Orthotics and Prosthetics, Vol. 28, No. 4, pp. 23-29, December 1974

A THERMOPLASTIC STRUCTURAL AND ALIGNMENT SYSTEM FOR BELOW-KNEE PROSTHESES

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Because changes in alignment are often indicated as the amputee patient progresses through the various stages of gait training, ideally prostheses should be provided with relatively simple means of changing alignment, days, weeks, or even months after the prosthesis is first applied. Until the amputee is able to walk unaided, i.e., without crutches or canes, often changes are required in the alignment of the prosthesis owing to the increased shift of weight towards the injured side and other changes in his gait pattern.

Although the system described in this paper will not lend itself completely to extended post-fitting changes, it represents a step in that direction. The system consists of a thermoplastic polyvinyl chloride (PVC) tubing that is available commercially from plumbing supply houses. During the early fitting stage of amputee management, this tubing represents both the structural connection between the socket and foot as well as a means of aligning the prosthesis.

STATIC ALIGNMENT

For the purpose of statically aligning the prosthesis, a vertical alignment jig[2] is used with a minor modification which consists of the exchange of the mandrel bushing with a metal

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[2]VFJ-100; A. J. Hosmer Corporation, P.O. Box 37, Campbell, Calif. 95008.

sphere which is held in the mandrel clamp (Fig. 1). The sphere is drilled to receive a standard ⅞-in. pipe inserted in the plaster cast so as to permit universal movement of the cast-socket up on the alignment jig for proper orientation of the socket in space.

A polyvinyl chloride (PVC) footplug and a wood base of plywood 1.5 to 2 cm thick is fastened to the foot base of the vertical alignment jig with screws (Fig. 2). The relationship between the socket and the foot is established, using standard procedures which need not be elaborated upon here.

Once this relationship has been established, the socket is moved proximally on the vertical bar of the alignment jig, and a PVC tube with two

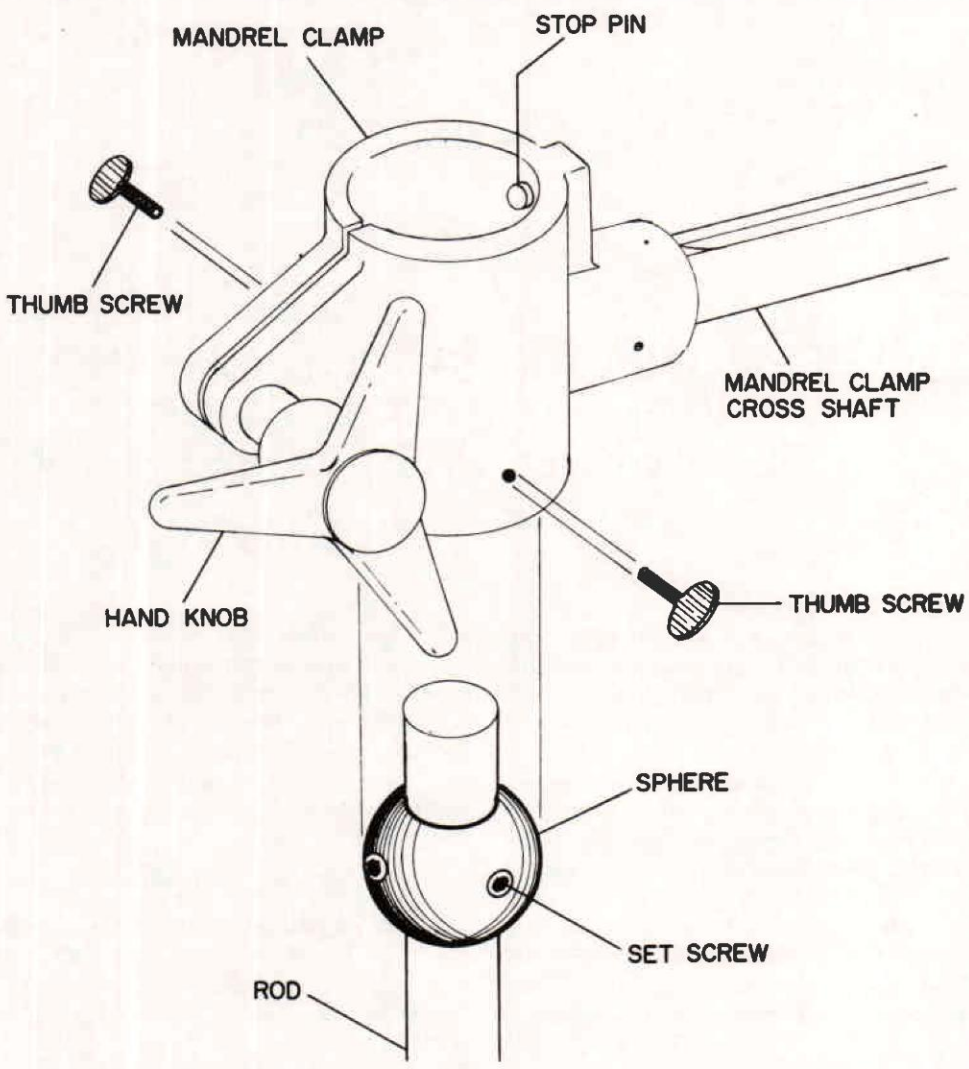

Fig. 1. Spherical insert for use with VFJ-100 fabricating jig.

longitudinal cuts of 15 cm depth at right angles to each other on the proximal end of the tubing is installed on the foot block with a hose clamp (Fig. 3). Before the tubing is cut longitudinally, two holes should be drilled through the tubing at the distal end of each of the planned cuts to prevent

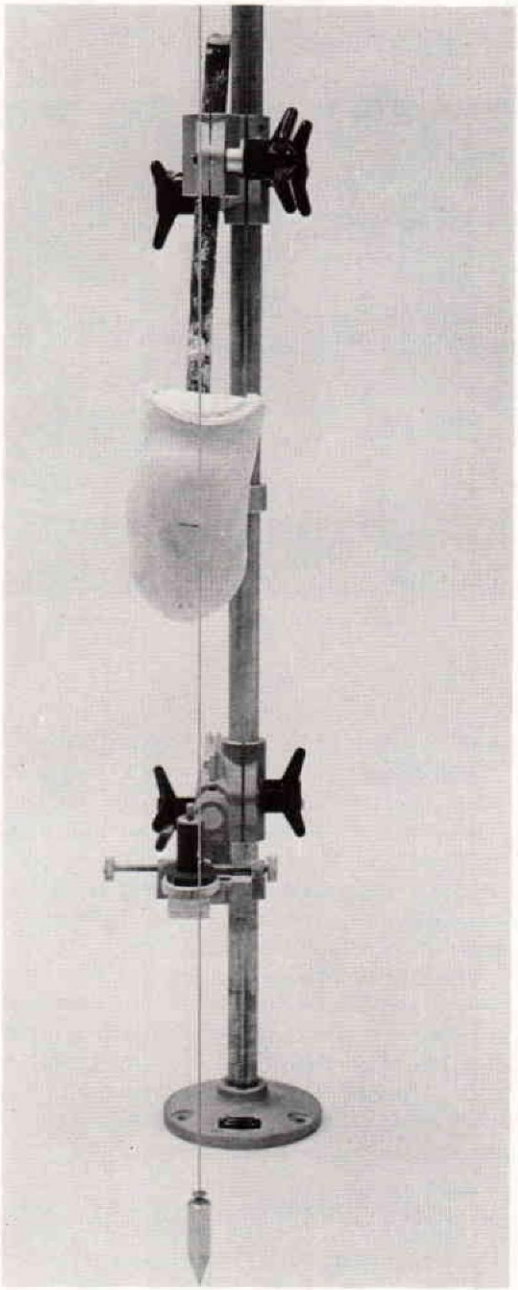

Fig. 2 A PVC footplug on a plywood base is placed in the alignment jig.

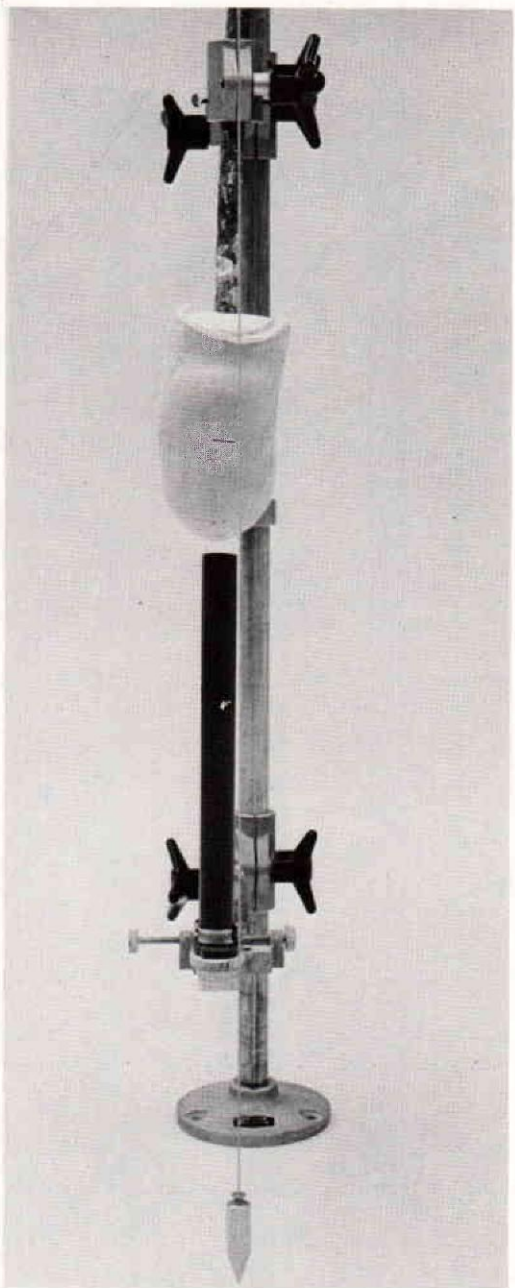

Fig. 3. Installation of the PVC tube.

stress concentrations at the end of the saw cuts.

The proximal end of the tube is heated to allow spreading of the tubing at the saw cuts made previously, and thus to produce four straps for attachment of the tube to the socket.

The socket with its outer surface roughed up is lowered to the appropriate level into the spreaded section of the tubing at the proximal end (Fig. 4). The plastic straps are heated, are made to conform to the shape of the socket, and are held in place temporarily by masking tape (Fig. 5). One layer of fiberglass stockinette is then pulled over

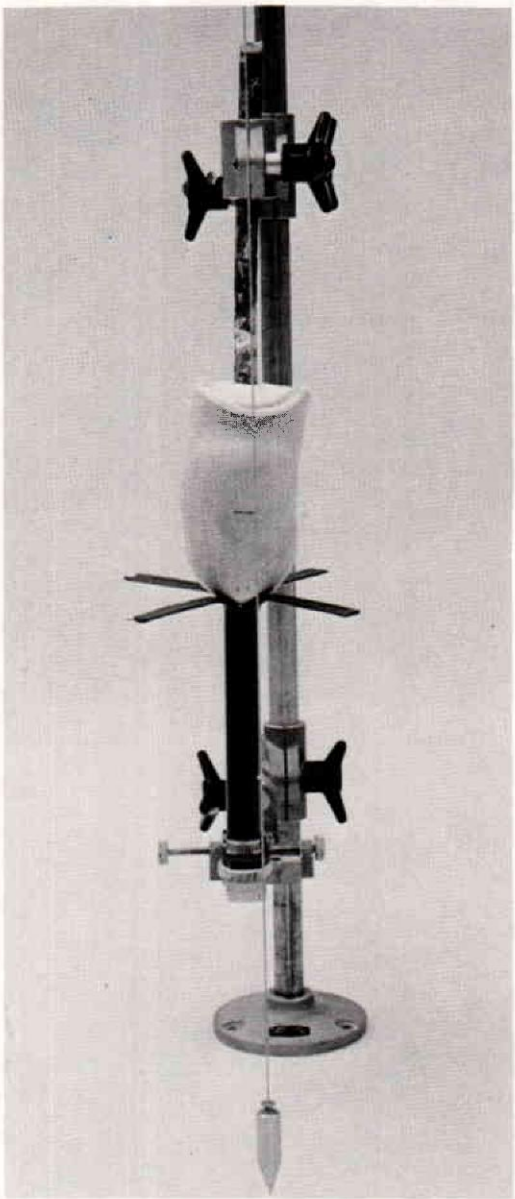

Fig. 4. View of setup showing the attachment straps before being formed in place.

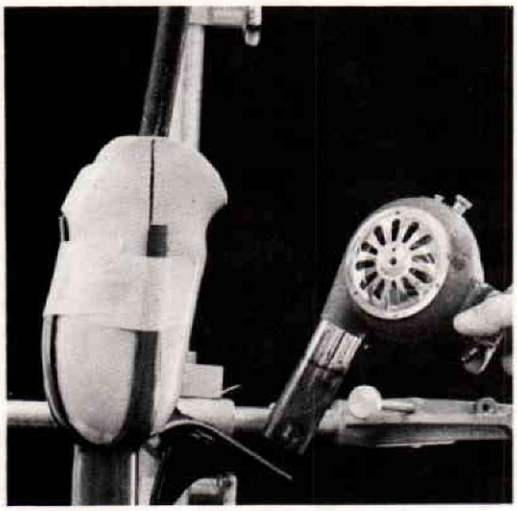

Fig. 5. First step in attaching the tube to the socket.

the PVC tubing from the foot block to the intersection of the plastic straps and the socket, at which point the fiberglass is tied to the PVC tubing (Fig. 6). A mixture of rigid polyester resin and silica powder is then spread over the socket and the plastic-strap area, and the tubular stockinette is pulled up to cover the portion of the socket over which the plastic straps extend.

When the stockinette has been pulled over the socket, additional amounts of the resin-silica mixture are spread onto the stockinette (Fig. 7). This may be done easily when plastic gloves are worn. After the resin has hardened, the foot is attached to the foot block and wooden base, and the prosthesis is ready for fitting (Fig.8).

DYNAMIC ALIGNMENT

Any alignment changes can be accomplished readily by heating the PVC tubing for either angular or translatory alignment adjustments. For example, to increase socket flexion, the proximal

tubing area should be heated near the attachment to the socket. If, however, a translatory movement is desired, e.g., anterior movement of the socket over the foot, the proximal area of the tubing immediately below the socket as well as at its attachment to the PVC plug must be heated in order to move the socket anteriorly over the foot (Fig. 9). These adjustments can be made by means of a heat gun directly on the tube while the patient is standing between parallel bars or, alternately, the adjustments indicated may be made by placing the prosthesis in the vertical alignment jig and by appropriately indexing the various adjustment scales on the jig where the alignment changes need to be made. The tubing can then be heated and a more accurate adjustment can be carried out.

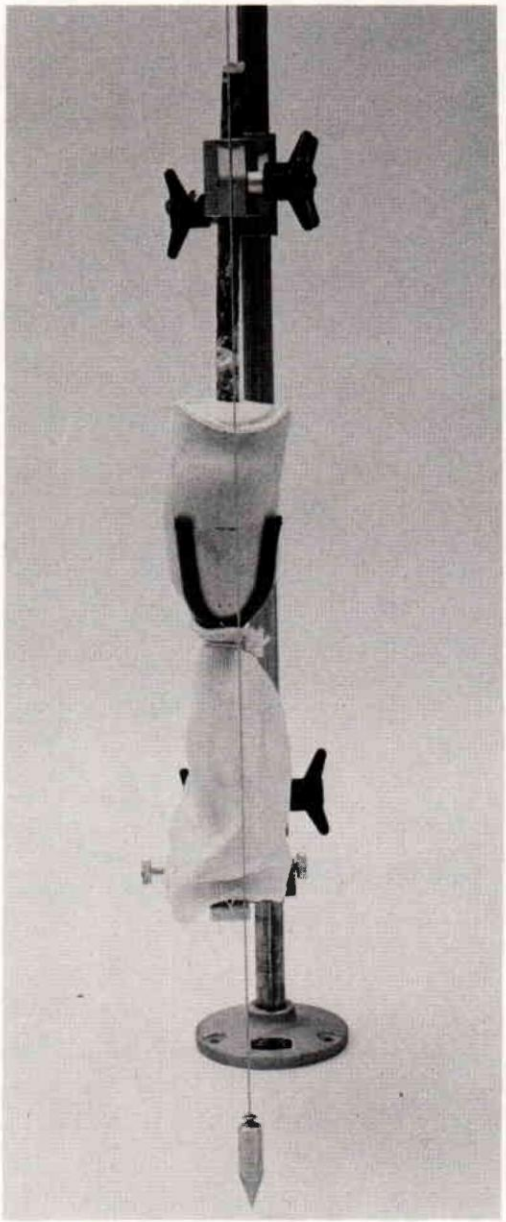

Fig. 6. Application of fiberglass stockinette used in attaching tube to socket.

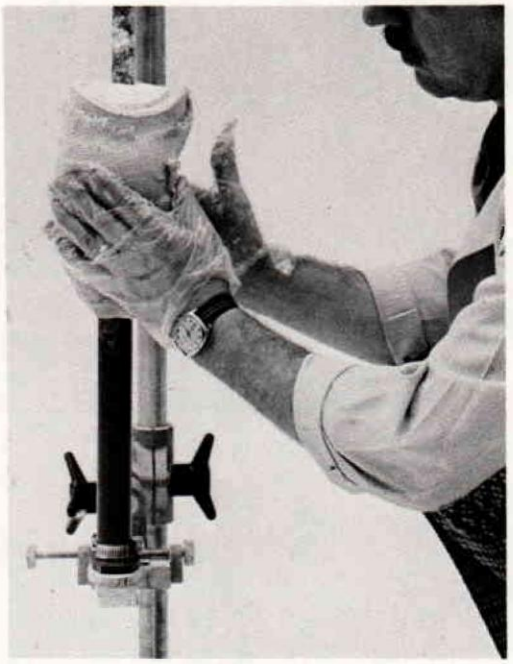

Fig. 7. Impregnating the stockinette with polyester resin and silica powder.

FINISHING

If a hard exterior finish is desired, a rigid foam buildup is made, shaped, and laminated in the conventional manner, i.e., extending from the wood ankle base over the socket.

When a soft exterior finish is desired, the PVC tubing is reinforced by laminating two layers of nylon stockinette over the tube and extending over the wood base and the socket. A soft foam cover is then applied, shaped, and finished appropriately.

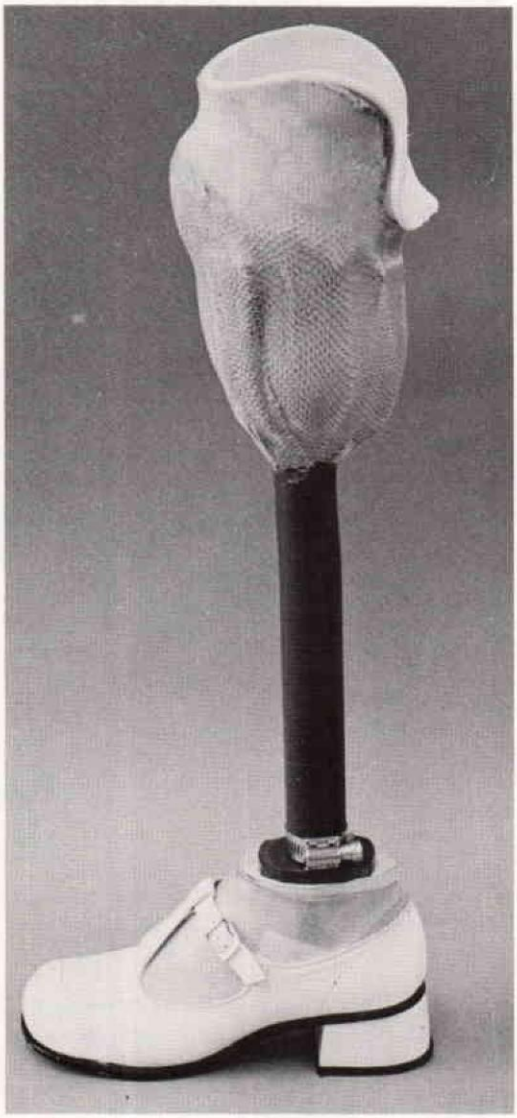

Fig. 8. Prosthesis ready for fitting.

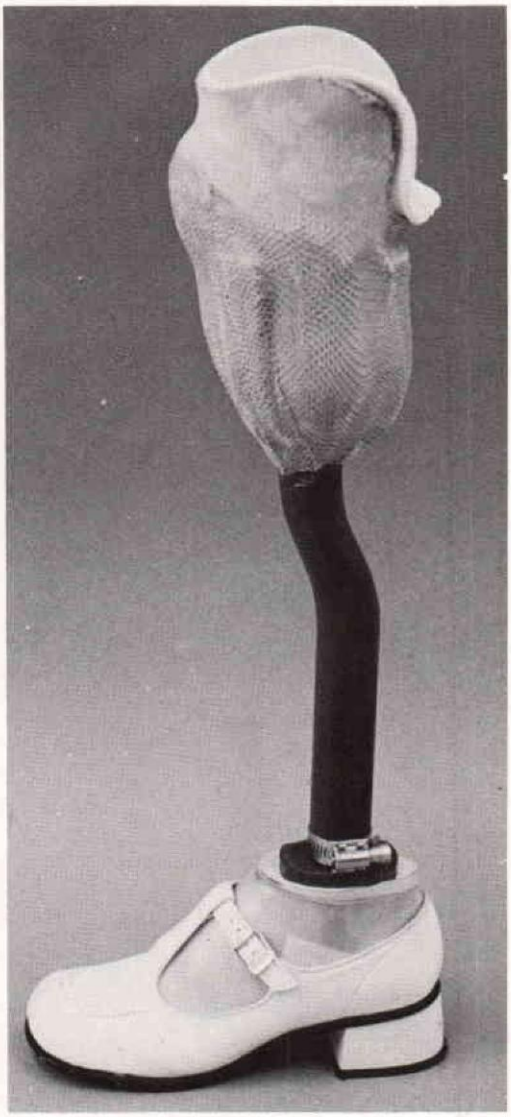

Fig. 9. Aligned prosthesis.

IMMEDIATE POSTOPERATIVE PROSTHETICS FITTING

The tube system has also been applied in a number of cases of below-knee immediate postoperative fittings, resulting in a considerable weight reduction, a condition especially important to geriatric amputees. There are no provisions for quick disconnection, but the light weight of the prosthesis seems to alleviate the need for removal of the prosthetic components from the socket.

SUMMARY

A below-knee prosthetics structural support and alignment system consisting of a PVC tube has been described. It results in extraordinary

weight reduction, especially when a soft exterior finish is intended and, at least in the early stages of prosthetics fitting, provides the possibility of infinite alignment changes to accommodate the patient's changing gait pattern. When a rigid exterior finish is indicated, this type of prosthesis is at least of the same or superior strength as the conventional BK prosthesis, and with a soft exterior finish of adequate strength when reinforced with fiberglass laminate as described above. It has also been found to possess definite advantages in postoperative prosthetics fittings in geriatric amputees to reduce the weight substantially. The utility of this system, i.e., whether a rigid or soft exterior finish is desired, or for the purpose of immediate postoperative fittings, has proven to be successful in its exclusive application for below-knee amputees over the past three years at the Institute of Rehabilitation Medicine, New York University Medical Center.