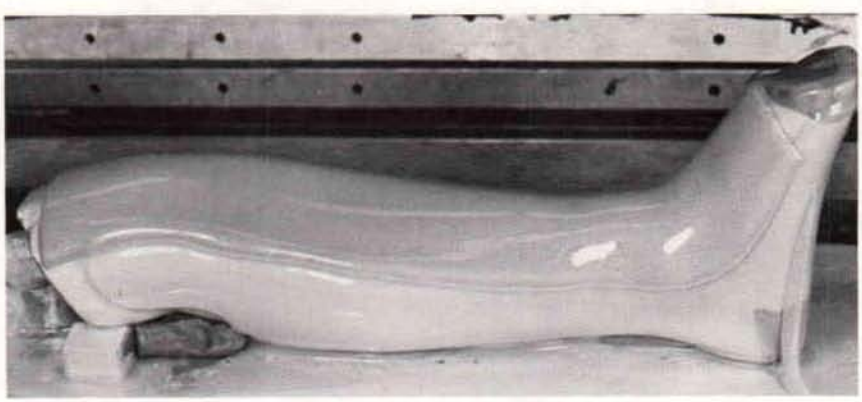


The Plastizote is held firmly around the model and rubbed so that the trim-lines of the posterior section will transfer to the foam. When cool, the foam is removed, and excess material is trimmed away. An overlap of approximately 1/4-in. is proper. The edges of the foam are finished with a slight bevel.



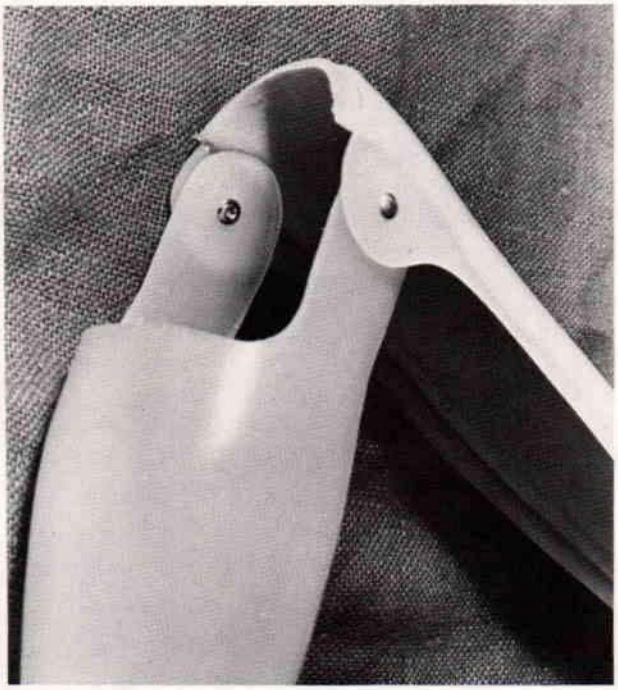
A nylon stocking is pulled over the model with the posterior section in place. The foam is positioned and held there with rubber cement. The foam should extend behind the intended proximal and distal trim-lines.

It is necessary to perforate the foam in order to "pull a vacuum" through it. Several small holes should be made with an awl. Pre-perforated Plastizote *cannot* be used because the holes are too large and the heated polypropylene will be forced into each hole.

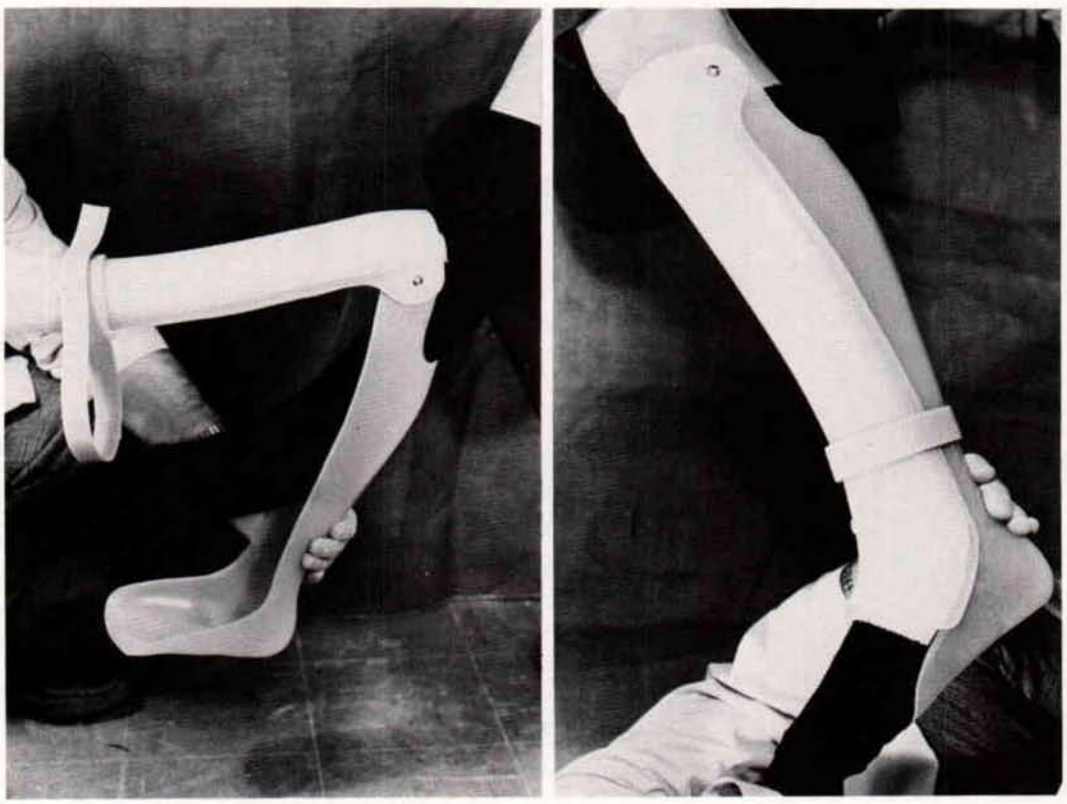


The anterior section is then molded using the same technique as for the posterior section. Because the depth of draw is less, 3/16-in. thick polypropylene has been found to be adequate in almost every case.

The anterior section is removed from the model by cutting carefully along the trim-lines indicated on the model. Care must be taken to insure that the posterior section is not cut. The edges are then finished in a conventional manner. The foam is not attached permanently, and may be pulled away from the edge so the polypropylene trim-lines can be finished properly.

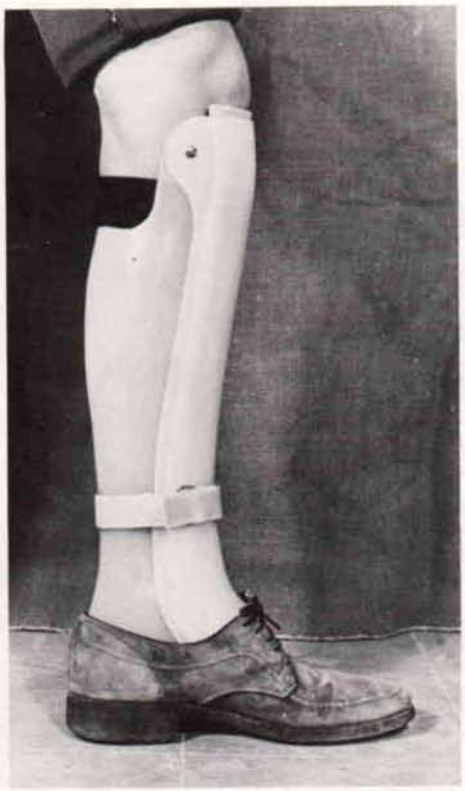


With the two halves together, holes are drilled for standard PTB retainer screws through the proximal section. This arrangement permits the anterior section to swivel freely about the posterior section. The inside portion of the retainer screw should be inset into the polypropylene to insure that excessive pressure on the shank does not develop.



A one-inch Velcro strap, with an "O" ring, is riveted to the anterior section just above the ankle. The orthosis is shown here with the anterior section swung open for entry.

With the posterior section held in place, the anterior section is closed and secured with the Velcro strap. When the knee is extended, the orthosis should be in total contact with the limb.



Conventional foot wear can be worn. Increasing or decreasing heel height will affect the knee as described in an earlier paper (*2*). After the patient has walked for a while, the orthosis is removed and the surface of the limb checked carefully to insure that areas of excessive pressure are not present. Appropriate modifications are made to the orthosis when excessive pressure is evident.

DISCUSSION

During the time the orthosis is being fabricated, the patient will require support and protection of his fracture. Generally, he will have come into the laboratory with a plaster cast. This cast should be bivalved and reapplied after the cast for the orthosis has been taken. The bivalved cast can be held in place with tape or additional plaster bandage. If any problem related to the fracture arises, i.e., paralysis, pressure areas, open wound, bony alignment, etc., it should be noted, and the referring physician should be notified by phone and in writing.

This orthosis has several advantages over other conventional methods of managing fractures:

1. It is very light, weighing between 6 and 10 ounces.
2. It may be removed easily for wound dressing.
3. The patient may bathe with hot water.
4. Polypropylene does not absorb body fluids.
5. Conventional shoes can be worn.
6. The cosmetic appearance is good.

To date, approximately 50 of these units have been fitted to patients in our Orthotic Clinic. Forty were prescribed for patients with delayed bony union; eight for patients with delayed union and open wounds, requiring frequent dressing changes; and two were utilized for patients with an acute fracture that had occurred less than one week before. Both of these patients were staff members of the Center. To date, all patients using this orthosis have complete bony union or are still wearing the orthosis with signs of fracture healing.

LITERATURE CITED

1. Sarmiento, Augusto, and William F. Sinclair, *Tibial and femoral fractures - bracing management,* University of Miami School of Medicine, circa 1973.

2. Stills, Melvin, *Thermoformed ankle-foot orthoses.* Orth. and Pros., 29:4 pp. 41–51, Dec. 1975.

Orthotics and Prosthetics, Vol. 30, No. 2, pp. 57–59, June 1976

NEW PUBLICATIONS

ARTHROGRAPHY OF THE SHOULDER by Julius S. Neviaser, M.D., Charles C. Thomas, 272 pp., 260 illustrations $22.50.

From the front and back flaps of the jacket:

"Arthrography of the Shoulder" provides considerable information on this joint. The author of this book emphasizes the minute points of technique. Normal arthrograms are illustrated, and anatomical variations of a normal shoulder joint are described in detail.

Frequent and unusual lesions of the shoulder are discussed. Chapters present clinical and arthrographic findings with explanatory roentgenographic illustrations. Outlines of conservative and operative treatment principles are also presented.

Individual chapters cover:

—adhesive capsulitis
—ruptures of the rotator cuff with and without history of an injury
—ruptures following a dislocation or fracture
—chronic and frequently misunderstood ruptures
—lesions of the biceps tendon with explanation of the frequency of such lesions
—dislocation of the shoulder, describing changes in the musculotendinous cuff for determination of operative procedure
—pathologic anatomy of old unreduced dislocations represented by graphic sketches
—the "stripping operation" for old unreduced dislocations
—changes in the joint which cause limitation of motion following fractures of the surgical neck of the humerus

Case presentations highlight specific problems in which a definite diagnosis has been made by the use of arthrography.

The text will be very useful in treatment of trauma in and about the shoulder joint. The contents will be of particular value to orthopaedic surgeons and radiologists, as well as traumatic surgeons."

ATLAS OF ORTHOTICS—Biomechanical Principles and Application, American Academy of Orthopaedic Surgeons, The C. V. Mosby Co., St. Louis, 507 pp., 836 illustrations, $42.50

This handsome volume is the successor to Orthopaedic Appliances Atlas, Volume 1—Braces, Splints, and Shoe Alterations (AAOS, J. W. Edwards 1952), and was published in December 1975. A comprehensive review will appear in the next issue of "Orthotics and Prosthetics."

NEUROLOGICAL AND SENSORY DISORDERS OF THE ELDERLY, edited by William S. Fields, M.D. Stratton Intercontinental Medical Book Corporation, New York, 244 pages

This book consists of selected papers and discussions from the 1975 Houston Neurological Symposium that was sponsored by the University of Texas Science Center at Houston.

The Table of Contents is:

Cerebrovascular Disease: Rehabilitation—William S. Fields, M.D., Professor and Chairman, Department of Neurology, The University of Texas Medical School at Houston

Differential Diagnosis of Dementia—Robert Katzman, M.D., Professor and Chairman of Neurology
Toksoz B. Karasu, M.D., Assistant Professor of Psychiatry, Albert Einstein College of Medicine, Bronx, N.Y.

Pathology and Pathogenesis of Dementia—Robert D. Terry, M.D., Professor and Chairman, Department of Pathology, Albert Einstein College of Medicine, The Bronx, N.Y.
Henryk M. Wiśniewski, M.D., Medical Director, MRC Demyelinating Diseases Unit, Newcastle General Hospital, Newcastle-upon-Tyne, England

Pharmacologic Responses of Elderly Persons to Neurotropic and Psychotropic Drugs—John M. Davis, M.D., Director of Research, Illinois State Psychiatric Institute; Professor of Psychiatry, University of Chicago, Ill.

The Aging Person in American Society: A Commentary on Social and Personal Relationships—Jon H. Fleming, Ph.D., Executive Director for Health Science Center Relations and Lecturer in Psychiatry, The University of Texas Health Science Center at Houston

Disorders of Vision: Degenerative Diseases—Richard S. Ruiz, M.D., Professor and Director, Program in Ophthalmology, The University of Texas Medical School at Houston

Disorders of Vision: Vascular, Metabolic and Endocrine—David L. Knox, M.D., Wilmer Institute, Johns Hopkins Hospital, Baltimore, Md.

Dizziness in the Elderly—J. U. Toglia, M.D., Professor and Acting Chairman, Department of Neurology, Temple University Health Sciences Center, School of Medicine, Philadelphia, Pa.

Degenerative Hearing Loss in Aging—Richard R. Gacek, M.D., Associate Surgeon, Massachusetts Eye and Ear Infirmary, Boston

Subject Index

PRIMARY ANATOMY, Seventh Edition, John Basmajian, The Williams and Wilkins Co., Baltimore, Maryland, $13.95.

From the preface to the Seventh Edition:

"*Primary Anatomy* has entered an explosive phase in its growth that has surprised and gratified both its author and its advocates. We must assume that the reason can be traced to our attempt to make this textbook both as free of jargon and as scientifically sound as precise words and drawings can make it. A feature that has been unique among small textbooks always has been its profuse special illustrations. These have been augmented further with more than 50 new or revised text-figures and a 26-page color atlas.

A new Chapter 16 has been written in response to widely expressed needs. This chapter is added for more advanced students than those who were the intended readers of early editions. More and more medical and dental students are now regular users—they require at least a general section on regional anatomy.

This edition has gone metric rather rapidly and thoroughly, not "inch by inch." While students in the U.S.A. number more than half of its regular users, even they are supposed to be at ease with the metric measures; those that are not should be! Non-U.S. readers now read this book in French, Spanish, Italian, and other foreign editions, and many of them are not familiar with obsolete "English" measures."

AN INTRODUCTION TO ORTHOPAEDIC MATERIALS, by John H. Dumbleton, Ph.D. and Jonathan Black, Ph.D. Charles C Thomas, Springfield, Illinois. 259 pp. $24.50.

From the cover:

"This text is intended for residents and others who need a firm understanding of the requirements, properties and status of orthopaedic materials. Coverage includes mechanical properties, bone and soft tissue, implant materials, friction, lubrication and wear, corrosion, biocompatibility

and failure analysis of devices. A unique feature is the inclusion of problems with worked solutions at the end of each chapter, a self-test (with answers) modeled on the Orthopaedic In-Training Examination of the American Academy of Orthopaedic Surgeons, and a critical bibliography for future reading.

Modern orthopaedics represents an interesting example of cooperation between the medical and physical sciences. The structural aspects of the musculo-skeletal system and the early introduction of the implantation of foreign materials have long required the practitioner of orthopaedics to possess a working knowledge of physical science and engineering principles. In recent years, with the practice of orthopaedics becoming increasingly sophisticated, the education of orthopaedists has broadened in the many basic sciences underlying this profession. The engineer and the physical scientist are both being called upon more and more to contribute to the education of orthopaedists as well as to further the practice of orthopaedics through problem oriented research."

AMPUTEE'S GUIDE—Below-the-Knee, Anne Alexander, R.P.T., Medic Publishing Co., P.O. Box 1636, Bellevue, Washington, 98009, Single copy price - 75¢. (See below for quantity discounts)

It has been recognized for many years that there has been a definite need for an up-to-date booklet, or booklets, that provide amputees with useful instructions and advice, but until now no one has taken the time to prepare a manuscript for such a publication. However, Anne Alexander, a long time member of the research team in Seattle led by Ernest Burgess has provided below-knee amputees with an excellently prepared, concise publication that should give that class of patients about all they need to know to help them to regain function and well being. It is considered to be a supplement to personal instruction, and certainly should be helpful in obtaining maximum results.

Every amputee clinic team should consider making a copy of this booklet available to each below-knee amputee patient it sees.

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The publisher advises that if the volume for below-knee cases is well received similar ones for patients with amputations at other levels will be made available.

INFORMATION FOR AUTHORS

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4. Write out numbers less than ten.
5. Do not number subheadings.
6. Use the word "Figure" abbreviated to indicate references to illustrations in the text (. . . as shown in Fig. 14)

PREPARATION OF ILLUSTRATIONS

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RESOLUTION CONCERNING THE METRIC SYSTEM

The following resolution was adopted by the Board of Directors of the American Orthotic and Prosthetic Association at its meeting in San Diego October 3, 1973:

WHEREAS by Act of Congress it has been determined that the United States should proceed towards adoption of the metric system as used almost universally throughout the rest of the world, and

WHEREAS the technological professions and many segments of the health professions have commonly used the metric system over an extended period of time, and

WHEREAS it is important for members of the orthotic/prosthetic professions to interact with their colleagues in the medical and technological communities for optimum patient service be it hereby

RESOLVED that the American Orthotic and Prosthetic Association endorses the use of the metric system by its members and other orthotic and prosthetic practitioners in the United States, and in witness of this endorsement and Association urges the editors of its journal *Orthotics and Prosthetics* to commence the dual reporting of weights and measurements in both the English and metric systems at the earliest possible date with the objective of employing the metric system solely by the time of the 29th Volume in 1975.

METRIC SYSTEM
Conversion Factors

LENGTH

Equivalencies

angstrom	= 1 x 10^{-10} meter (0.0 000 000 001 m)
millimicron*	= 1 x 10^{-9} meter (0.000 000 001 m)
micron (micrometer)	= 1 x 10^{-6} meter (0.000 001 m)

To Convert from	To	Multiply by
inches	meters	0.0254†
feet	meters	0.30480†
yards	meters	0.91440†
miles	kilometers	1.6093

AREA

To convert from	To	Multiply by
square inches	square meters	0.00063616†
square feet	square meters	.092903

VOLUME

Definition

1 liter = 0.001† cubic meter or one cubic decimeter (dm^3)
(1 milliliter = 1† cubic centimeter)

To convert from	To	Multiply by
cubic inches	cubic centimeters	16.387
ounces (U.S. fluid)	cubic centimeters	29.574
ounces (Brit. fluid)	cubic centimeters	28.413
pints (U.S. fluid)	cubic centimeters	473.18
pints (Brit. fluid)	cubic centimeters	568.26
cubic feet	cubic meters	0.028317

MASS

To convert from	To	Multiply by
pounds (avdp.)	**kilograms**	**0.45359**
slugs‡	kilograms	14.594

FORCE

To convert from	To	Multiply by
ounces-force (ozf)	newtons	0.27802
ounces-force (ozf)	kilogram-force	0.028350
pounds-force (lbf)	newtons	4.4732
pounds-force (lbf)	kilogram-force	0.45359

*This double-prefix usage is not desirable. This unit is actually a nanometer (10^{-9} meter = 10^{-7} centimeter).
† For practical purposes all subsequent digits are zeros.

STRESS (OR PRESSURE)

To convert from	To	Multiply by
pounds-force/square inch (psi)	newton/square meter	6894.8
pounds-force/square inch (psi)	newton/square centimeter	0.68948
pounds-force/square inch (psi)	kilogram-force/square centimeter	0.070307

TORQUE (OR MOMENT)

To convert from	To	Multiply by
pound-force-feet	newton meter	1.3559
pound-force-feet	kilogram-force meters	0.13826

ENERGY (OR WORK)

Definition

One joule (J) is the work done by a one-newton force moving through a displacement of one meter in the direction of the force.

1 cal (gm) = 4.1840 joules

To convert from	To	Multiply by
foot-pounds-force	joules	1.3559
foot-pounds-force	meter-kilogram-force	0.13826
ergs	joules	1×10^{-7}†
b.t.u.	cal (gm)	252.00
foot-pounds-force	cal (gm)	0.32405

TEMPERATURE CONVERSION TABLE

To convert °F to °C $\quad °C = \dfrac{°F - 32}{1.8}$

°F	°C
98.6	37
99	37.2
99.5	37.5
100	37.8
100.5	38.1
101	38.3
101.5	38.6
102	38.9
102.5	39.2
103	39.4
103.5	39.7
104	40.0

*A slug is a unit of mass which if acted on by a force of one pound will have an acceleration of one foot per second per second.

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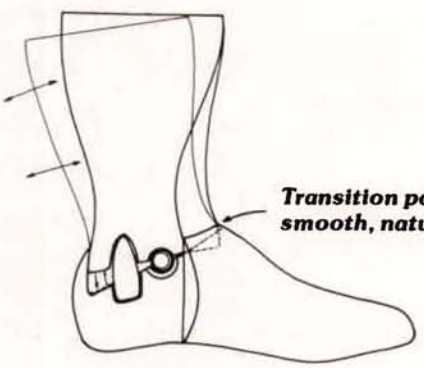

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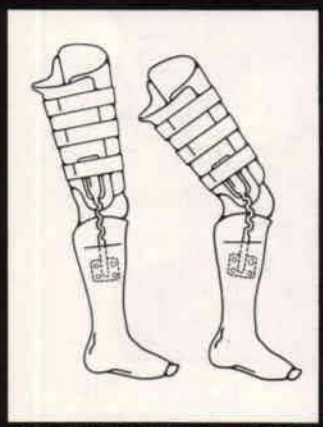

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*References: Vert Mooney, M.D.; Milton Ashby, M.D.; Benjamin E. Lesin, M.D.; Western Orthopedic Conference, October 29, 1975

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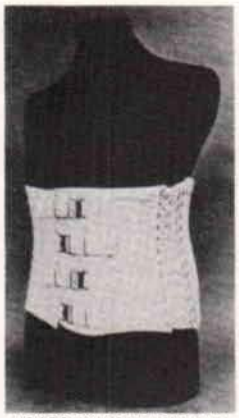

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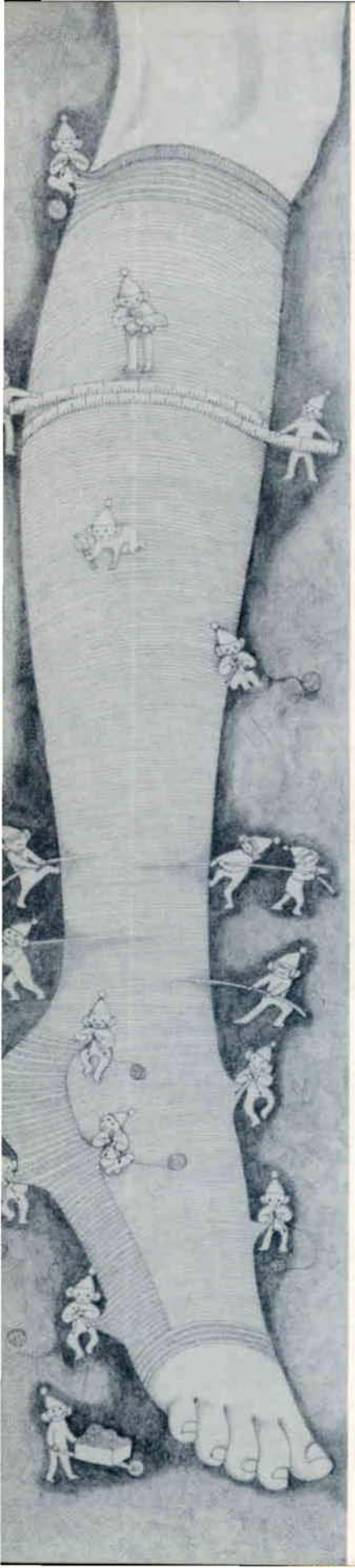

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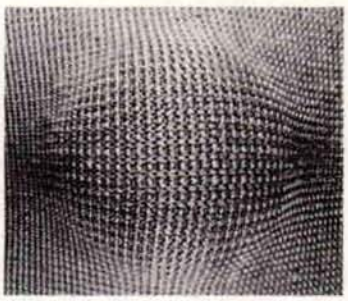

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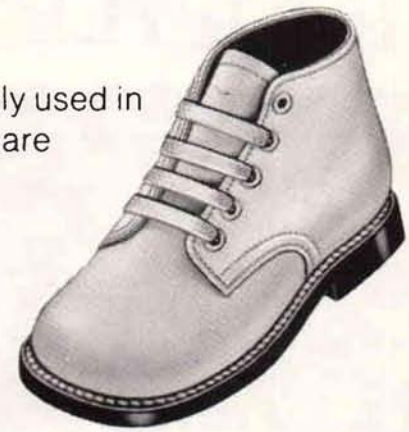

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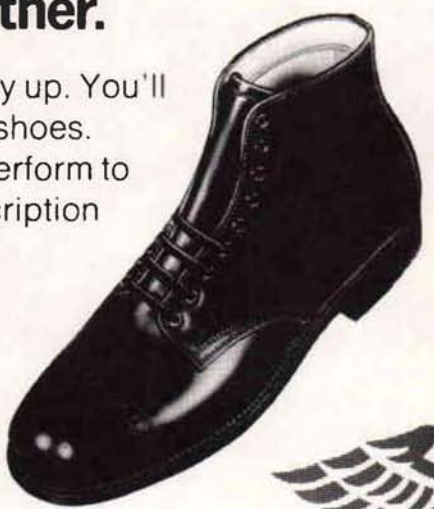

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