

# Advanced Designs of Plastic Lower-Limb Orthoses<sup>1</sup>

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During the past several years, more and more effort has been placed on development of more advanced orthoses for the lower limbs. Many of the new ideas have been tried and put into use at the Spain Rehabilitation Center in Birmingham since the first of July 1971. Most of the patients fitted here have been paraplegics.

The patients were fitted first with a posterior-type plastic custom-molded orthosis of the type used by various universities and research centers around the country. The ankle is held in place by means of a plastic custom arch support molded as part of the orthosis. The proximal portion of the orthosis is trimmed to a point  $\frac{3}{4}$  in. below the head of

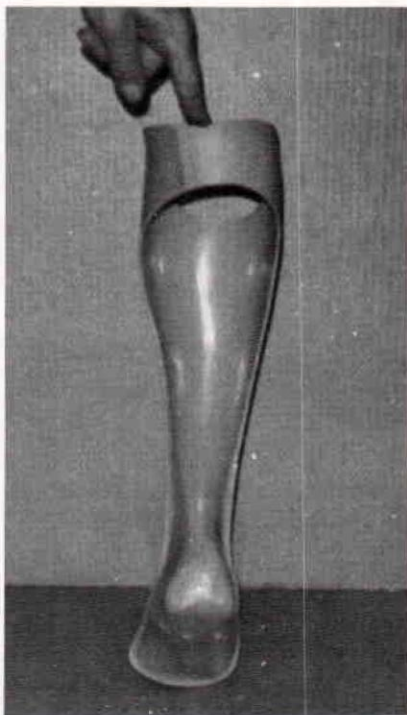


Fig. 1

Anterior view of the posterior-type plastic orthosis.

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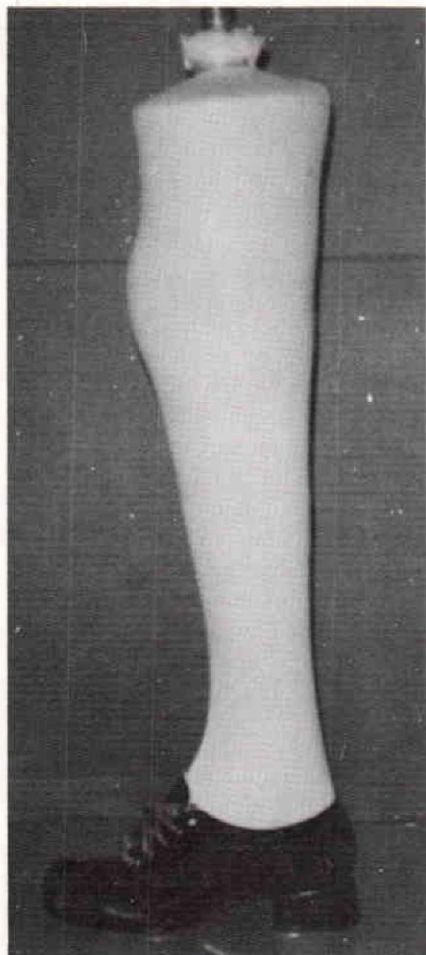


Fig. 2

Plaster cast set up in shoe to check alignment.

the fibula, as in the more conventional BK orthoses. To permit donning of the orthosis, the posterior wall is trimmed to a point about 1 in. below the lower anterior trim of the calf band (Fig. 1). The position of the ankle depends on the height of the shoe heel the patient is to wear.

While the cast is being taken the patient's knee is held in about 5-10 degrees of flexion, and the ankle is held in the corrected position until

the plaster sets. Also, the foot is held in plantar flexion in order to provide normal alignment when the patient is standing with the shoe on (Fig. 2).

This orthosis is quite satisfactory for the paralyzed patient with "drop foot". In some cases, a strap is added to the ankle to prevent the foot from slipping forward in the shoe, and also to prevent valgus and varus (Fig. 3).

The orthosis seems to provide good ankle support and lateral stability during walking. The angle of the ankle in the shoe at heel strike showed that the patient's knee was forced into flexion. This action brought the foot flat on the floor, allowing normal action throughout the gait cycle.

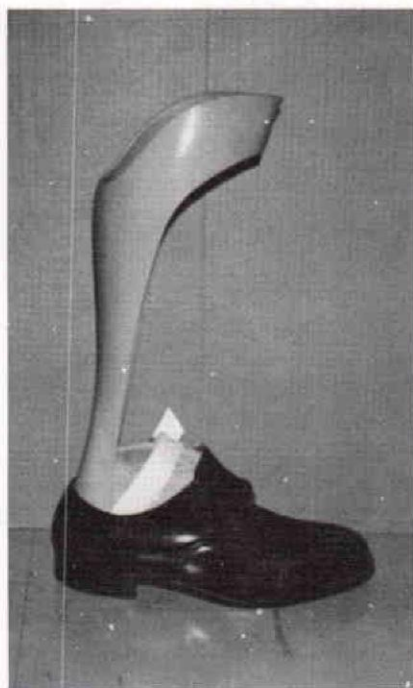


Fig. 3

Orthosis with strap added at the ankle to prevent the foot from slipping forward in the shoe.





Fig. 4

Side view of the anterior leaf-type of plastic orthosis.

### THE ANTERIOR-LEAF TYPE

After many patients had been fitted and evaluated with the posterior-type BK orthosis, an entirely new approach was attempted. A new design using anterior support was developed to allow plantar flexion at heel strike, dorsiflexion at heel off, and transverse rotation throughout the gait cycle. The fore-foot was enclosed with a flexible tunnel for the foot to slide into (Fig. 4). This stopped the anterior slipping of the foot on the foot plate. Valgus and varus are also controlled by the custom foot plate. The design of the anterior leaf at the ankle allows plantar and dorsiflexion; however, care must be taken in modification of the cast in this area.

A buildup of approximately  $\frac{1}{4}$  of an inch must be added over the

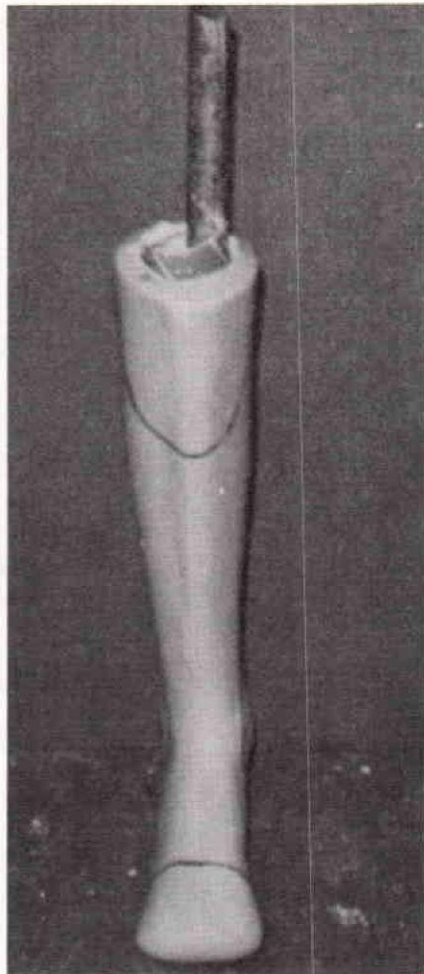


Fig. 5

Anterior view of cast for anterior-leaf orthosis showing buildup over the crest of the tibia.

crest of the tibia along its entire length. The resulting space allows the orthosis to plantar flex and dorsiflex without rubbing the tibia (Fig. 5). Relief over the superior portion of the navicular may be needed in some cases.

### FABRICATION OF THE NEW ORTHOSIS

1. Wrap and cast the patient's limb in the corrected position. Mod-

ify the cast along the tibial crest, and over the navicular, if necessary.

2. Place one layer of  $\frac{1}{2}$ -oz. Dacron felt over the entire cast.

3. Add two layers of nylon stockinette over the Dacron.

4. Place a  $\frac{1}{2}$  in. by 6 in. by  $\frac{1}{16}$  in. piece of spring steel wrapped with one layer of fiberglass cloth in

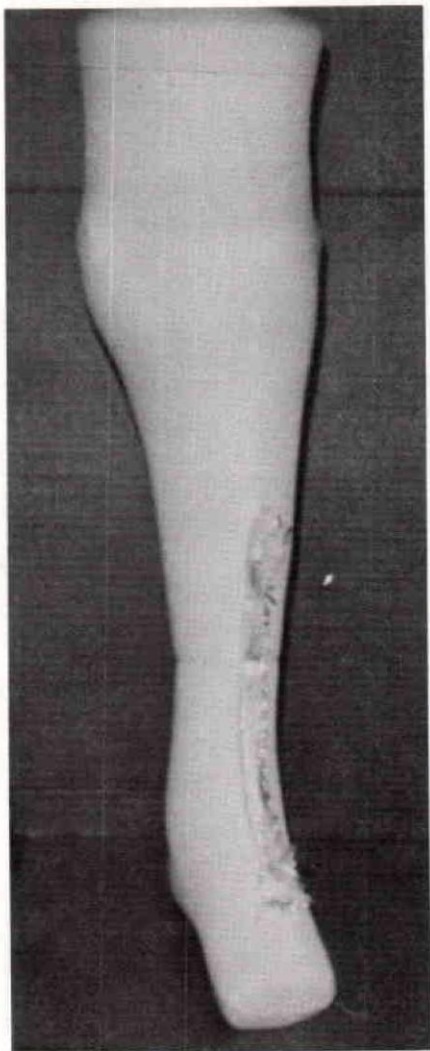


Fig. 6

Anterior view of cast for anterior-leaf orthosis showing placement of fiberglass covered spring steel leaf.

the curve of the ankle. It should extend proximally about 4 in. distally about  $1\frac{1}{2}$  in. to 2 in. (Fig. 6).

5. Two more layers of nylon stockinette are placed over the steel, starting at the ankle and reaching over the proximal portion of the cast. The foot portion should not be covered with these layers, in order to keep the foot plate as thin as possible.

6. Two more layers of nylon stockinette are placed over the entire model.

7. Add the PVA bag and laminate with a mixture of 70 per cent 4110 rigid polyester resin and 30 per cent flexible 4134 polyester resin.

8. After the lamination has cured, draw the outline of the orthosis on the model, and cut out with cast saw. Trim the edges and begin the fitting procedure with the patient.

## ADVANTAGES AND DISADVANTAGES

1. The cosmesis provided by this orthosis is more acceptable to both male and female than is the more conventional types of orthoses. Shoes can be changed readily and knee socks or ladies' hose can be worn over the entire orthosis.

2. The weight of the orthosis is greatly reduced.

3. The disadvantage of the orthosis is the time and labor required for fabrication, thus increasing the cost.

## ABOVE-KNEE VERSIONS

For CVA patients who require "long leg braces," we added knee



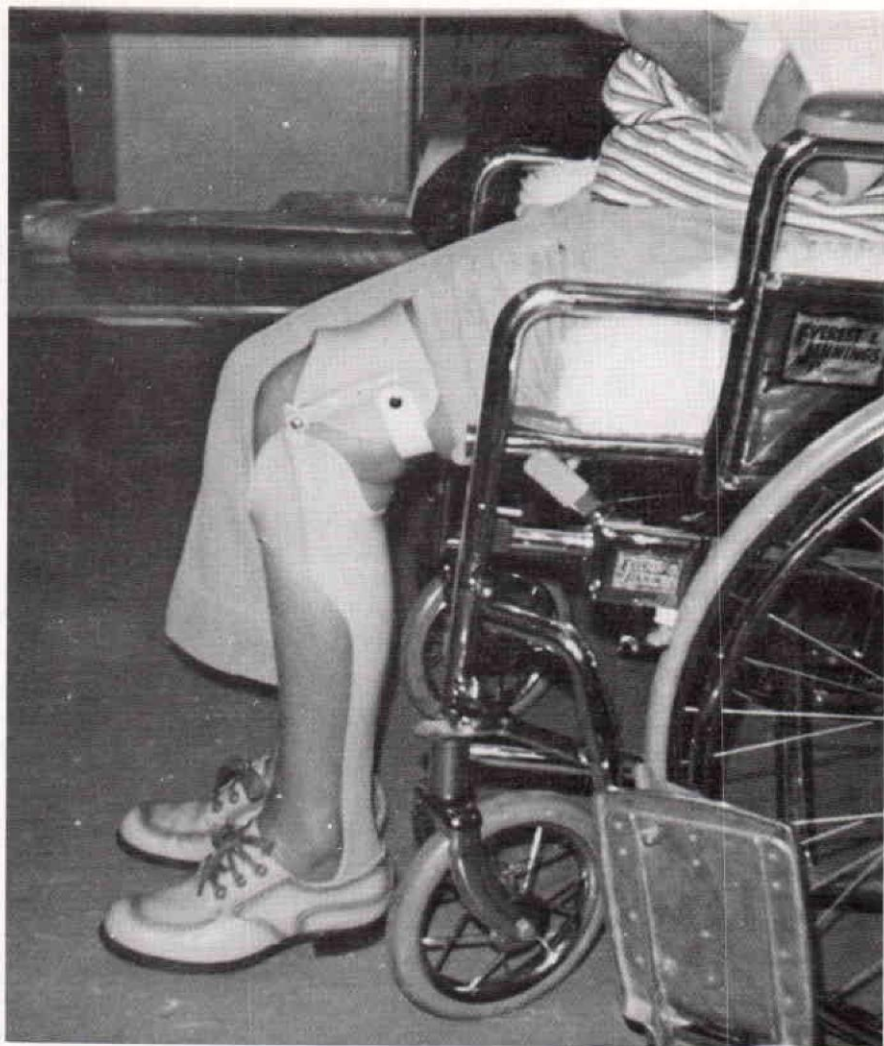


Fig. 7

Posterior-type below-knee orthosis modified to control recurvatum.

joints and anterior thigh bands to the posterior type (Fig. 7) to control drop foot and recurvatum of the knee.

Knee joints were used after trying orthoses made of one-piece lamination. The only reason for adding the knee joint was for cosmesis while the patient was sitting. After many patients were fitted with this type of orthosis, we found that

the strap around the upper thigh band was not needed. A simple thigh band covering about  $\frac{3}{4}$  of the circumference of the thigh just above the femoral condyles served just as efficiently (Fig. 8). Male patients wearing trousers, or females wearing hose over the orthoses automatically flex the thigh portion when sitting. This orthosis is being worn and accepted very suc-

cessfully by many patients here. The advantages and disadvantages are the same as with the below-knee orthosis.

Further development of above-knee orthoses has been undertaken for spinal-cord-injury patients. Orthoses for these patients must be strong enough to support the body and withstand the medial and lateral forces placed upon them during locomotion.

The orthoses shown in Figure 9 are for a patient with injury to the spinal cord at the T-10 level. Knee locks are used. The lower portion of the orthosis is constructed in the

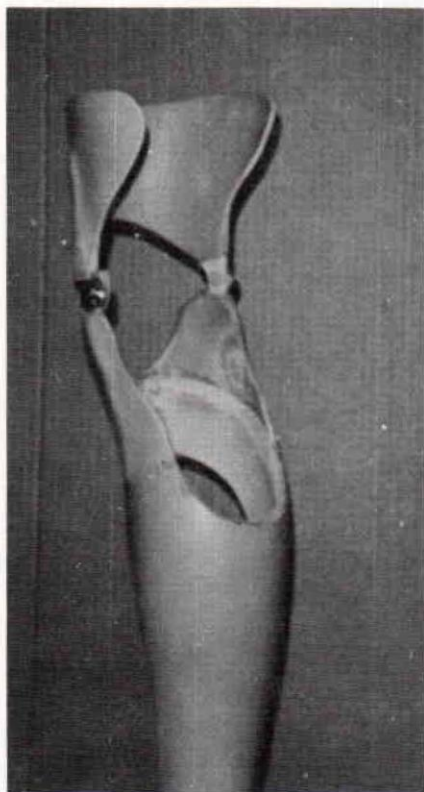


Fig. 8

Another view of the type of orthosis shown in Figure 7. Note that the posterior strap is not present in this later version.

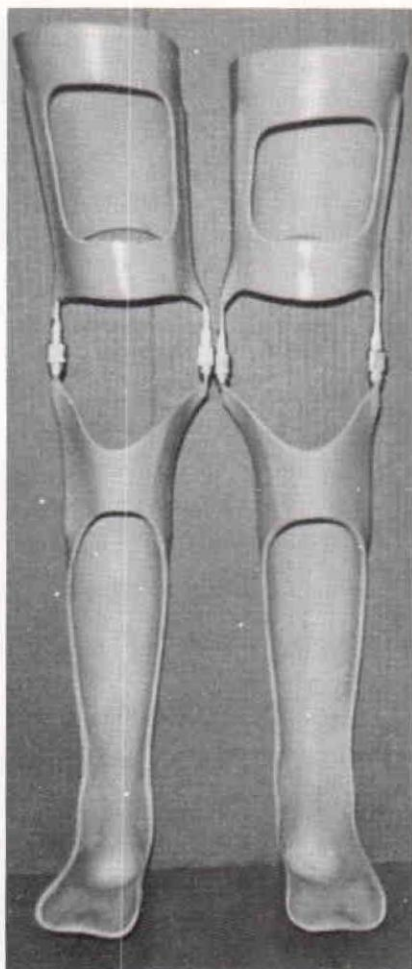


Fig. 9

Anterior view of plastic orthoses designed for a patient with an injury of the spinal cord at the T-10 level.

same manner as the posterior-type below-knee orthosis, having a custom footplate and posterior leaf. The thigh portion is made of a one-piece plastic laminate.

Donning the orthosis is made easy by cutting a window in the anterior portion of the thigh piece to form two solid bars. The top of the proximal bar is slightly lower than the top of the posterior section, and the lower posterior edge is higher



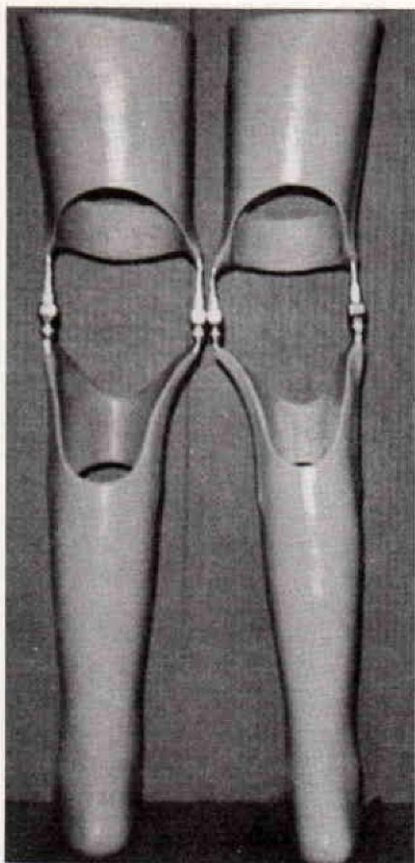


Fig. 10

Posterior view of orthoses shown in Figure 9.

than the top of the lower anterior bar (Fig. 10).

This type of orthosis is also being accepted and worn successfully at the Spain Rehabilitation Center. The advantages and disadvantages

are the same as for the other plastic braces. While working with these patients, it has been demonstrated that genu valgus and genu varum can be held or corrected as in the double upright metal orthosis.

## CONCLUSION

Observation of the patients wearing these new-type orthoses show that the control and action desired in most below-knee appliances can be obtained.

When fitting patients with these orthoses, care should be taken initially with the fit of the footplate. Patients with little or no sensory feedback are not aware of pinching, rubbing, or excessive pressure when such conditions occur. The patient should be allowed to walk or bear weight for only a short time before checking the area in contact with the footplate. The patients should be seen from week to week, or month to month, on an outpatient basis to check for wear and any further adjustments that might be needed.

New developments and concepts in orthotics are making it possible to reduce rehabilitation time. We are trying to add to this achievement through research and experimental procedures by developing the best orthotic prescription possible for the patient.