

## New plastic joints for plastic orthoses

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### Abstract

Plastic joints for orthoses have more advantages than metal joints. They are lightweight, noiseless, comfortable to use, rust proof, corrosion free, and radiolucent.

Two types of plastic joints were developed by the authors, one for the ankle joint and the other for the knee joint, elbow joint or hip joint. Polypropylene was chosen as the joint material because of its appropriate flexibility and toughness.

### Introduction

The use of plastic orthoses for lower limbs is increasing due to recent advances in thermoplastic materials and vacuum forming technique (Watanabe et al, 1976, a, b). The posterior leaf spring type (C.P.R.D., 1971) and spiral type (Lehneis, 1974) of ankle foot orthoses are widely used all over the world.

However, when regarding dorsiflexion or plantarflexion of the foot in these orthoses, the position of the mechanical ankle joint of the

orthosis differs basically from the axis of the anatomical ankle joint i.e. the talocrural joint axis. Moreover, the corrective force of the posterior leaf spring type of ankle foot orthosis on varus or valgus deformity of ankle is weak. Therefore in many cases, one has no choice but to use a conventional ankle foot orthosis with lateral metal uprights and metal ankle joints.

### Development of plastic ankle joint

Since plastic is lightweight, noiseless, good for cosmesis and radiolucent, we have been trying for several years to develop a plastic ankle joint that possesses a similar function to a metal joint (Watanabe et al, 1978).

Ten types of plastic joints (Fig. 1) were made for trial and for experimental use. All of these joints have some advantages and disadvantages, however, a rectangular shape with small flexible plastic bar and stopper(s) in the middle, has been chosen as the plastic ankle joint to develop (Fig. 1c, and Fig. 2).

The plastic material for an ankle joint must have appropriate flexibility, be good for cosmesis, have fairly good durability, be easily processed and inexpensive. In order to choose an appropriate material for the plastic ankle joint, experimental tests on seven types of thermoplastics were carried out. These were polyvinyl chloride, polycarbonate, polypropylene, low density polyethylene, acrylonitrile-butadiene-styrene resin, Ortholen, and Subortholen.

For flexibility the force necessary to bend the plastic piece was investigated. For distortion the restoration of form after a certain force had been applied to the plastic object was examined. A durability test was conducted by bending the plastic object more than 200,000 times cyclically. The result of these tests showed that polypropylene was the best material with respect to the above features.

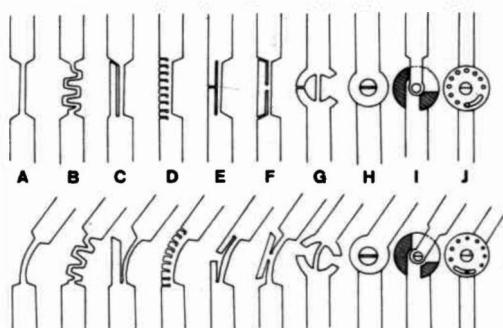


Fig. 1. Ten types of plastic joints produced for experimental use.

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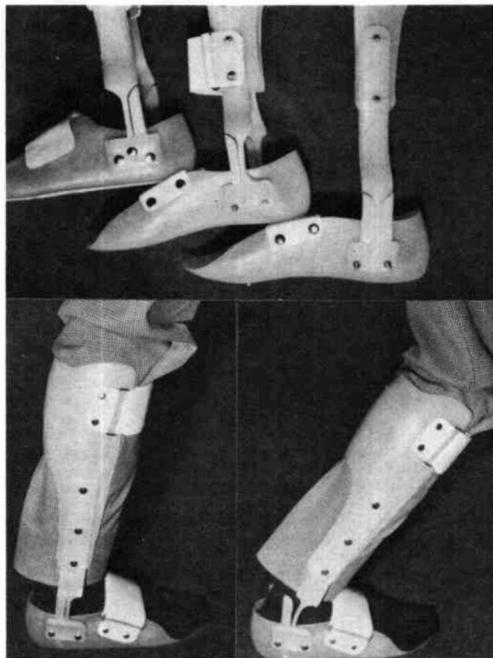


Fig. 2. Top, ankle joints showing plantarflexion stop, dorsiflexion stop and stop motion. Bottom, plastic ankle-foot orthosis with plantarflexion stop.

By cutting a part of the stopper, the plastic ankle joint can be set with a dorsiflexion stop, plantarflexion stop, limited motion or free motion (Fig. 2).

More than forty ankle foot orthoses with these plastic ankle joints were prescribed for patients with hemiplegia, peripheral nerve palsy of the lower limbs and Achilles tendon rupture and good results were obtained.

#### **Development of plastic knee joint and elbow joint**

In order to develop the new plastic knee joint, the ten plastic knee joints already mentioned (Fig. 1) were evaluated. Unlike the ankle joint, smooth flexibility up to about 130 degrees is necessary for the knee joint. Therefore, the C, D, E, and F types are not suitable.

After screening the others carefully, the circular type (G) with a small flexible plastic bar in the centre was chosen for clinical test (Fig. 3), the material again being polypropylene. The flexion angle of the knee is set for each patient according to his knee pathology.

A smaller plastic knee joint can be used as an elbow joint in an elbow orthosis (Fig. 4) and a larger one as a hip joint in a hip orthosis.



Fig. 3. Knee orthosis fitted with plastic knee joint.

#### **Discussion**

A plastic lower limb orthosis set with lateral uprights and plastic joints has an obvious advantage compared with a conventional orthosis set with metal joints or a plastic posterior leaf spring type orthosis. The newly developed plastic ankle joint has stoppers on both sides and is made to stop almost all ankle motion. It can be brought into wider application by cutting the stopper(s) in accordance with the patient's symptoms and type of disability allowing functional use of the ankle joint. Complete removal of the anterior stopper of the

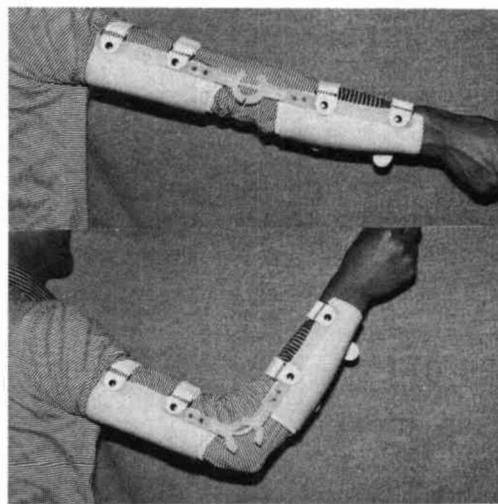


Fig. 4. Elbow orthosis with plastic elbow joint.

joint, for example, will be effective for the drop-foot condition as a plantarflexion stop ankle joint. By removing the posterior stopper, it becomes a dorsiflexion stop joint for pes calcaneus.

The plastic ankle joint is also effective for correcting varus or valgus deformity of the ankle because of its laterally positioned uprights.

The same principle can be applied to the plastic knee joint, elbow joint and hip joint. The desired flexion angle can be obtained by shaving the stopper of these joints appropriately.

Generally speaking, a lock mechanism is also necessary for the plastic knee joint and hip joint. Several locking methods (Fig. 5) have been tested but a completely satisfactory one has not been found. However this will be a theme for future research.

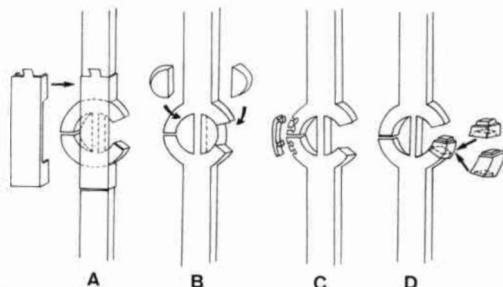


Fig. 5. Experimental locks for the plastic knee joint.

The plastic joints have been fitted to fracture patients as part of a functional orthosis (Fig. 6). They have also been fitted as quickly made orthoses or temporary orthoses with good results. Their one disadvantage is that they are less durable than metal joints.

## Summary

The main features of the newly developed plastic joints for plastic orthoses are that they are lightweight, noiseless, comfortable in use because of the coincidence of the joint axes, corrosion free, and radiolucent.

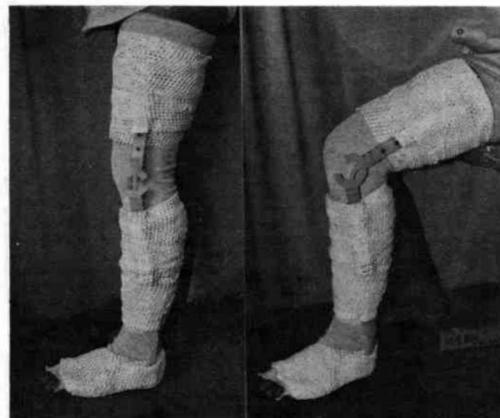


Fig. 6. Functional orthosis with plastic knee and ankle joints.

## REFERENCES

- COMMITTEE ON PROSTHETICS RESEARCH AND DEVELOPMENT (1971). Seventh workshop panel on lower extremity orthotics of the subcommittee on design and development. *Orth. and Pros.*, **25(1)**, 1-31.
- LEHNEIS, H. R. (1974). Plastic spiral ankle-foot orthoses. *Orth. and Pros.*, **28(2)**, 3-13.
- WATANABE, H. et al. (1976a). Plastic lower-limb orthoses. *Sogo Rihabiriteshon*, **4**, 53-61.
- WATANABE, H., OGATA, K., OKABE, T., AMANO, T. (1976b). The evaluation of plastic lower extremity orthoses. *J. Kumamoto Medical Society*, **50(6)**, 411-417.
- WATANABE, H. et al. (1978). Ankle-foot orthosis with newly developed plastic ankle joint. *Sogo Rihabiriteshon*, **6**, 835-840.