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

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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.

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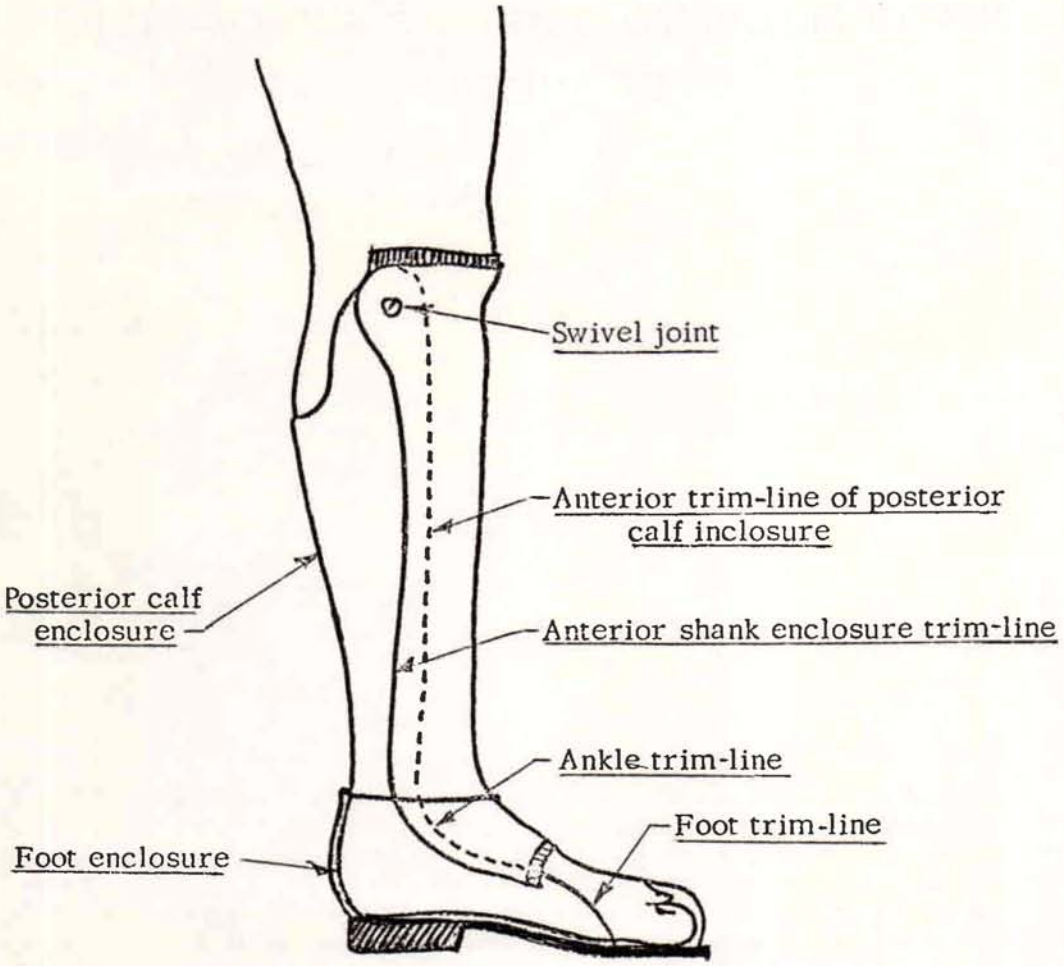
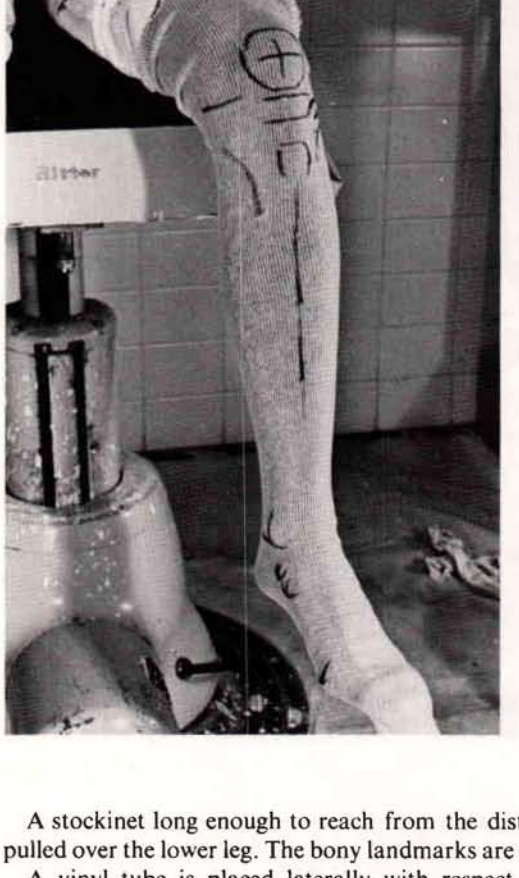
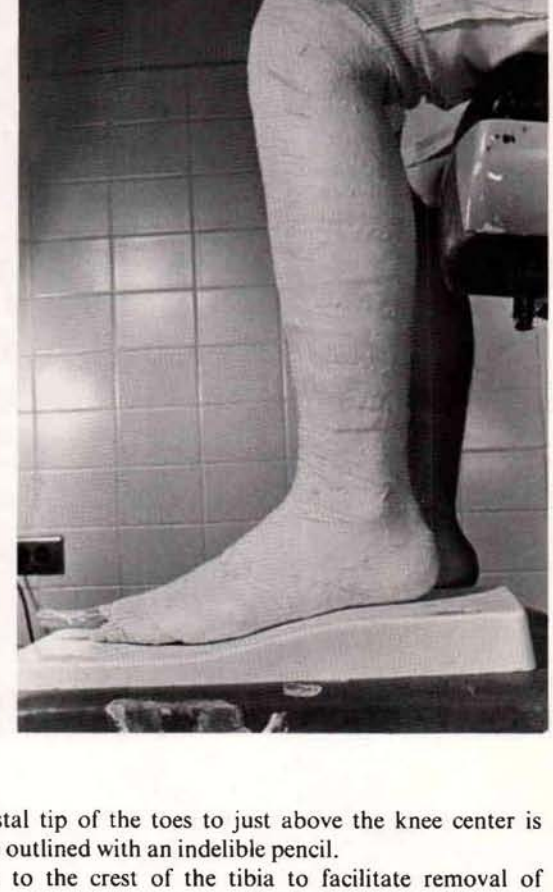



The nomenclature describing the orthosis is basically the same as that suggested for the molded ankle-foot orthosis (*2*), but the anterior shank enclosure part is added.

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.

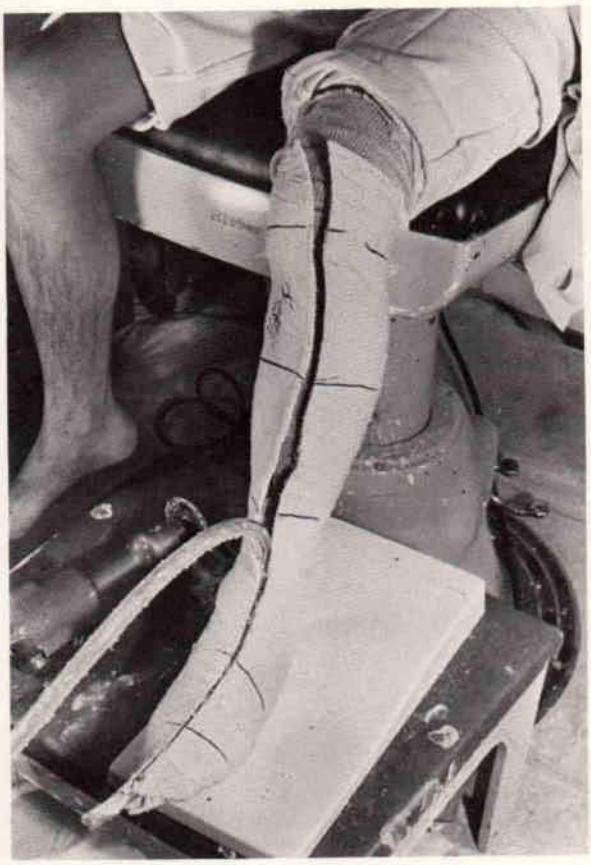
## FABRICATION



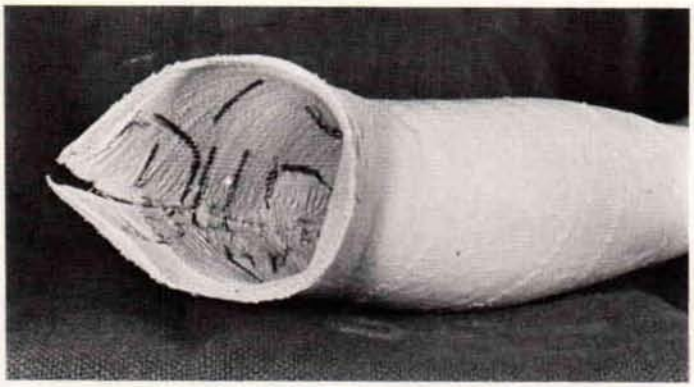


A stockinet long enough to reach from the distal tip of the toes to just above the knee center is pulled over the lower leg. The bony landmarks are outlined with an indelible pencil.

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.

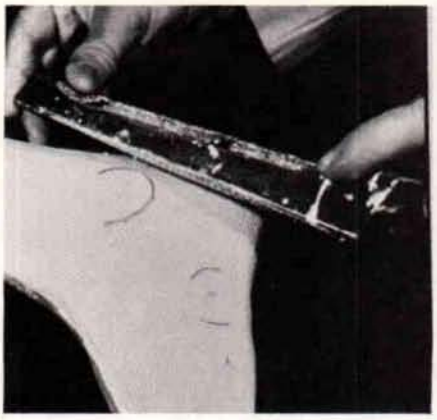


A cast cutter is used to cut the cast. The vinyl tube is removed and the stockinet is split with bandage scissors.



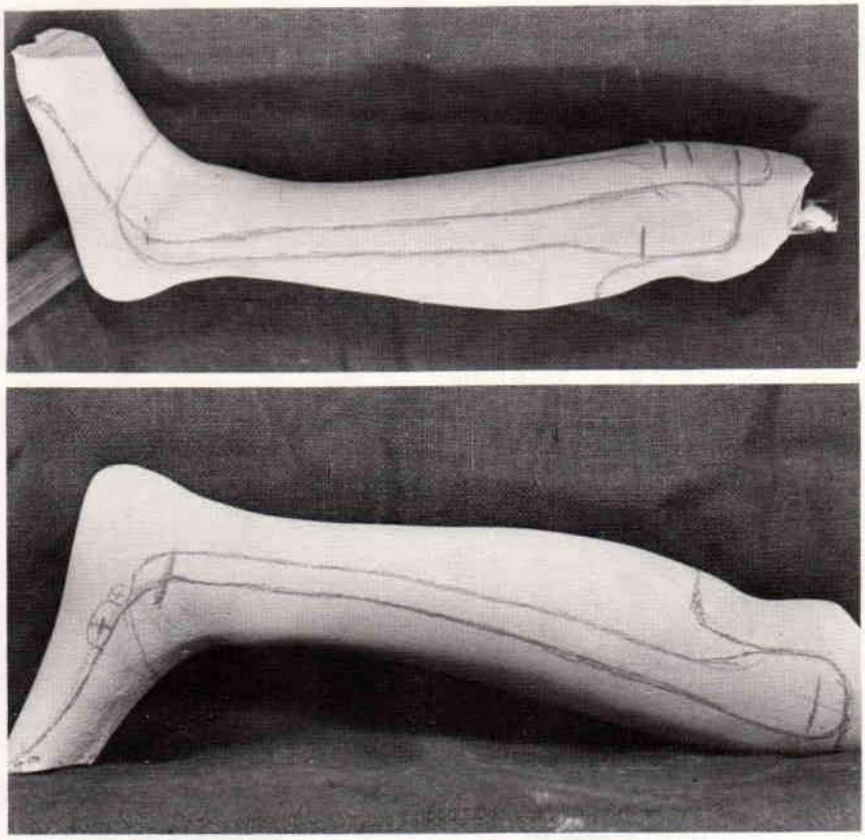
The cast is resecured along the cut seam with tape or staples, and plaster strips are applied along the seam to avoid leakage of the plaster slurry when the positive model is formed. The indelible pencil mark will have been transferred to the negative cast. They can be reinforced if needed, of course.

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.



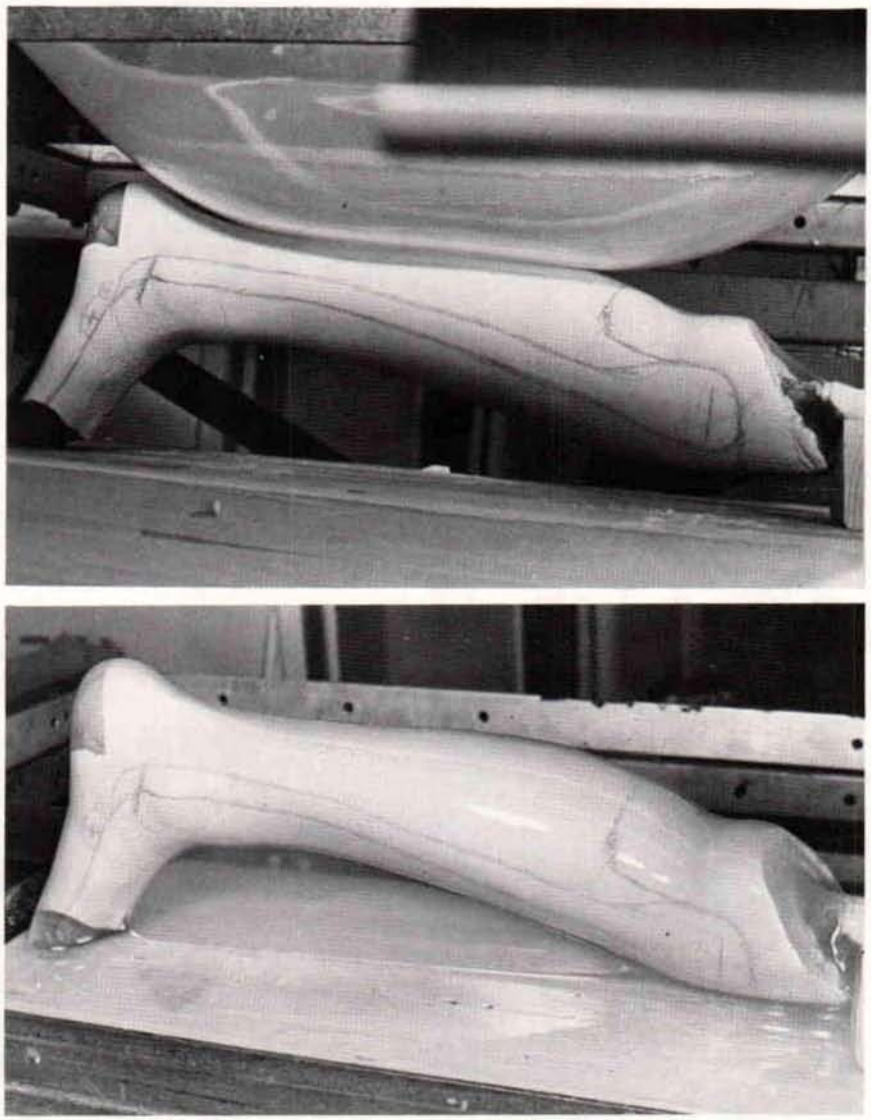
Basically, the modification of the model that is required is removal of the stockinet marks and smoothing the surface. Material may be removed from the area of the calcaneus in order to insure purchase and control when considered necessary.

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.

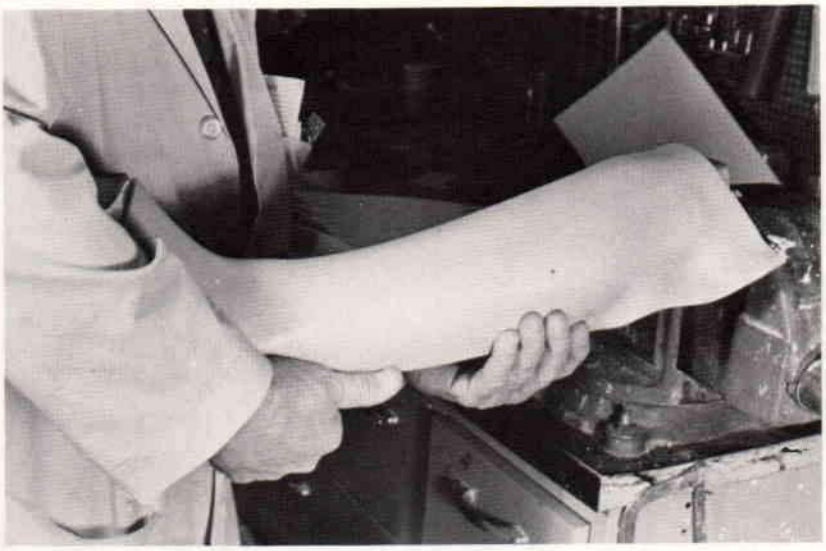


The peripheries of the parts of the orthosis should be outlined on the model. The anterior trim line of the posterior section should be anterior to the mid-line of the leg at the knee and should pass through the mid-line of the medial and lateral malleoli. The trim-line at the ankle is dependent on the 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.

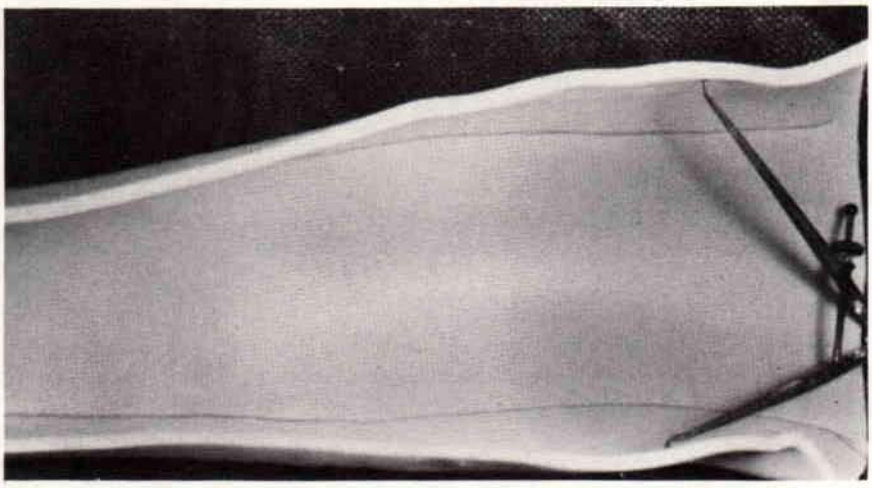
The anterior section must overlap the posterior section by at least 1/2-in. and is brought down over the dorsum of the foot depending upon the amount of dorsiflexion desired. The toe of the model is cut off so that it will rest in a stable position on the platen.



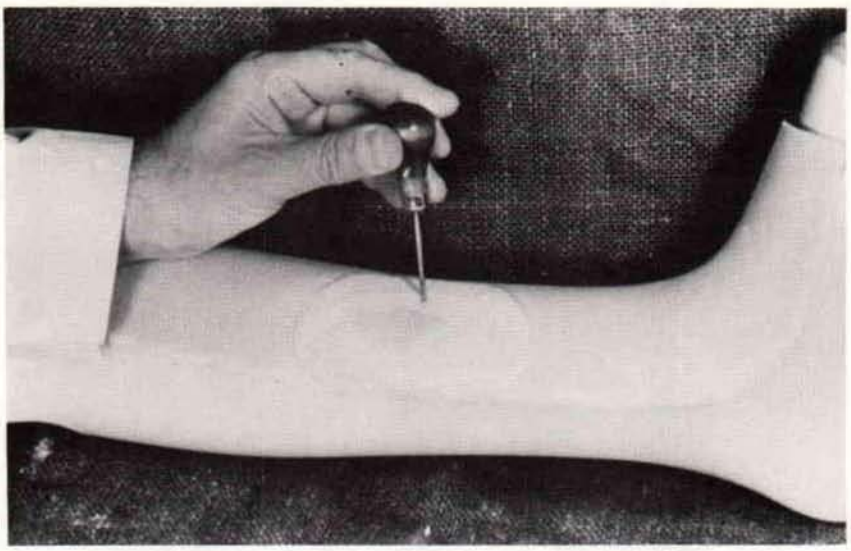
A nylon stocking is pulled over the plaster model and the proximal end is raised off the platen so that the material may pull around the anterior section. Standard 3/16-in. or 1/4-in. thick polypropylene is formed over the model using the vacuum method. The thickness of the material used depends upon 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.

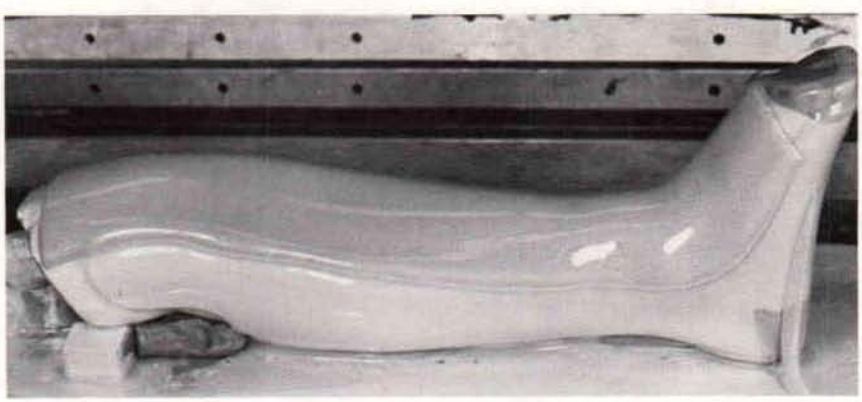


The Plastizote is held firmly around the model and rubbed so that the trim-lines of the posterior section will transfer to the foam. When cool, the foam is removed, and excess material is trimmed away. An overlap of approximately 1/4-in. is proper. The edges of the foam are finished with a slight bevel.



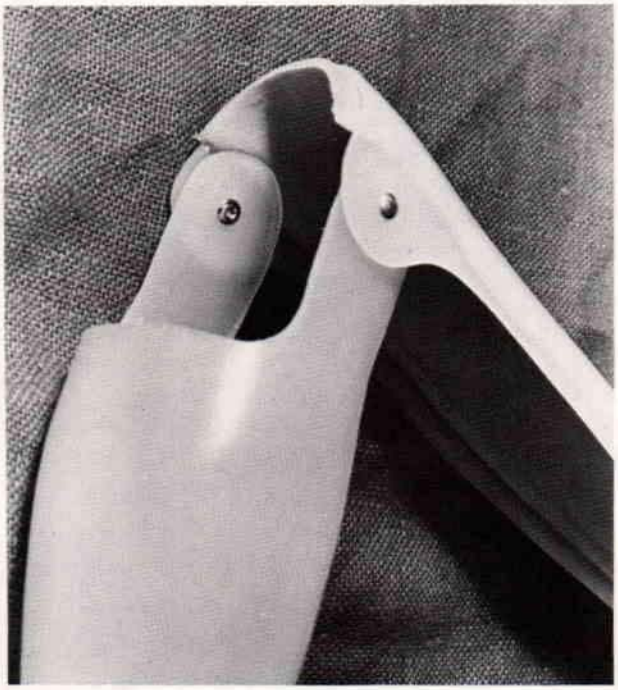
A nylon stocking is pulled over the model with the posterior section in place. The foam is positioned and held there with rubber cement. The foam should extend behind the intended proximal and distal trim-lines.

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.

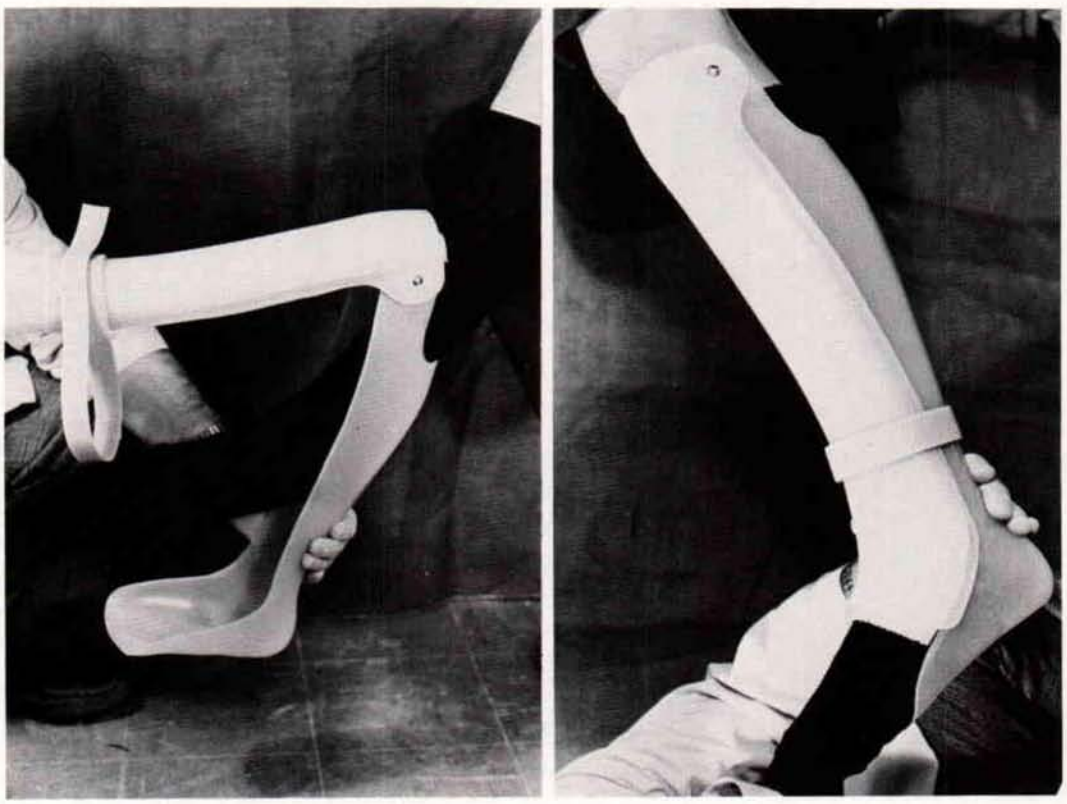


The anterior section is then molded using the same technique as for the posterior section. Because the depth of draw is less, 3/16-in. thick polypropylene has been found to be adequate in almost every case.

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.

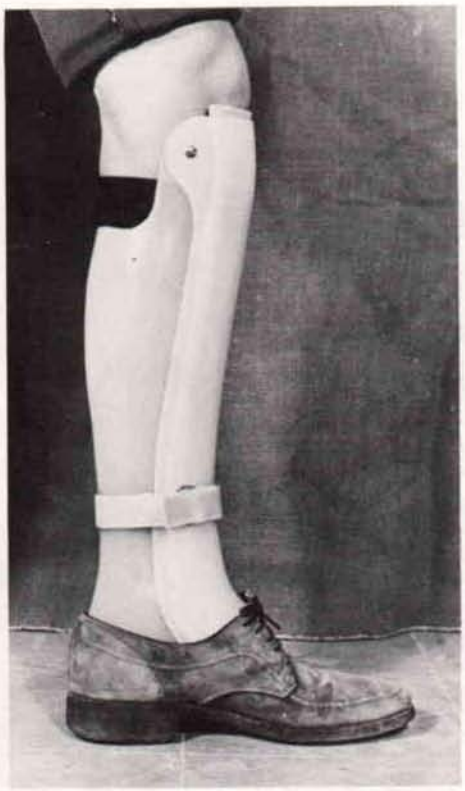


With the two halves together, holes are drilled for standard PTB retainer screws through the proximal section. This arrangement permits the anterior section to swivel freely about the posterior section. The inside portion of the retainer screw should be inset into the polypropylene to insure that excessive 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.