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Orthotics and Prosthetics

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Orthotics and Prosthetics

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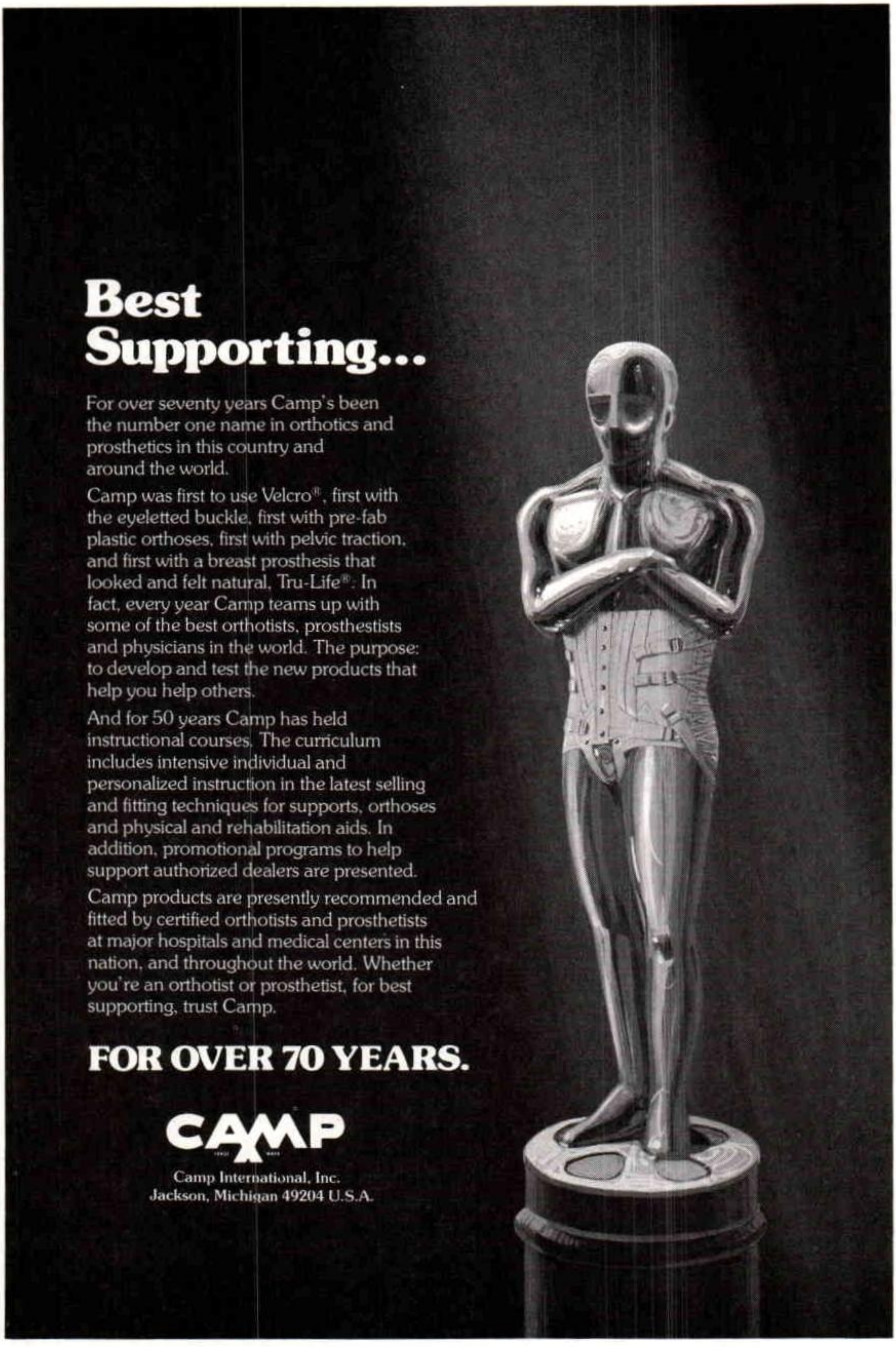
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Concerning the Orthotics Profession

Much has been made of late concerning the struggle in which the orthotic profession is engaged. This striving for professional recognition is analogous to the growing pains during the early years of general surgery, orthopaedics, and dentistry.

The quotation given below was discovered in a volume written in 1904 by the founder of the American College of Surgeons. In it, I have taken the liberty of exchanging the word "orthotist" for "surgeon" and "orthotics" for "medicine" or "surgery." The result is, I think, quite appropros of current opinion developing within the orthotics profession.

"To succeed one must make good. To fulfill the tenants of his calling an orthotist must understand diseases accurately, and appropriately manage his patients. To accomplish this he must have knowledge. To possess knowledge of the science of orthotics he must familiarize himself with the achievements of the most competent orthotists; he must make frequent visits to the masters of orthotics and witness their work; he must visit his confreres in other lands; he must know by comparison how nearly right he is, measured by the standards of his peers. When he discovers or achieves something that all medical men should know, he must be unselfish enough to present it at meetings, and to publish it in journals. He must learn to talk and he must learn to write—all of this that every patient may be benefitted by every advance in orthotic science. His best friends should be his associates, be scientific books, and the people of all classes that come to him for aid. His recreation should be a change of work, and devotion to his calling should be his greatest pleasure.

"He cannot serve two masters—society and his profession. He must learn to think. He must practice economy. He must practice orthotics as a profession and not as a business. Rich and poor are afflicted with similar diseases, and he must treat them with equal care and with equal faithfulness.

"If an orthotist makes a mistake, he must endeavor not to make the same mistake twice. If he is criticized, let him make sure that he does not deserve it. If he is misjudged by honest critics, let him endeavor to correct the misunderstanding. If he is the victim of malicious prejudice, let him ignore it. If he is unjustly attacked, let him not stoop to competitive methods. Above all, let him work to develop a judicious mind and a determination to carry out the ideals of his profession for the benefit of every human being with whom he has contact."

—Franklin H. Martin, 1904
(adapted)

I believe that we can better mold our future only if we understand our past.
Robert L. Rhodes

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Orthotics and Prosthetics, Vol. 32, No. 3, pp. 3-6, September 1978

An Ankle-Foot Orthosis For Immobilization of the Ankle

HERBERT E. KRAMER[1]
WILLIAM D. ARNOLD, M.D.[1]

New Ankle Immobilizer

A lightweight, flexible, posterior-opening ankle immobilizer (Figs. 1-4) has been designed and used at the Hospital for Special Surgery for the past four years. The appliance has been prescribed on 67 occasions for patients with severe degenerative and hemophilic arthritis, primarily for the relief of pain. Most patients have had substantially restricted ankle motion. The device has not been used to replace the standard drop-foot brace.

Structurally, the ankle-foot orthosis is flexible posteriorly at the point of entry and rigid along the anterior, medial, and lateral surfaces. This combination of flexibility and rigidity is provided to prevent dorsiflexion and to provide mediolateral stability to the ankle. A plastic foam (Pelite) is placed along the crest of the tibia to prevent excessive pressure. When a problem is anticipated over the malleolus, additional Pelite is incorporated over the positive model at the time of fabrication. The flexibility of the plastic in the posterior area affords the patient the opportunity of adjusting the appliance by the use of Velcro straps with relatively uniform pressure. Because the appliance encompasses the entire ankle region, it tends to minimize local edema, a circumstance that contributes substantially to the patient's comfort during walking and standing.

Fig. 1. The "long" ankle-foot orthosis on a hemophilic patient.

Casting Procedures

A casting board for the appropriate heel height is used. With the shank maintained in a vertical position, or as near vertical as possible mark out the anticipated problem areas and cast in the usual manner (1). Because arthritic patients may have limited motion, the foot should not be forced into an attitude that causes pain.

Fitting

Fitting for the arthritic and the hemophilic patient differs primarily in the extent to which the proximal trim line of the orthosis terminates. For the hemophilic patient the proximal border extends to three-quarters to one inch distal to the fibular head (Fig. 1). For the arthritic patient the height is less and the trim line termintes below the gastrocnemius muscle approximately six inches above the medial malleolus (Fig. 2).

Posteriorly the calcaneous is free of all plastic contact. The heel pad and the Achilles tendon at the point of insertion is exposed. The plantar surface of the orthosis terminates three-quarters of an inch posterior to the metatarsal heads extending dorsally to the mid-instep region (Fig. 3).

A lightweight leather tongue is attached to one side of the flexible plastic opening with three or four Velcro straps attached for securing the appliance. A SACH-type heel cushion with a rocker bar extending posterior to the metatarsal region of the foot is added to the shoe. This attachment of soft rubber allows for the sole of the shoe to compress, reducing the force that would otherwise be transmitted on the appliance (Fig. 4).

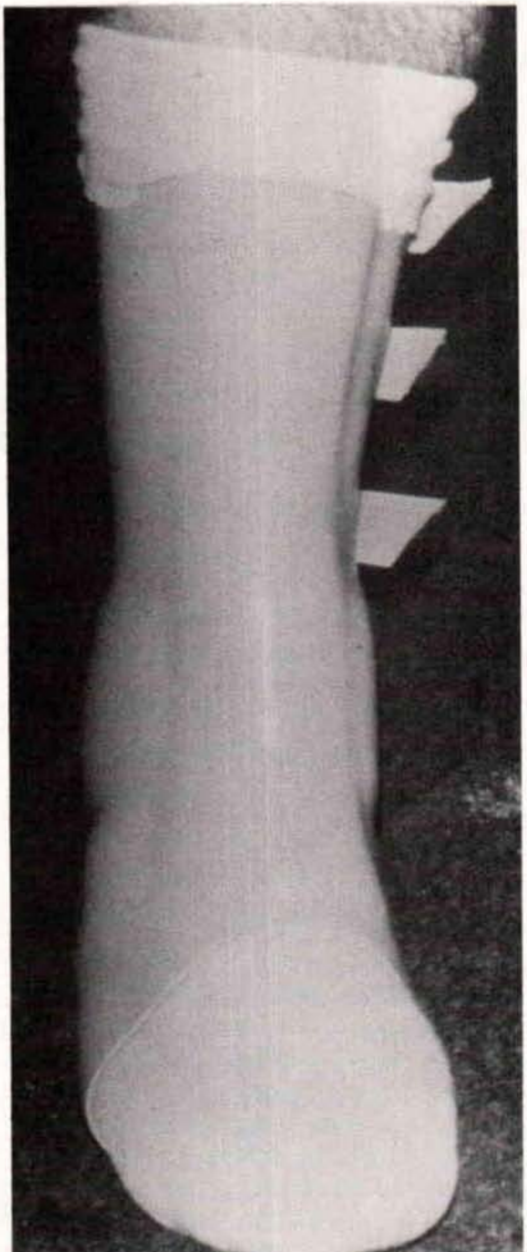


Fig. 2. The shorter length ankle-foot orthosis on an arthritic patient.

Fabrication Procedures

The materials used for the orthosis are as follows: five lengths of Banlon stockinet, five long strips and three short strips of fiberglass, a long strip of Pelite (optional), and two discs for the malleoli.

Fig. 3. Lateral view of the ankle-foot orthosis showing the length of its plantar surface.

Fig. 4. The ankle-foot orthosis and shoe adjusted with the SACH-type heel cushion.

First the Pelite, when used, is placed along the anterior aspect of the shank, extending past distal and proximal trim lines and brought anterior to the lateral and medial midlines. Secondly the discs are placed over the malleoli. This is then covered by the inner PVA sheeting sleeve and two full layers of the Banlon stockinet. Next, a long fiberglass strip consisting of five layers is placed on the anterior aspect of the shank, not extending beyond the lateral midlines. The fiberglass over the dorsum of the foot is slit so as to provide a "Y" configuration. Each arm of the "Y" is brought around the foot to form a stirrup which extends slightly posterior to the first and fifth metatarsals. The malleolar areas are not covered with fiberglass, so that these areas may be heated and extended when it is necessary to provide for relief. The five layers of fiberglass are covered with another Banlon stockinet, and the three short fiberglass layers are placed over the entire plantar aspect of the foot, covering everything with the last two Banlon stockinets and the outer PVA sleeve. The resin mix used is polyester 60%-4110 and 40%-4134. The Banlon and fiberglass may be increased by one layer if necessary for heavier adults.

Acknowledgment

The authors with to thank Mr. David Schneider for his assistance in the development of the ankle-foot orthosis.

Summary

The flexible posterior-opening ankle-foot orthosis has been remarkably well received by hemophilic and arthritic patients. It is light in weight, streamlined in appearance, and, therefore, easy to camouflage. Functionally, the unique characteristics of the material where rigidity is combined with flexibility affords the patient the opportunity of controlling the distribution of pressure over the area of the ankle.

Of the 67 patients fitted at the Hospital for Special Surgery, only a few patients encountered some difficulty. Where the dorsal trim line of the appliance blends into the plantar surface trim line of the foot, there was evidence of the plastic "creasing" at approximately the first and fifth metatarsal head regions. Consequently, this stress point must be reinforced with fiberglass during the initial lamination. Also, to reduce the stress on the orthosis on this point, the rocker bar on the plantar surface of the shoe must be maintained in good repair. In most such cases the crease was cut away which relieved the problem without interfering with the function of the orthosis. Other than the need for an occasional relief from pressure, no other significant problems were encountered.

Footnotes

[1]The Hospital of Special Surgery, 525 East 70th St., N.Y., N.Y. 10021

References

(1)Marx, Herbert, *Lower limb orthotic designs for the spastic hemiplegic patient,* Orthotics and Prosthetics, 28:2, June 1974, pp. 14-19.

Orthotics and Prosthetics, Vol. 32, No. 3, pp. 7-20, September 1978

The Polypropylene Single-Hip Spica

DAVID A. VARNAU, B.S., C.O.[1]

The polypropylene hip spica described here is a marriage of former orthotic designs (1) (Fig.1) coupled with more recent polypropylene technology. A number of practitioners have used this design in the last couple of years (12, 13). Because the costs of the finished plastic hip spica are high, its application needs to be limited to those patients that can make proper use of it.

Description

The hip spica orthosis consists of a two-piece plastic shell design (Fig. 2). The upper shell features a girdle with its proximal border high on the contralateral side to the xiphoid level and just above the iliac crest on the ipsilateral side. The girdle is contiguous with the thigh section which extends distally to mid-knee of the affected leg. The one-piece shank/ankle shell (2) is of the familiar posterior leaf-spring design (Fig. 2). Aluminum fracture-cast type of polycentric knee joints[2] are used. Finally, both upper and lower shells employ anterior openings with flexible polyethylene tongues secured with Velcro closures.

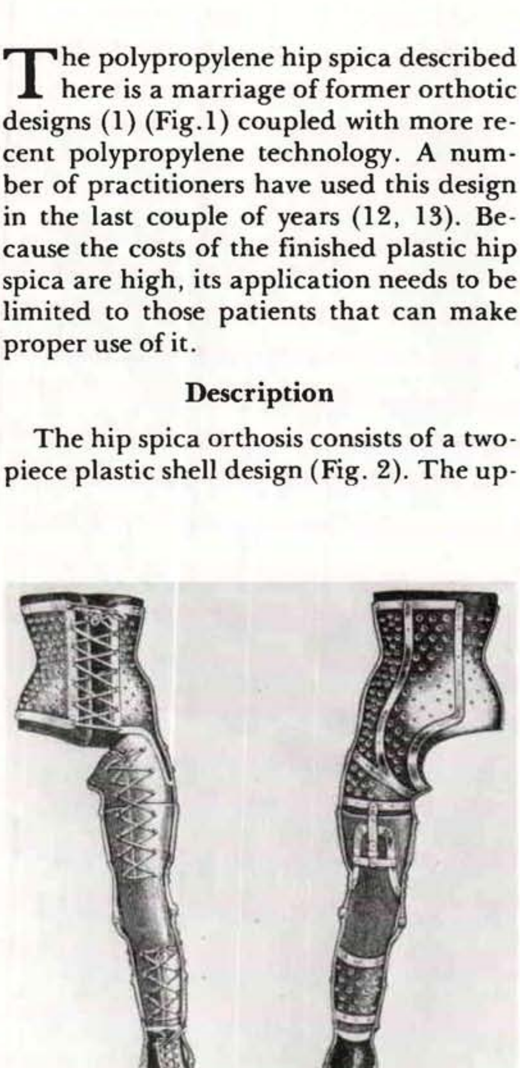


Fig. 1. Dollinger brace, circa 1880. From *Atlas of Orthopaedic Appliances*.

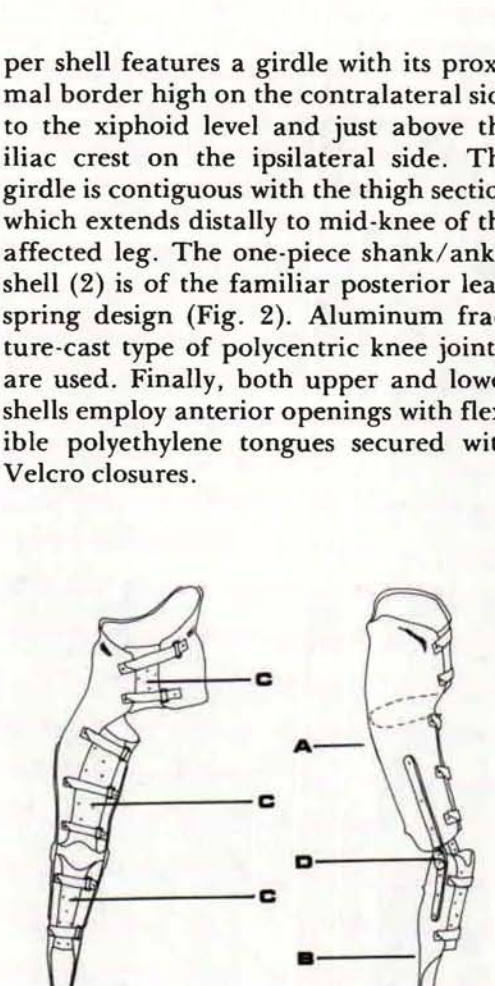


Fig. 2. Plastic hip spica with: (A) polypropylene torso/thigh shell; (B) polypropylene shank/ankle shell; (C) anterior polyethylene tongues at abdomen, thigh, pre-tibia, and (D) aluminum fracture cast polycentric knee joints.

The orthosis immobilizes the patient's hip in an attitude of abduction and slight flexion. Knee motion is free, whereas plantar flexion and dorsification are restricted.

Case Report

TMD is a 19-year-old black female with a history of sickle cell anemia. She sustained a transverse fracture of her right proximal femur (Figs. 3A and 3B). Osteomyelitis (Salmonella B and Myco fortuitum) had been confirmed by open biopsy prior to the fracture. She presented a 14 cm draining incision on her lateral right thigh (Fig. 4). Following three weeks of ten-pound traction with a tibial Steinmann pin, a plaster hip spica was applied. The wound required repacking daily and debridement weekly.

Application and removal of the spica cast on a bi-weekly basis was arduous and management of the draining would through the windowed cast could only be

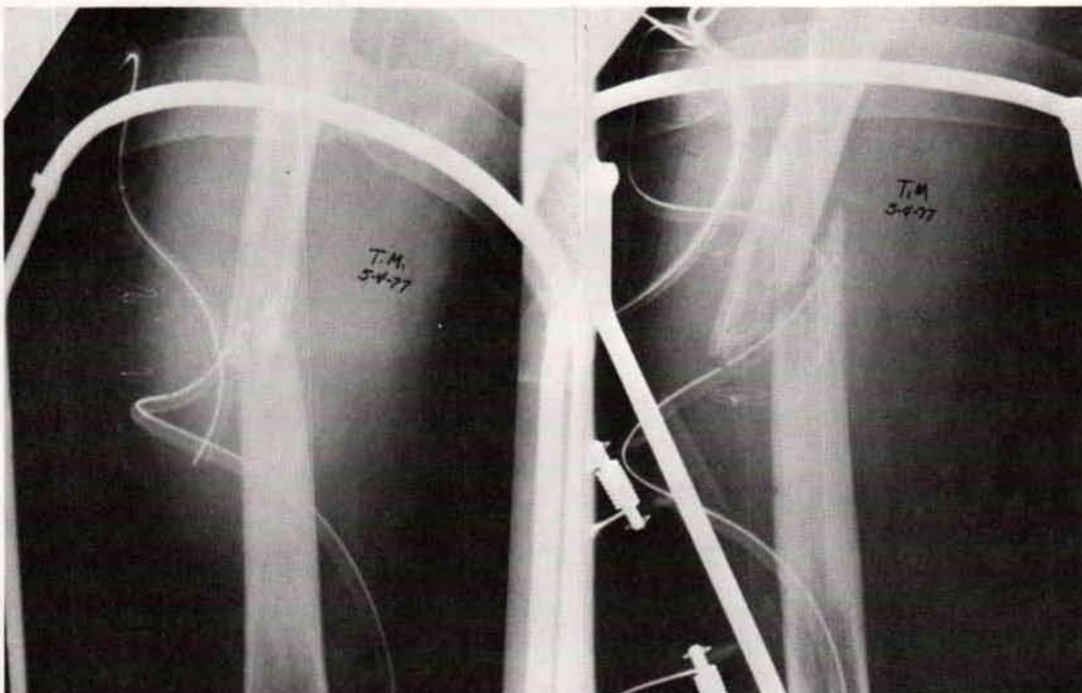


Fig. 3A. A – P view of right proximal ⅓ femoral fracture. Patient was x-rayed while in balanced traction.
Fig. 3B. Lateral view presents fractured femur with evidence of osteomyelitis at fracture site.

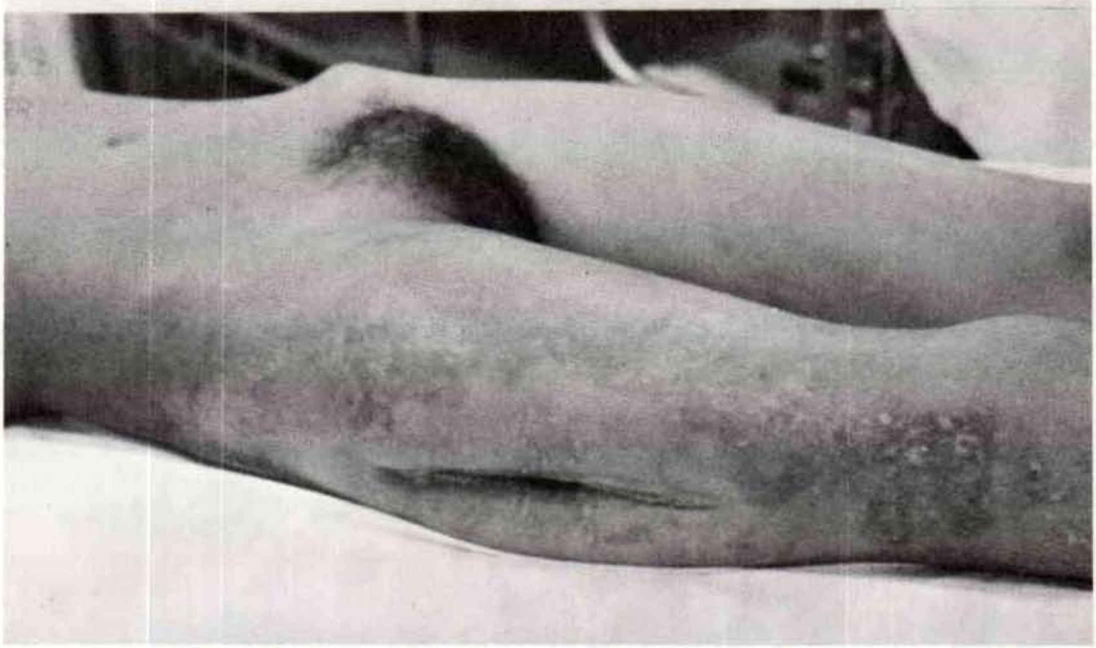


Fig. 4. The draining 14-cm long incision on patient's right lateral thigh at site of osteomyelitis and fracture.

less than optimal. One month after the first cast application, an orthotic design was requested that would be removable and washable so as to augment wound care while assuring maintenance of alignment.

Experience

The results of our first fitting of the plastic hip spica orthosis were quite pleasing. The patient's spirits brightened because of the greater mobility possible with the lightweight design (Figs. 5-9). Wound management was successfully facilitated (Figs. 10 and 11) with the orthosis, and the patient's hospital stay was shortened. Generous callous and control of the infection is apparent on X-ray (Figs. 12A and 12B) six weeks following fitting with the orthosis.

Casting

To obtain an impression for the polypropylene hip spica, the patient was placed supine[4] on a Stryker fracture table (7)(Fig. 13A) with both feet secured to the stirrups. A generous dry dressing was placed over the wound by the physician. The patient's abdomen and involved leg were wrapped with bias stockinette because application of the tubular stockinette was not feasible.

After suprailiac traction similar to the Risser casting approach (8) was established, the following landmarks were identified with a transfer pencil: anterior superior iliac spines, medial tibial plateau, pubis, and lower border of the breasts. Then measurements were taken of the following: ASIS-to-MTP and MTP-to-base of heel. A cast removal strip was applied anteriorly.

Fig. 5. Ant. view of patient wearing the plastic hip spica. Note that although patient is standing with her feet together, her right hip is actually abducted 15 deg.

Fig. 6. Anterior view of patient showing more detail.

Care was taken to assure that during the casting the ipsilateral hip was held in the position the physician requested, namely, 15° abduction and 15° flexion. The knee was maintained in extension and the ankle was kept in neutral.

To obtain a negative model, wrapping began with the abdomen and proceeded distally to the knee center. After a brief period to allow the plaster to set, the upper cast impression was removed. Meanwhile, the patient's right foot was freed and held with manual traction while the cast impression was taken of the lower leg, beginning with the knee center and

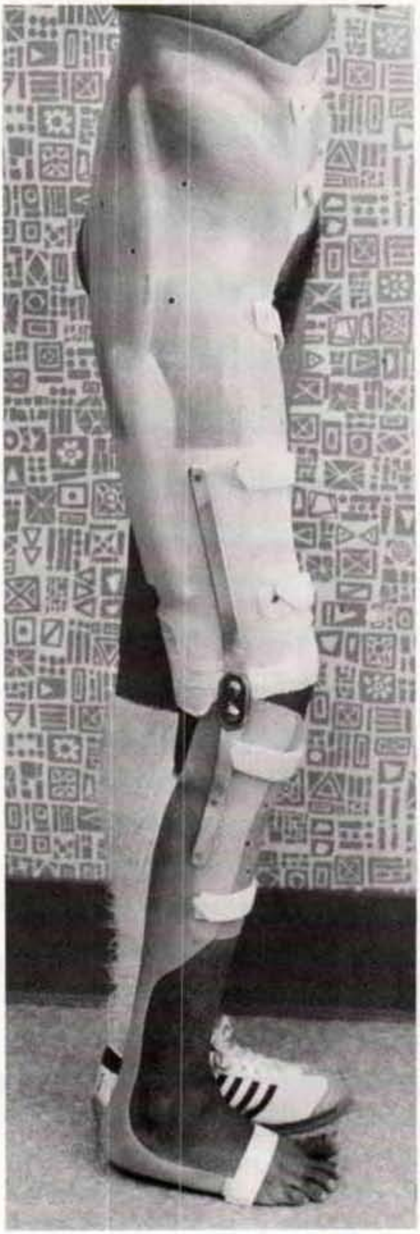


Fig. 7. Ipsilateral side, lateral view. Hip is flexed 15 deg for comfortable sitting. But because hip is flexed, knee must also be flexed for erect standing. A shoe with a heel wedge is indicated.

Fig. 8. Contralateral side, lateral view. Proximal trim is at xiphoid level. Distal trim is 2 in. above pubic level.

Fig. 9. Posterior view. Since patient complained of occasional pinching of right buttock, trim should be located more laterally for comfortable sitting.

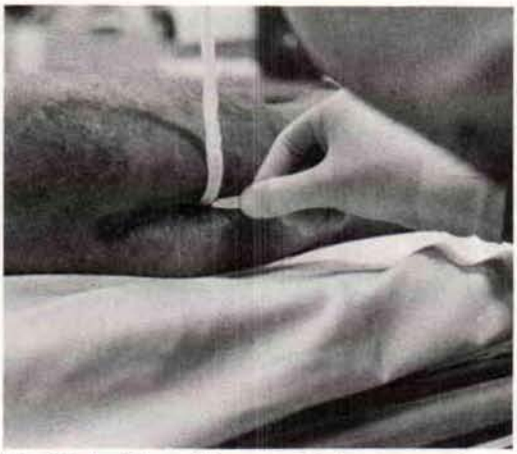


Fig. 10. Packing of the wound following careful removal of orthosis.

proceeding distally. Thus, the negative model was obtained in two sections (Fig. 13B). This facilitated its removal and permitted the physicians to more quickly begin reapplying a walking spica cast which was to be worn until the orthosis could be made and fitted.

Cast Modification

Positive model modification of the torso is similar to that of the Milwaukee cast. Following removal of the negative mold from the positive model (Fig. 14), the bony landmarks are re-identified. Plaster is added to the postero-lateral lumbar areas to provide symmetrically relief of muscle attachment at the iliac crests.

Anteriorly, the positive mold is modified, while the pelvis is maintained in a symmetrical position. Plaster is cut away to create a groove in the waistline to "provide a comfortable purchase on the soft tissues over the pelvis" (3), and to accommodate fulcrum action of the orthosis (Fig. 15). The iliac crests and the anterior

Fig. 11. After application of a dry dressing, bias stockinet is wrapped on leg to absorb any perspiration in the orthosis.

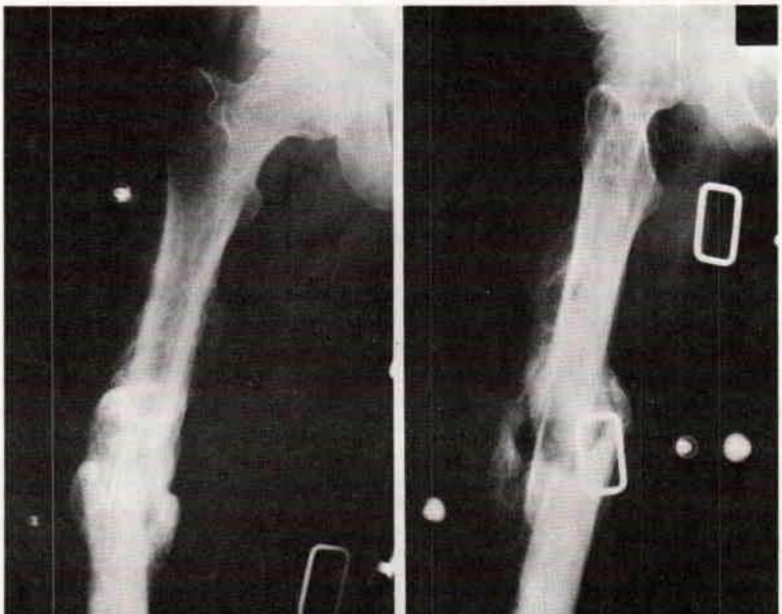
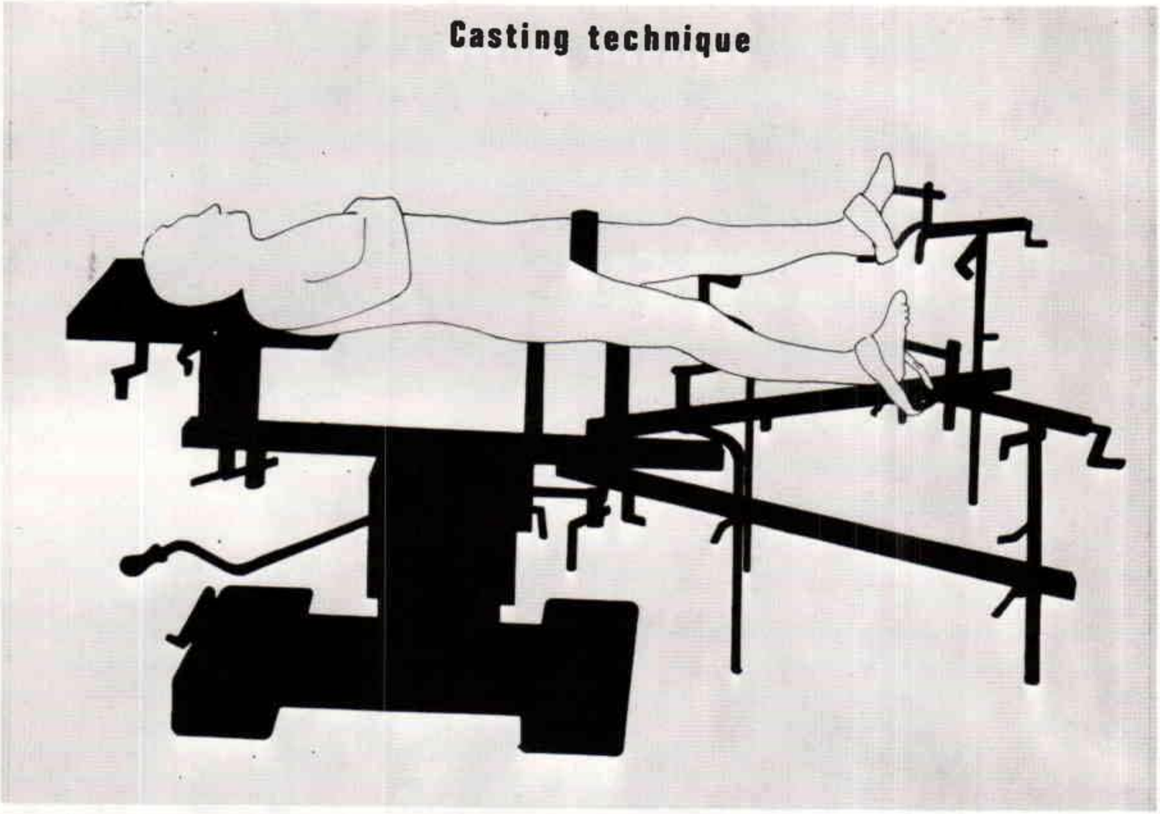


Fig. 12A. A-P view of fracture 6 weeks after fitting with the orthosis, 14 weeks post-injury. Note generous callous formation. Some varus angulation was accepted. Fig. 12B. Lateral view.



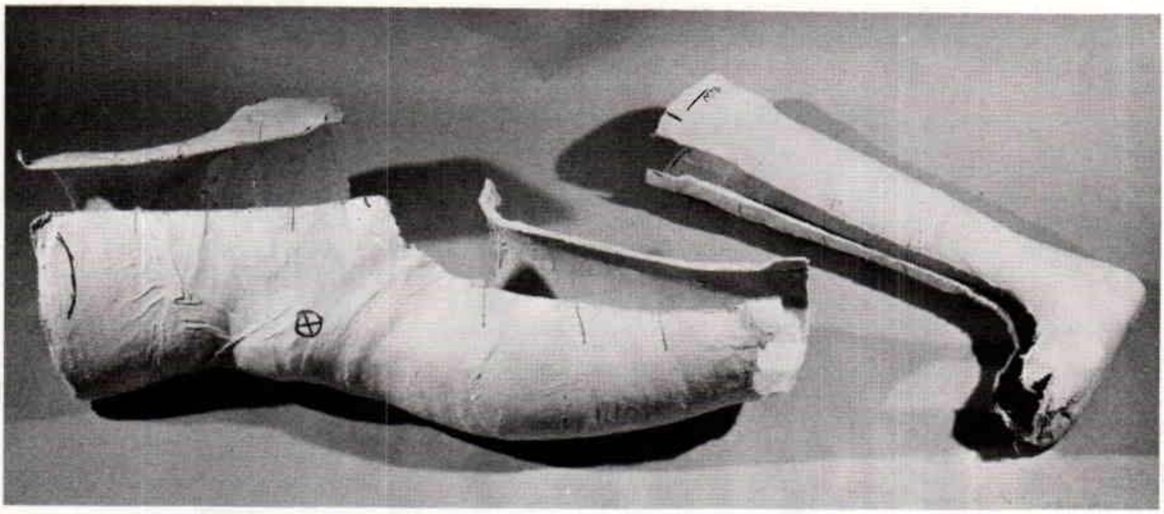


Fig. 13A. Patient is positioned on fracture table while the negative model is obtained. The fracture table shown above is the same as those commonly used in orthopedics for applying a conventional plaster hip spica. Fig. 13B. Negative model following removal from patient. Model was taken in upper and lower sections and the two sections were referenced to each other.

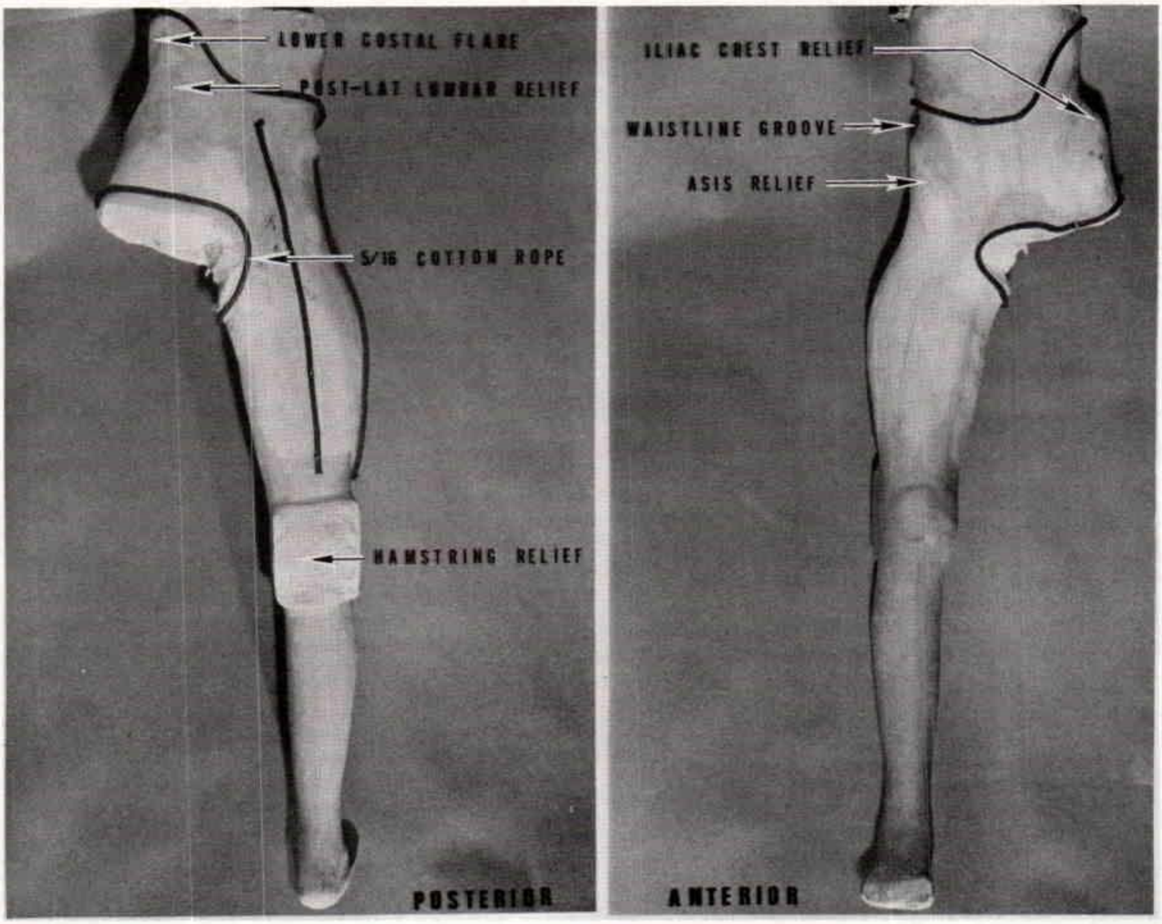


Fig. 14. Positive model modifications. Cotton rope (dyed for photographic contrast) provided a continuous flare of torso trim lines. The rope is also used on the posterior and lateral thigh to create corrugations for added strength.

superior spines are built up with a ¼-inch plaster relief which continues anteriorly and distally to the pubic level (Fig. 14). A flared plaster build-up is added just above the waistline groove to prevent impingement on the lower costal margin. Finally, provision for comfortable flexed-knee sitting is made by adding hamstring reliefs on the posterior knee area. Nylon-core cotton rope 5/16-inch in diameter nailed to the cast serves as an ideal method for providing a continuous flare at the torso trim lines, both proximally and distally. Moreover, the rope is used along the posterior aspect of the thigh and buttocks area to create corrugations in the plastic to provide additional resistance to buckling.

Fabrication

The initial stage of fabrication includes the construction of the anterior

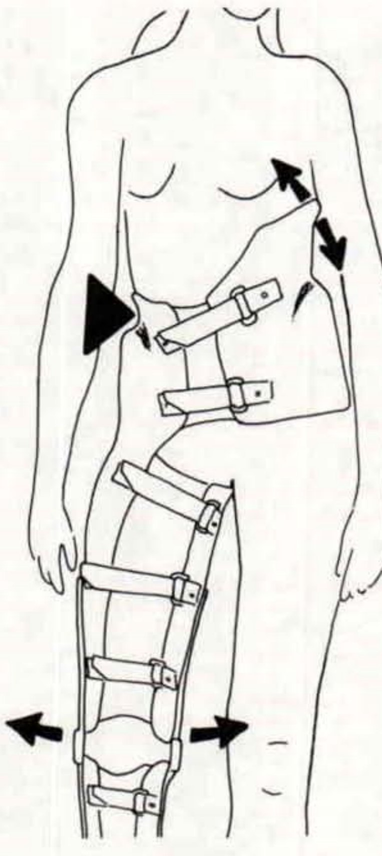


Fig. 15. The waistline grooves are recommended to prevent irritation of iliac crests due to any slight mediolateral fulcrum action of the orthosis.

tongues. Recommended is 1/16-inch polyethylene heated to 285°F and molded over the cast. The material is stretched completely around the cast and sealed to itself to assure good conformity to the patient's contours.

The fabrication of the lower polypropylene is at 410°F under vacuum in the usual manner (2) (11).

Molding polypropylene over the upper section, however, is far more difficult. The standard drape-molding technique for stretching an undersized piece of polypropylene over a large, irregular cast was repeatedly unsuccessful. The polypropylene could not be stretched sufficiently. To solve this problem, four pieces of aluminum angle stock were clamped together with the plastic sandwiched between (Fig. 16). These bars, fastened on the two long sides of the plastic, provided the fabricators with a means (Fig. 17) of stretching the polypropylene uniformly.[5] Just after sealing the polypropylene to itself, the bars were cut free from the molten plastic to avoid hindering the molding process. To compensate for the stretching of the plastic during molding, thicker polypropylene 3/16-inch thick was used.

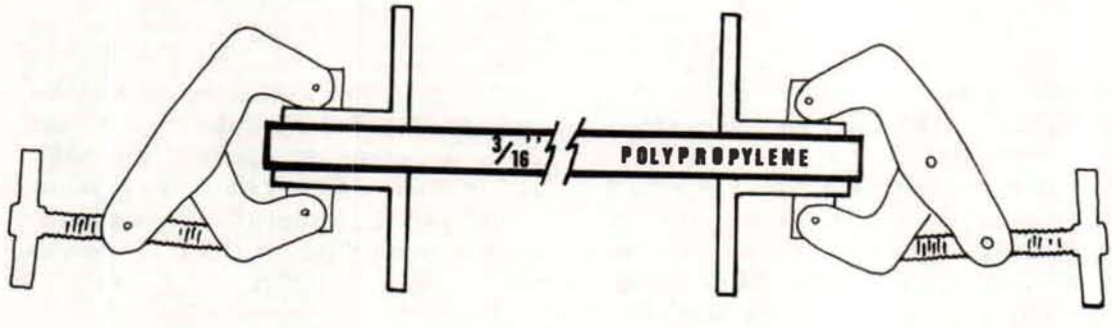


Fig. 16. Prior to heating the pastic in the oven, two pieces of angle aluminum are clamped together with the polypropylene sandwiched between on each long edge of the plastic.

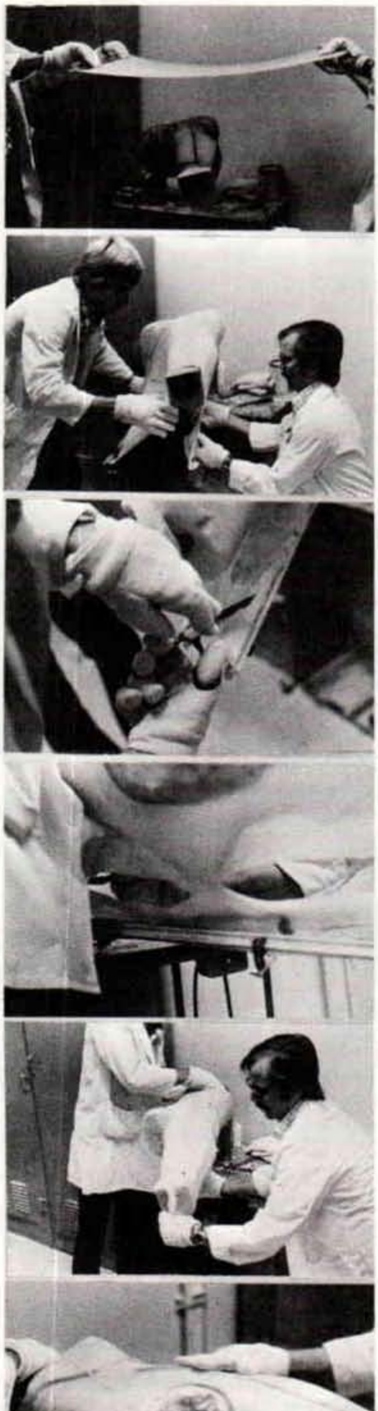


Fig. 17. Fabrication series, from top to bottom, illustrates: stretching of the plastic, drawing it around the cast, trimming the angle aluminum free, sealing the plastic, and finally obtaining vacuum.

Assembly

The polypropylene shells were trimmed and replaced on the positive model. Polycentric knee joints were aligned, contoured and riveted to the shells. The anterior tongues were trimmed and secured in position. Finally, Dacron-backed Velcro closures were attached to the finished orthosis (Figs. 18-20).

Special Considerations

The patient found it impossible to don a shoe independently on her affected side, owing to a very stiff knee initially, and to the fact that ipsilateral hip motion was prevented by the orthosis.

Alternate designs for the polypropylene hip spica orthosis have been used by Irons (6), Donaldson (4) and Voner (10). Specifically, one variation of the design described merely consisted of a "mini-spica" without the lower shell and knee joints (Fig. 21). In another case, the shank section *was* employed but using a polypropylene tibial fracture orthosis design that immobilized the lower leg and prevented rotational movements in the ankle. The latter effectively blocks ankle motion—a feature that our design at UCLA did not include. Furthermore, Irons et al. also report fabricating the plastic "mini-spica" orthosis from another patient's positive model that, with some modification, provided adequate fit and alignment of the bony segments. The casting procedure was thereby eliminated in that instance.

Fig. 18. Anterior view of completed orthosis.

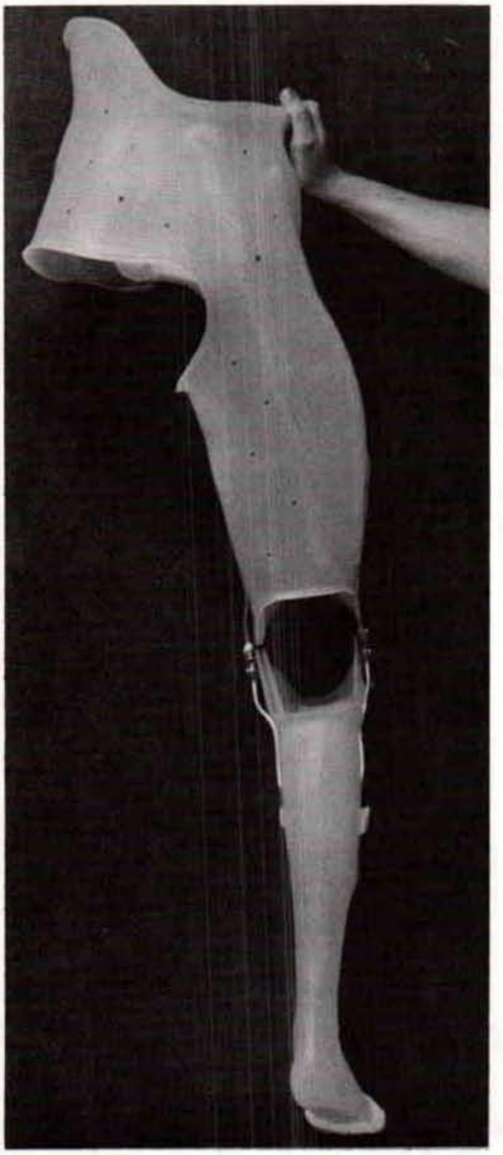


Fig. 19. Lateral view of completed orthosis.

Other Applications

Obvious uses of the plastic hip spica are numerous. Besides that of treating delayed union of proximal femoral fractures, other indications might include long term post-operative immobilization following hip fusion, and unstable hip arthroplasty. The "mini-spica" can be used to support the inflamed arthritic hip and thereby relieve pain (7). Older, debilitated patients, especially, can benefit from the lightweight feature of the orthosis and thus avoid disuse-osteoporosis.

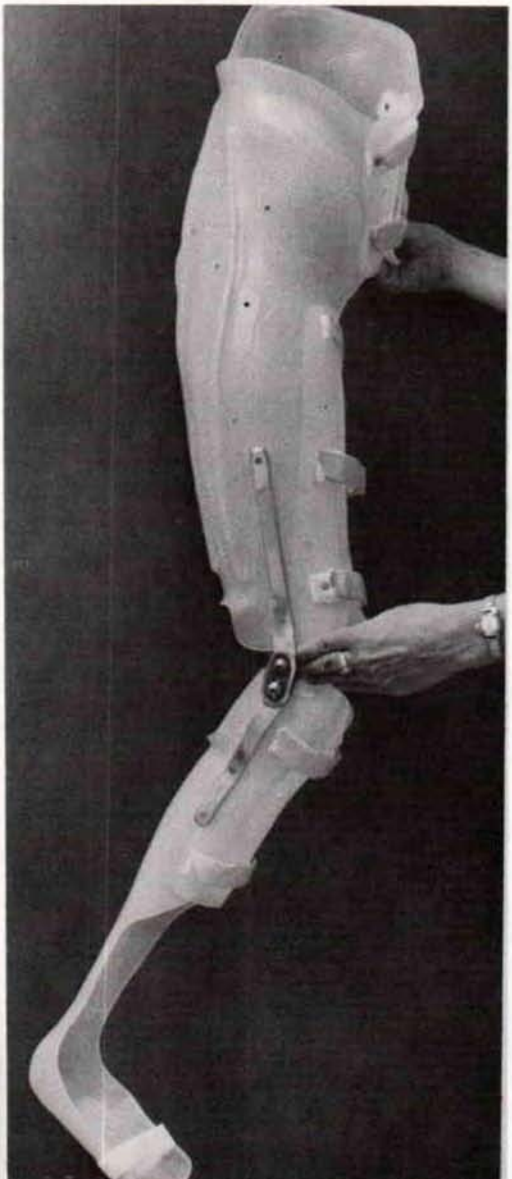


Fig. 20. Posterior view of completed orthosis.

Conclusion

A polypropylene single hip spica offers the patient and the physician many advantages. In certain cases, treatment with the orthosis is not only more convenient but far superior.

Summary

A molded single hip spica has been described. Its special features of being removable and washable were cited. Use of the plastic spica has been reported on a patient with a proximal femoral fracture, osteomyelitis and draining wound. All stages of the fabrication sequence were detailed. Variations of the design have been mentioned. A special drape-molding technique used in the fabrication has been introduced.

Acknowledgment

I would like to express my appreciation to George Irons, C.P.O. and Neal Donaldson, C.P. for their consultation and prior design formulation. My thanks go, also, to Barry Townsend and the members of the UCLA Prosthetic-Orthotic Laboratory Staff for their assistance in all phases of the process. Special attention should be given to Jim Baird for his innovation of the special drape-molding procedure. Finally, tribute is given here to Dennis Sakai, M.D.[6] for providing us with the challenge.

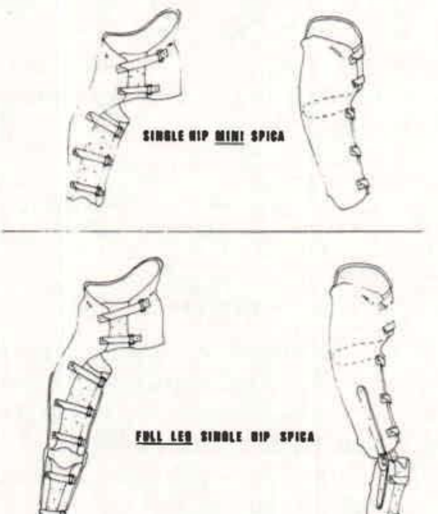


Fig. 21. The three variations of the polypropylene single hip spica orthosis.

Footnotes

[1]Clinical Orthotist, UCLA Prosthetic-Orthotic Laboratory, Center for the Health Sciences, UCLA Hospital and Clinics, Los Angeles, California 90024

[2]United States Manufacturing, Glendale, California

[3]Slight hip flexion is advisable to provide comfort while the patient is sitting.

[4]Certain patient conditions may permit casting of the patient while the patient is standing (5).

[5]This special technique has proven to be indispensible in drape-molding items such as large body jackets where the circumferential dimension is appreciably greater than the size of plastic sheet the oven can accommodate.

[6]Assistant Professor, Division of Orthopedic Surgery, School of Medicine, University of California at Los Angeles.

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Orthotics and Prosthetics, Vol. 32, No. 3, pp. 21-24, September 1978

Spenco-Lynadure Soft Inserts

MICHAEL T. WILSON, C.P.O.[1]

Soft interfacing material for prosthetic sockets have been used routinely for years when the mechanical and physiological condition of the residual limb is incompatible with the rigid properties of the prosthetic socket necessary to maintain dimensional stability. The primary function of soft interfacing is to dissipate resultant pressures on the limb during weightbearing. Secondary functions are to accommodate or compensate for minor discrepancies in socket design, to assist in donning supra-condylar sockets, and to allow for skeletal growth.

A comprehensive description of fabrication techniques and clinical applications has been presented by Radcliffe and Foort (1) in 1961. The interface suggested then consisted of a rather firm expanded rubber (Kemblo) and horsehide glued together. During the last decade, this type of insert has been replaced largely by expanded thermoplastics because they are lighter, are easier and quicker to use in fabrication, and are easy to keep clean. However, some of the physical properties of the thermoplastics are inconsistent with the physical requirements of the insert, the main problem being "cold flow" of the material. Some types of thermoplastics present less problems than others, but to one degree or another, all are susceptible to gradual dimensional changes caused by sustained and prolonged pressure. This problem is aggravated by the heat given off by the body.

With this in mind, the evaluation of new insert materials and techniques that would combine the favorable qualities of both Kemblo inserts (dimensional stability) with thermoplastic inserts (lightness and hygiene), seemed appropriate. The result of this evaluation is an insert made of expanded neoprene lined with nylon on the inside (Spenco), and laminated to nylon stockinet impregnated with a RTV urethane elastomer (Lynadure) on the outside. The combination of these materials results in an insert that is not only as structurally stable as Kemblo, and as light and hygenic as thermoplastics, but has several other favorable qualities with respect to use as an interface material. Unlike thermoplastics, neoprene is not heat sensitive, and is virtually 100 per cent resilient. There are no cold flow problems, and yet neoprene is remarkably soft and forgiving. Expanded neoprene (Spenco) also has an incredible capacity to absorb shear forces generated between the limb and socket, a property particularly appropriate in the fitting of dysvascular or burn patients. Spenco-Lynadure liners are very light in comparison with Kemblo inserts. They are extremely hygienic because they can be removed from the prosthesis, and washed by machine.

Fabrication

The type of Spenco to be used should be closed-cell 1/8-inch thick, with tex-

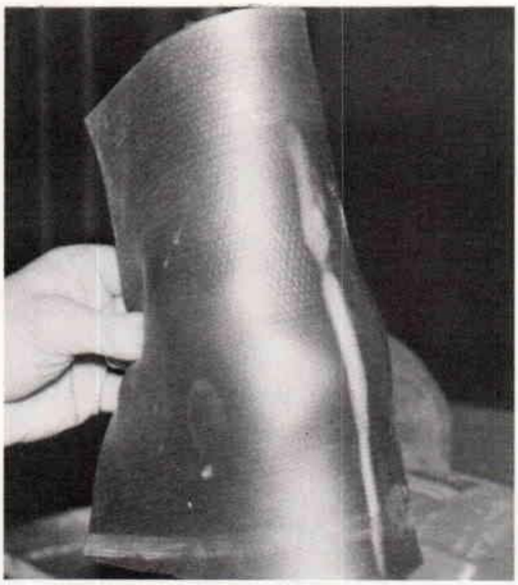

Fig. 1. The Spenco material is wrapped around the positive model, anterior to posterior, and the anterior centerline is marked with chalk.

Fig. 2. The posterior centerline is marked on both flaps of the Spenco material.

tured backing. The Spenco material is draped around the plaster positive, anterior to posterior, and the anterior centerline is marked with chalk (Fig. 1). Without the use of Yates clamps, the posterior centerline of the positive model is located and marked on either fold of the Spenco sheet (Fig. 2). The Spenco is removed from the positive model, and is folded in half along the chalk marking on the anterior part. A four-stitch-per-inch seam is used to sew along the posterior marking. Oil or Vaseline will help in feeding the material through the machine (Fig. 3).

After the Spenco has been sewn, it is pulled over the positive model. No longitudinal or peripheral tension should be present. The Spenco is sanded with wet-and-dry sandpaper dipped in TGW neoprene primer until the neoprene becomes rough and sticky from abrasion and chemical decomposition (Fig. 4). Closed-cell 1/4-inch neoprene is glued over the distal end of the Spenco for additional padding. Both surfaces must be primed and sanded before glueing. Figure 5 illustrates a supracondylar type insert with the attached distal pad, and with several layers of Kemblo glued together proximal to the medial condyle. Electrician's tape is used over the seam so that the Lynadure cannot seep between the stiches. Directly over the Spenco, the distal pad, and the Kemblo wedge, one or more layers of a nylon stockinet is applied with as little peripheral tension as possible. A PVA sleeve is pulled over the stockinet, smooth side in, and the atmospheric pressure is reduced by 1-3 inches of mercury, or just enough to pull the Spenco into the recesses of the plaster positive.

The Lynadure is introduced through the small end of the PVA sleeve. The

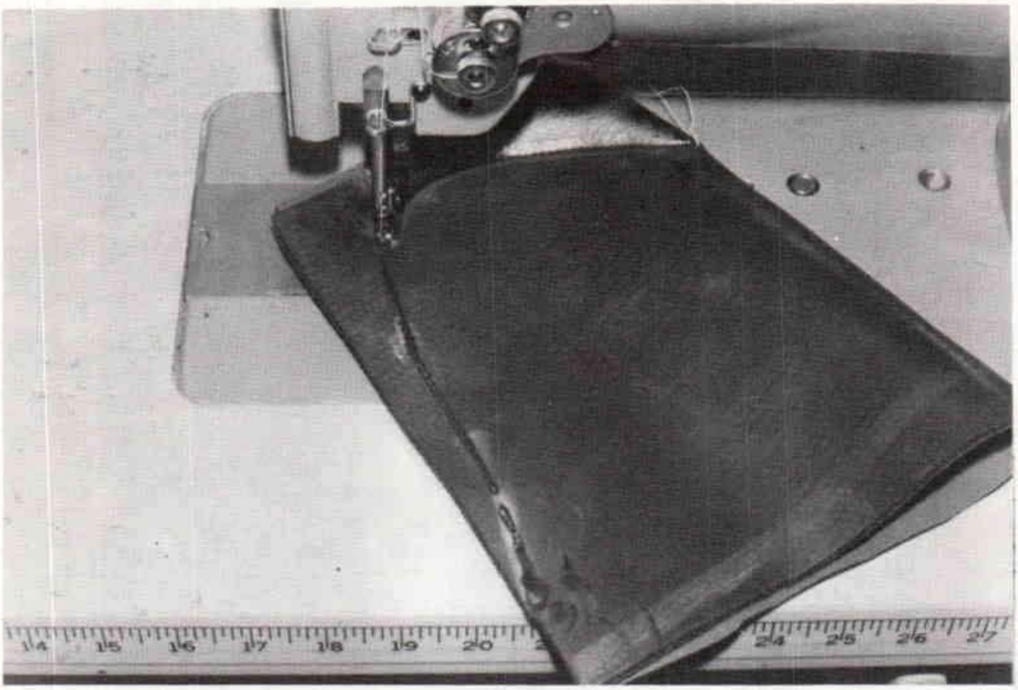

Fig. 3. A four-stitch-per-inch seam is used to sew along the posterior margin.

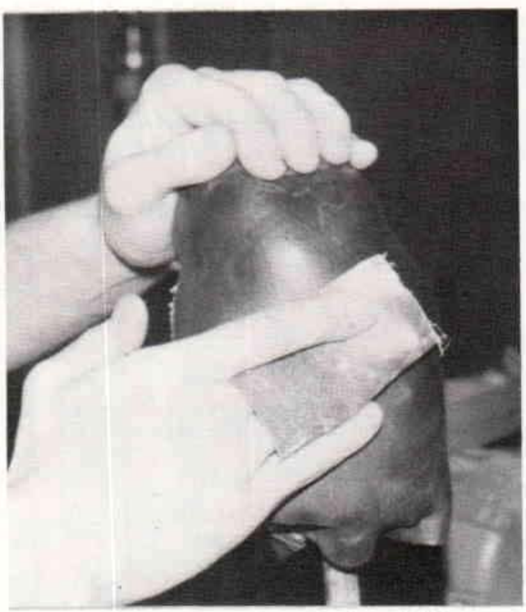

Fig. 4. The outer surface is sanded until it becomes rough and sticky.

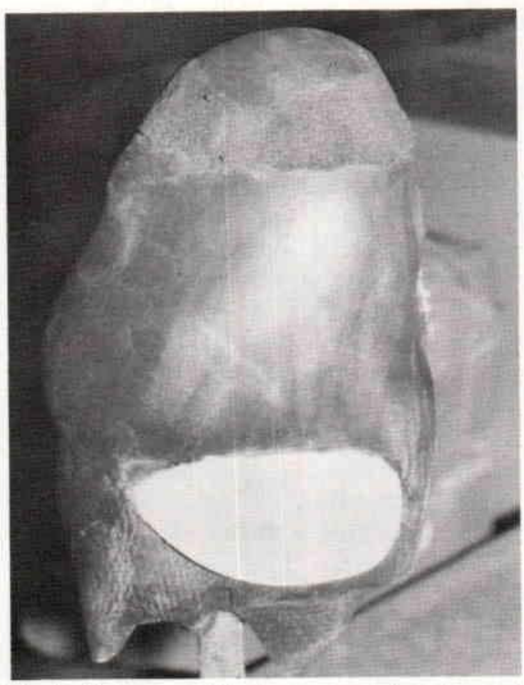

Fig. 5. A supracondylar insert consisting of several layers of Kemblo glued together may be used.

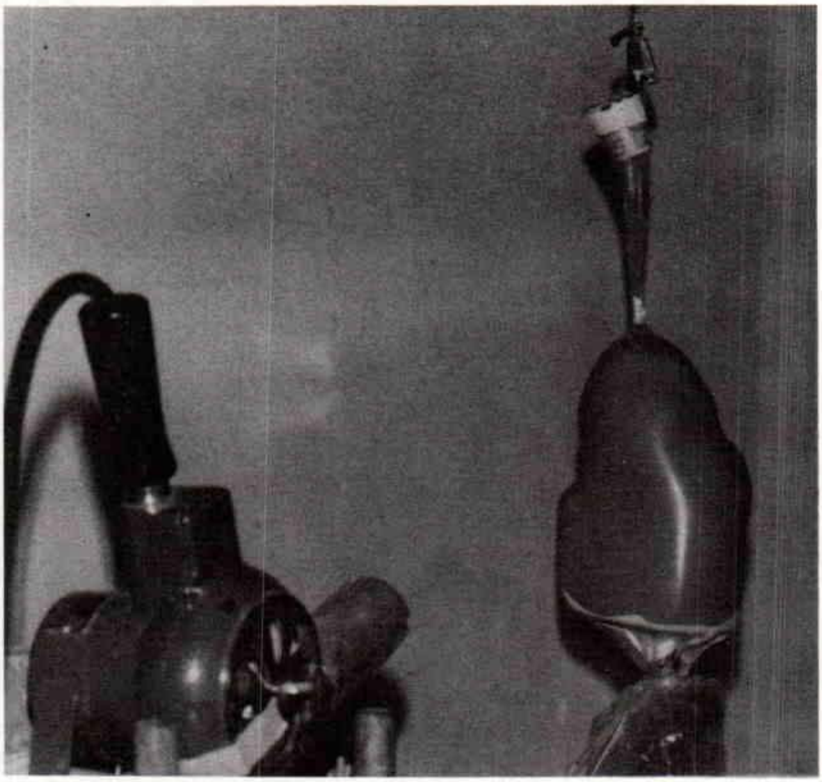

Fig. 6. Demoulding time can be reduced by use of a heat gun.

mixing ratio of Lynadure is 10 parts resin to 3 parts promoter. Pot life (working time) at room temperature is about 7-10 minutes. Demolding time can be accelerated to about 30 minutes with heat (180 deg. to 200 deg. F. (Fig. 6). It is best to laminate the plastic socket directly over the Lynadure while it is still in the curing stage. To make more efficient use of time and materials, the heat generated from the polyester curing cycle provides a near perfect temperature for the curing of the Lynadure. The shelf-life of Lynadure is 12-16 weeks after the container is opened.

I have used these inserts routinely in my own practice for about 12 months with very good results. Patients must apply the liner to the limb, and then insert both liner and limb into the socket. The only problem so far is the tendency for the Lynadure to delaminate from the Spenco, a problem that can be avoided if the Spenco is sanded and primed adequately before laminating with Lynadure.

Footnotes

[1]Medical Care Services, Inc., 1259 Monument Boulevard, Concord, California 94520

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Orthotics and Prosthetics, Vol. 32, No. 3, PP. 25-31, September 1978

Orthotic Management for Genu Recurvatum and Genu Varus

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MARGARET M. KENDRICK, M.D.[2]

"Necessity is the mother of invention." In this particular case study, the patient refused to have surgery and anti-inflammatory drugs were ineffective. We turned to orthotic management as a solution to the problem.

The patient is a 60-year-old white female, registered nurse who had genu varus on the right side and bilateral genu recurvatum, more severe on the left (Fig. 1). She had had these problems all her life but they had been getting worse gradually. This condition posed no problem until 1968 after a ten-mile hike. Because she thought that her knee pain was the result of not being in condition, she repeated the same prolonged walk the following day. When the pain did not abate, she sought medical care, and being a military dependent, was seen at a government installation.

Blood studies ruled out rheumatoid arthritis or other collagenvascular diseases. Her sedimentation rate was elevated slightly with a Westergren of 25mm/hour (normal 0-20). Her x-rays shows minimal degenerative arthritic changes and generalized osteoporosis. She was placed on aspirin, 10 mg 6 times per day. This made her more comfortable but did not resolve the basic problem. She had to limit her standing and walking time, but she could sit, climb

Fig. 1. White female patient, 60 years of age, with genu varus on the right and genu recurvatum on both sides.

stairs, and ride a bicycle in relative comfort. Other anti-inflammatory drugs were tried, but none were found to be superior to aspirin.

The patient's past contributory history included a total hysterectomy with bi-lateral salpingo-oophorectomy in 1958 for a positive Panicolaou smear, after which osteoporosis developed. Her general physical status was relatively good except for hypertension. She was on diuretics which apparently maintained relatively good control. However, she did have an elevated chloesterol count infrequently, and was extremely allergic to many materials which was manifested by skin

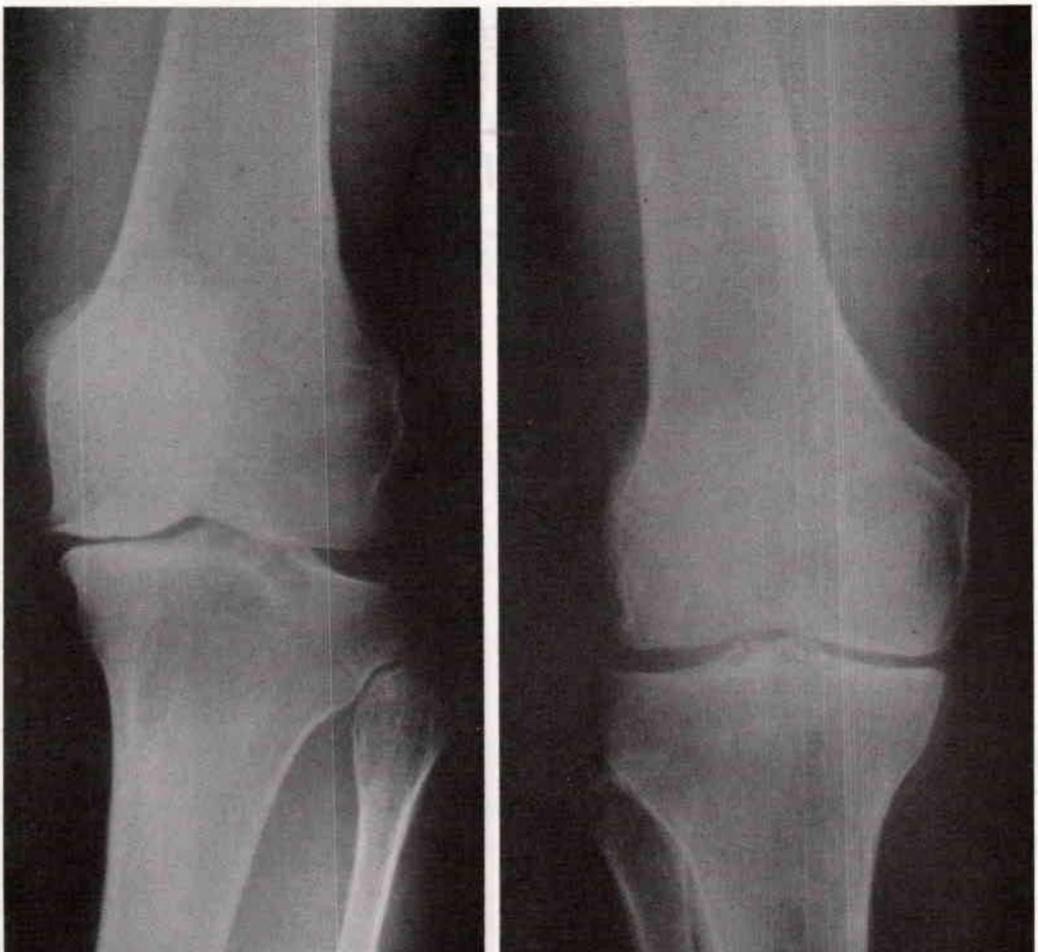

Fig. 2. Two X-Ray views of patient in 1976.

lesions.

Because her tolerance for standing and walking decreased continually, her physicians felt that she should consider total knee replacements as the best resolution of the problem. This she refused to do, and consulted one of the authors for an alternative solution. At this time a prescription was given for orthotic management, which was taken back to the military installation, but they refused to honor it because they felt that this would not resolve her problem. Surgery was still recommended. The patient continued on aspirin and gradually decreased her walking time until she was re-evaluated at Georgetown University Hospital in 1976. New x-rays were taken at that time which showed further deterioration of both knees with more spur formation and further narrowing of the joint space (Fig. 2). By this time she could not stand or walk without outside support. Her total standing and walking for the day was probably limited to one hour. She was on 60 mg of aspirin in divided doses throughout the day, and could not tolerate being out of bed without this medication. It was at this juncture that she decided to go ahead with the orthoses on her own as she still refused to consider surgery.

The patient was referred to the Orthotics-Prosthetics Service at The Fairfax Hospital. Bilateral moulded plastic knee-ankle-foot orthoses with recurvatum and genu varus control were recommended. Free offset knee joints ¼-inch (0.62 cm) thick polypropylene was used for both the above-knee and below-knee sections. Polypropylene was selected because of its low cost, light weight, good cosmetic appearance, interchangeability of shoes, and the fact that she was not allergic to this material. To obtain free ankle motion the plastic ankle-foot complex was moulded and trimmed appropriately.

Fabrication

Two layers of tube gauze to reach from the distal tip of the toes to the groin were pulled over the entire right leg. Bony landmarks were outlined with an indelible pencil. A vinyl tube or a 1-inch (2.5 cm) elastic webbing was placed down the entire anterior section of the leg. The patient was in sitting position with legs over the edge of the treatment table. One roll of elastic plaster bandage followed by one roll of standard plaster bandage was applied to the foot and lower one-third of the leg. The foot was placed on a standard footboard with approximately 5 degrees of plantar flexion (Fig. 3). After this section was set the patient was placed in the supine position with the right side

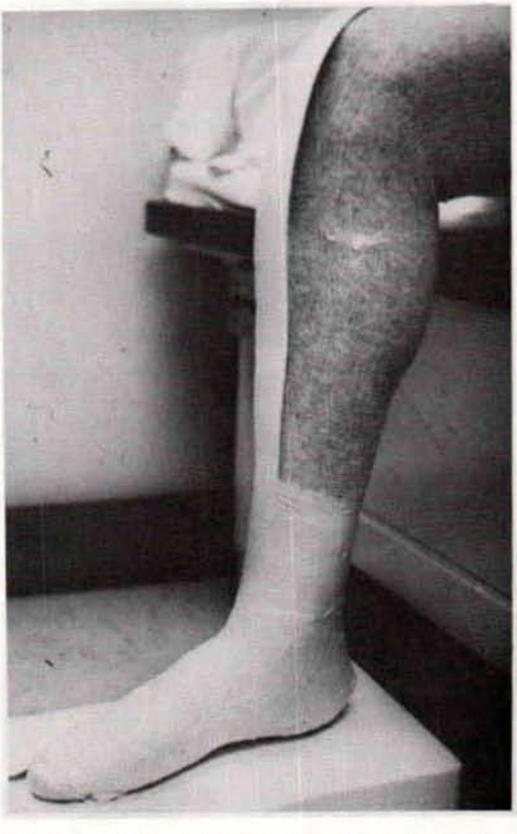

Fig. 3. A standard footboard is used to achieve the desired attitude of the ankle during casting.

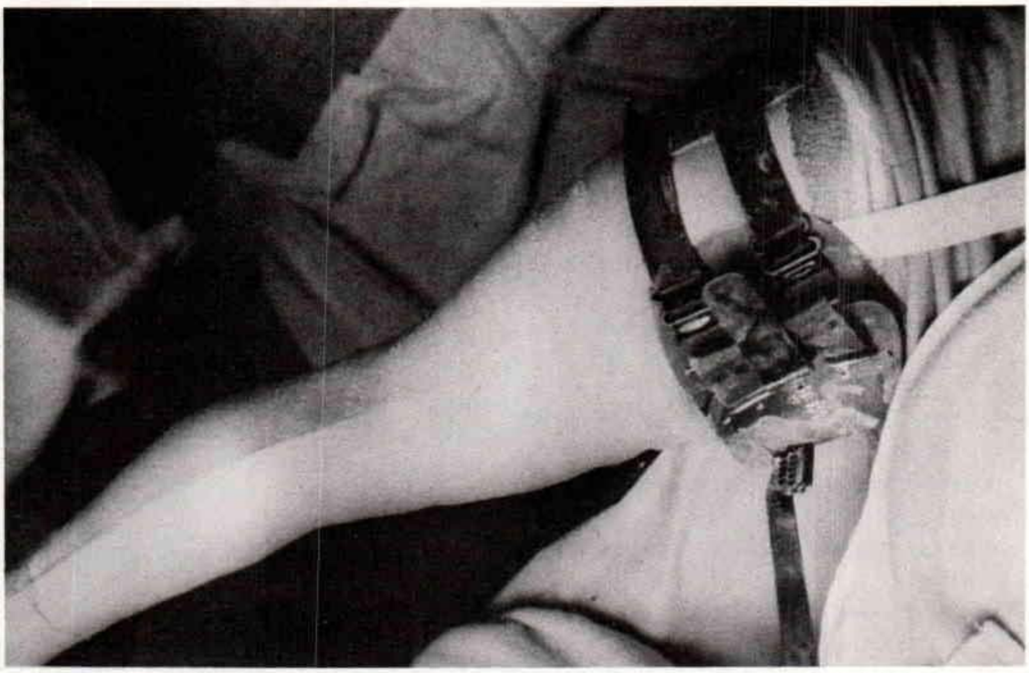

Fig. 4. An NYU above-knee prosthetics casting brim is used for casting of the thigh section.

of the body very close to the edge of the treatment table and on a slight angle to allow wrapping of the entire leg and prevent any abduction of the thigh. A New York University prosthetics casting brim[3] was used to form the proximal section (Fig. 4). This gave a quadrilateral shape that prevents rotation about the thigh section.

After the cast was set, it was removed with a cast cutter in the conventional manner. The same casting procedure was used for the left lower limb.

The following measurements were taken bilaterally: 1) medial-lateral dimension of the knees, 2) circumference at ischial level, 3) length from the perineum to the plantar surface of the foot, and 4) the distance between medial-tibial plateau and the plantar surface of the foot.

The casts were resecured along the cut seam with staples, plaster strips were applied along the seams to avoid breakage. A Pope alignment jig[4] of the appropriate medial-lateral measurement was inserted at the knee center and slightly posterior of each cast. The casts, after being slushed with a soap solution to act as a parting agent, were filled with a plaster-of-Paris slurry. A ½-inch (1.25 cm) water pipe coated with Vaseline was inserted anterior to the Pope jig to coincide approximately with the long axis of the leg. While the plaster was setting the water pipe was turned slowly to facilitate removal later. The negative wrap was removed and the indelible pencil marks were reinforced as necessary.

Basically, the modification of the cast in the above-knee section was a quadrilateral shape with attention to flat medial and posterior walls. Bony landmarks—head of fibula, malleolus, navicular, and achilles tendon—were provided with the necessary reliefs. Particular attention was paid to the fibula head and to the area of the peroneal nerve. Stockinet marks were removed and both casts were smoothed. Measurements were checked during modification of the cast.

The next step was to contour the uprights to the shape of the model using the Pope jig to be sure that the uprights were square, at the appropriate height, and in the correct anterior-posterior placement (Fig. 5). Distally the length of the uprights was between two and three inches (5 to 7.5 cm) proximal to the malleolus. Any space between the cast and uprights was filled with plaster. Holes (#29) were drilled in the uprights in the thigh and calf section, and the uprights were nailed to the cast.

The uprights were placed against the cast, and, thus, inside the polypropylene. We felt this would provide control of genu varus and good cosmesis. Also we were able to use 5/8-inch (1.56 cm) rather than ¾-inch (1.87 cm) uprights because of the added strength achieved with this method.

The cast was dried thoroughly in the oven before vacuum forming. The pipes and uprights were removed from the casts which were cut in half, horizontally just proximal to the end of the Pope jig.

Two nylon stockings were pulled over each plaster model, and the uprights were again secured to the model. Each section was vacuum formed with ¼-inch (0.62 cm) thick polypropylene (Fig. 6).

The vacuum-formed polypropylene and uprights were removed from each section with a cast cutter, and then trimmed and smoothed.

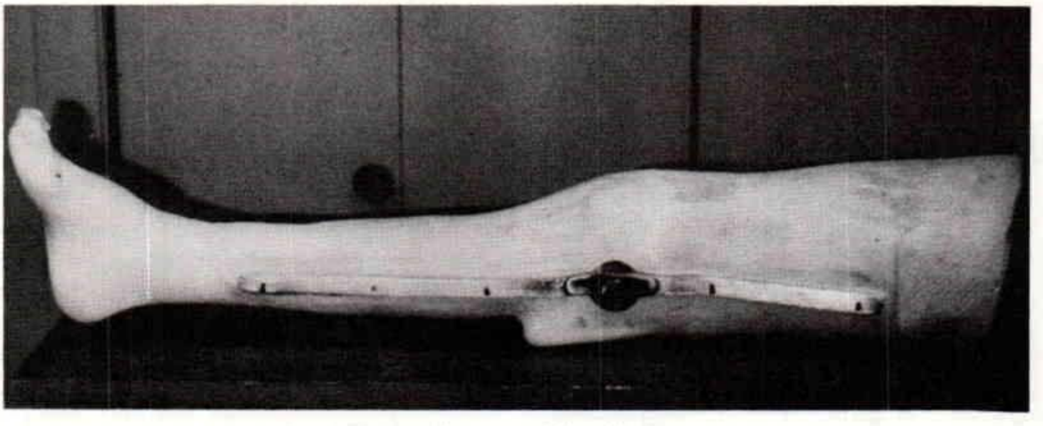

Fig. 5. Alignment of the side-bars.

The below-knee trim lines were approximately 1-inch (2.5 cm) anterior to the uprights with a single anterior-proximal 2-inch (5 cm) Velcro closure. The above-knee section encompassed the thigh medially, laterally, and posteriorly with two 2-inch (5 cm) Velcro closures anteriorly. The uprights were tapped and attached to the polypropylene shells with #8-32 screws (Fig. 7).

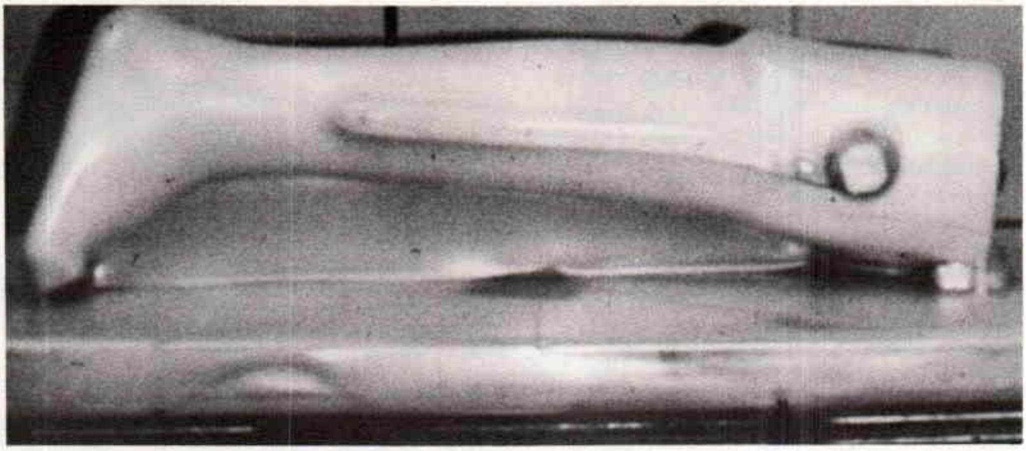

Fig. 6. The shank-and-knee portion immediately after the vacuum forming procedure.

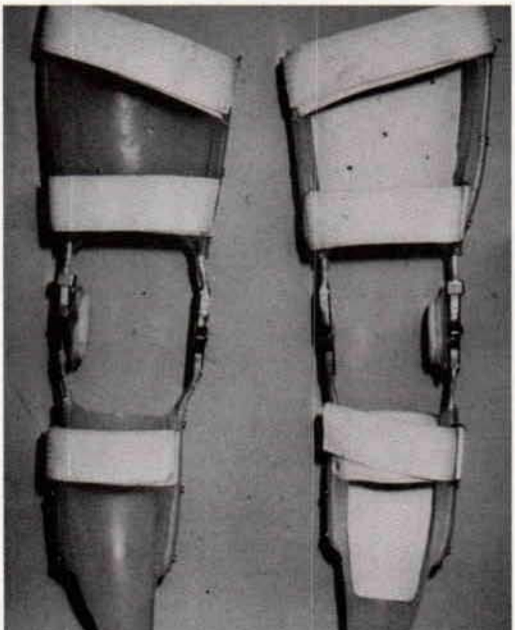

Fig. 7. Anterior view of the two orthoses.

Fitting

The orthoses were fitted and were tolerated well by the patient. Small adjustments were made for pressure areas. After several weeks an outer knee dial was added to each orthosis for more control of genu varus (Fig. 8). In other patients with genu varus and valgus the orthotist used a vacuum-formed polyethylene control pad lined with Pelite. And, recently in some patients, because of the intimate fit achieved with the moulded plastic shells, the orthotist has been able to eliminate the need for any varus or valgus control pad or dial (Fig. 10).

At the present time the patient is wearing her orthoses from the time of rising in the morning until going to bed at night. She takes them off only when she is dressing for a formal occasion or when bicycling. She is perfectly comfortable wearing them and does not require aspirin or any other anti-inflammatory drugs. She is walking as much as she desires for her usual activities as a housewife requiring no other outside support. The latest report that we received from her January 1, 1978 indicates that she had been out dancing on several occasions wearing her orthoses and enjoyed the entire evening.

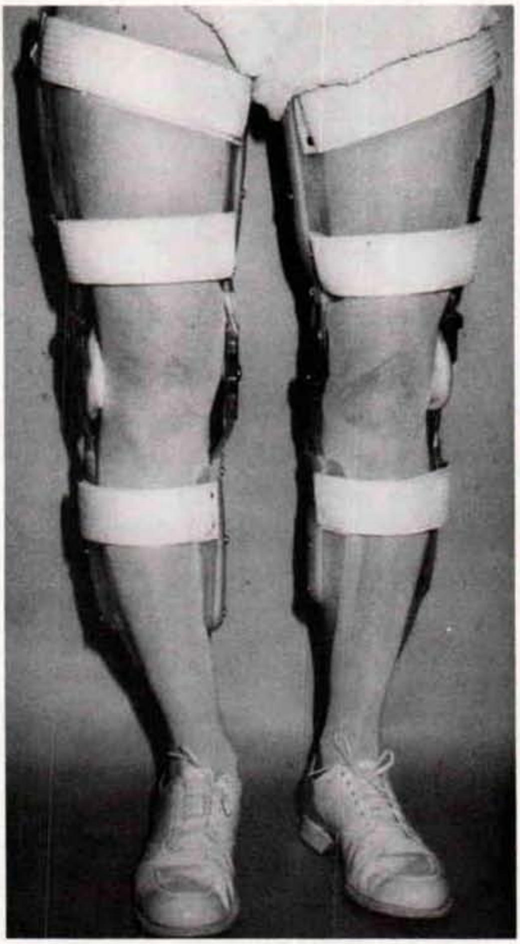

Fig. 8. Anterior view of patient with both orthoses in place.

Footnotes

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[3]Fillauer Orthopedic, 2710 Annicola Highway, Chattanooga, Tennessee 37406

[4]Pope Brace Company, 197 South West Avenue, Kankakee, Illinois 60901

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The Salop Skate—An Orthosis For Improving 'Drag-To' Gait

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G.K. ROSE, F.R.C.S.[1]

Many patients with paralysis of the legs, particularly those with some degree of deformity or limitation of movement in joints, perform 'drag-to' gait. Because of their inability either to walk reciprocally or to raise their body from the ground to perform 'swing-through' or 'swing-to' gait, they use a rollator or, less commonly, crutches to pull themselves forward and drag their feet behind them. It is most prevalent amongst obese patients since they are less likely to be able to raise their body from the ground to perform 'swing-to' or 'swing-through' gait. Few such patients are very effective ambulators because the technique requires a high level of energy consumption, and most eventually subside into a purely wheelchair existence. The degree of locomotion difficulty varies considerably with the type of floor. High friction surfaces such as rough concrete or cord carpet are particularly troublesome, and completely defeat some patients.

Observation of 'drag-to' gait pattern (Fig. 1) showed that the cycle commenced with the toes of the footwear in contact with the ground and the heels raised. As the patient progressed forward, the heels came down onto the ground and the rollator (or pair of crutches) was then moved forward. This completed the cycle since the heels were then raised automatically.

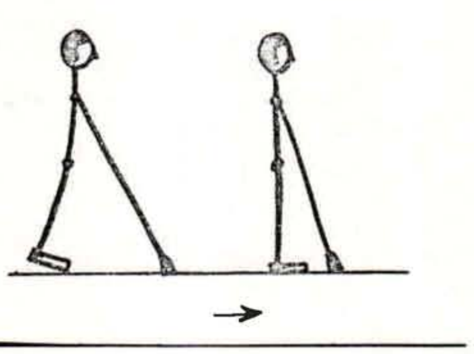


Fig. 1. The "Drag-to" gait.

A device, designated as the 'Salop Skate' (Fig. 2), has been designed to be worn on the patient's feet to reduce the friction between the feet and the ground. The principle is to use wheels beneath a platform (a in Fig. 3) onto which the feet are strapped. In order to prevent the patient rolling backwards when the heels are raised at the start of the cycle, the wheels used are rubber covered roller clutches (b in Fig. 3) that permit forward rotation only. Also on the bottom of the platform at the rear are mounted rubber covered 'brake stops' (c in Fig. 3) of the same height as the roller assembly, so that as the 'drag-to' cycle is completed and the heels grounded, the stops come into contact with the floor and prevent the patient overshooting forwards.

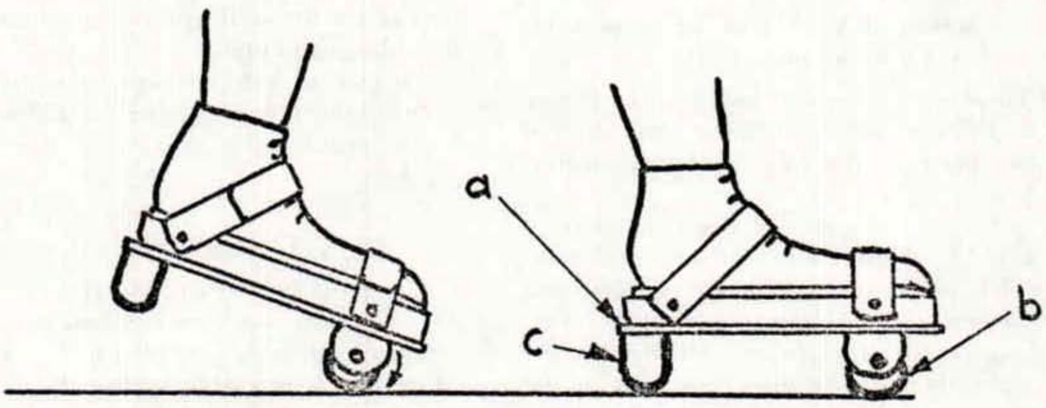


Fig. 3. Side view of the Salop Skate.

Fig. 2. The Salop Skate in use.

Fabrication

The Salop Skate consists of a 1/8-in.-thick aluminum plate of sufficient size to contain the patient's feet when standing comfortably (typically 11-in. wide x 7-in. deep). Two roller assemblies are attached to the underside of the plate in a position which aligns with the metatarsal heads of the patient. These assemblies each consist of the following components:

1 M.S. Bushing 1-in. O.D. x 7/8-in. I.D. (toleranced bore) x 1-in.-long, zinc plated, with a 1/8-in.-thick bonded covering of Dainite (rubber compound).

1 Torrington RCB-081214 combined clutch-and-roller bearing.

1 bearing pin 1/2-in. diameter x 2-3/8-in. long silver steel.

2 Torrington NTA-815 thrust bearings and 4 TRA 815 washers.

2 nylon brackets 7/16-in. wide (machined from 1-3/4-in. dia. nylon rod).

2 Roll Pins, 1/8-in. dia.

4 Screws 2BA x 1/2-in. long c'sk head, M.S. cadmium plated.

These are assembled as shown in Figure 4, and then attached to the outer sides of the plate in the line of the metatarsal heads.

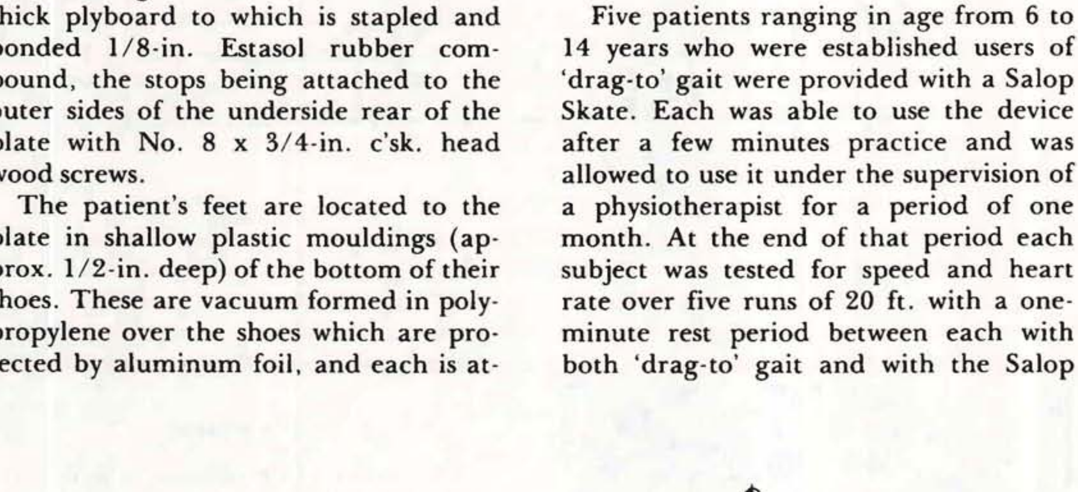
The brake stops are constructed from 1-1/4-in. high x 2-1/2-in. wide x 3/4-in. thick plyboard to which is stapled and bonded 1/8-in. Estasol rubber compound, the stops being attached to the outer sides of the underside rear of the plate with No. 8 x 3/4-in. c'sk. head wood screws.

The patient's feet are located to the plate in shallow plastic mouldings (approx. 1/2-in. deep) of the bottom of their shoes. These are vacuum formed in polypropylene over the shoes which are protected by aluminum foil, and each is attached to the plate with four 1/8-in. dia. pop rivets through appropriate holes in mouldings and plate.

Two sets of Velcro straps are riveted to each of the polypropylene mouldings to locate around the ankle and over the forefoot.

Clinical Trials

Five patients ranging in age from 6 to 14 years who were established users of 'drag-to' gait were provided with a Salop Skate. Each was able to use the device after a few minutes practice and was allowed to use it under the supervision of a physiotherapist for a period of one month. At the end of that period each subject was tested for speed and heart rate over five runs of 20 ft. with a one-minute rest period between each with both 'drag-to' gait and with the Salop



THE SALOP SKATE

Fig. 4. Exploded view of the Salop Skate.

	DRAG-TO GAIT		USING SALOP SKATE		Change in performance using Salop Skate
Patient	Average Speed ft/sec.	Heart Rate b.p.m.	Average Speed ft/sec.	Heart Rate b.p.m.	Percentage increase in speed
			PLASTIC FLOOR PERFORMANCE		
a	1.39	130	1.58	122	13.7
b	0.76	194	1.01	187	32.8
c	0.82	190	1.54	185	87.8
d	1.36	171	1.60	154	17.6
e	1.26	173	1.61	162	27.8
			CORD CARPETED FLOOR PERFORMANCE		
a	—	—	—	—	—
b	—	—	—	—	—
c	0.41	210	1.11	188	170.0
d	0.74	161	1.15	150	55.4
e	1.08	151	1.46	151	34.9

Results of Patient Trials using 'drag-to' gait and the Salop Skate on two floor surfaces.

TABLE I

Skate on a plastic floor. Three of the patients were also tested on cord carpet.

Table 1 shows the average speed and heart rate for each of the trials and the percentage increase in speed when patients used the Salop Skate. It can be seen that on the plastic floor the average speed with the Salop Skate increased in every case over that for 'drag-to' gait with a concurrent lower heart rate. On cord carpet the average speed increased in every case with a lower heart rate in all but one case, where the higher speed was achieved at the same heart rate. The average percentage increase in speed on the plastic floor was 35.9 percent and on carpet 86.8 percent.

The patient's subjective impression was in every case that it was much easier to ambulate with the Salop Skate. Both these impressions and the objective results were confirmed by the longer term (12 months minimum) experience of the patients. All had improved independence in that they could ambulate further with less assistance and over surfaces which have previously defeated them. One girl, who has been on the verge of subsiding into a wheelchair existence, is once again an assured ambulator within her school environment.

Discussion

The clinical trials indicated the advantages of the Salop Skate to paralyzed patients who perform 'drag-to' gait by giving them quicker ambulation at a lower energy cost. It offers tremendous potential for improvement in locomotion for 'drag-to' ambulators, particularly since the training period is so short. Results from the speed/heart rate trial, the subjective impressions of the patients and the long term experience were all positive and none of the patients involved in the trials wishes to discard the device.

The method of manufacture adopted was purely for prototype construction and a production device would need some small modifications. These would primarily involve a bonded metal-to-rubber stop bar and an adjustable footclamp arrangement with quick-release buckle and strong fabric straps.

The device has commercial potential and negotiations are in hand with a British orthotics manufacturer who hopes to have the Salop Skate available in 1978.

Summary

'Drag-to' gait, in which the patient uses a rollator or crutches to drag their feet along the ground rather than swinging through, is used by many patients suffering from considerable degrees of paralysis of the lower limbs. This method of ambulation is adopted because the subjects have insufficient strength to raise their body from the ground and on high friction surfaces it is extremely energy consuming. A simple, effective device known as the Salop Skate which sharply reduces energy consumption by providing low friction 'drag-to' ambulation has been developed and described here.

Footnotes

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Orthotics and Prosthetics, Vol. 32, No. 3, pp. 37-43, September 1978

Tissue Pressure Tolerance As a Guide to Wrist-Hand Orthosis Design

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An individual with paralyzed wrist extensor musculature presents a challenge to orthotists. When the wrist is inadvertently maintained in a flexed position, wrist, hand, and finger flexion contracture deformities may result. The weight of the hand itself, and the mechanical and orthotic limitations present formidable problems.

The orthotic recommendation for a patient with paralyzed wrist extensors is often a static wrist-hand orthosis which supports the patient's wrist against flexion while maintaining an extension angle at the wrist, opposition of the thumb, and curvature of palm.

A successful wrist-hand orthosis is not only one with a good appearance, but more importantly, fits well. A wrist-hand orthosis which fits improperly can create excessive pressure.

The forearm, wrist, and hand can be treated as a simple first-class lever system with a force and lever on each side of a fulcrum. This lever system allows an analysis of the demand torque (hand) and support torque (orthosis). Then it follows that force can be deduced from the torque and pressure estimated by the ratio of force to associated area over which the force is applied. Lastly, the estimated values for pressure can be compared to tissue tolerance values and excesses identified.

In a normally extended wrist (30 deg.), the flexion demand torque must be equal to the extension support torque as shown in Figure 1.

$$F_E \cdot d_E = W_H \cdot d_H \qquad (1)$$

$$\text{Support} = \text{Demand}$$

Where, F_E = extensor musculature force required to keep wrist extended lbs.

d_E = extensor lever arm from extensor tendon midline to wrist joint axis n inches.

W_H = weight of hand producing

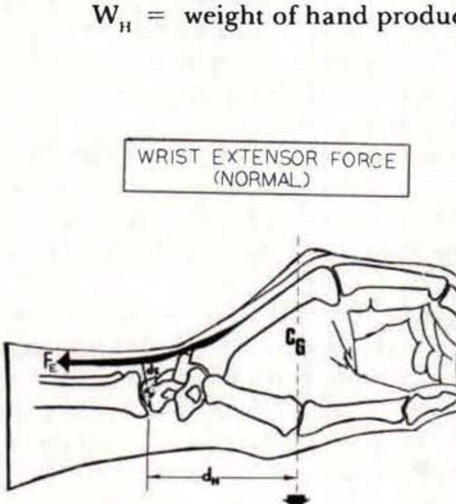

Fig. 1. Graphical presentation of equation (1).

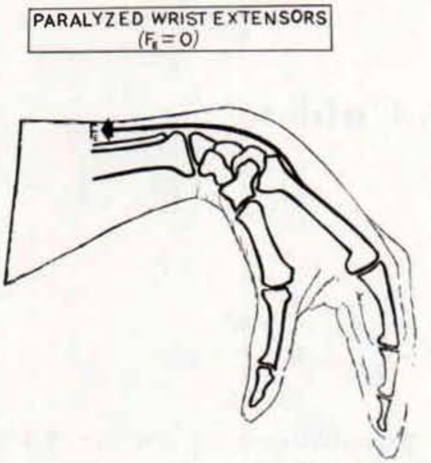

Fig. 2. Schematic of hand with completely paralyzed wrist extensors.

wrist flexion lbs.

d_H = hand lever arm from center of gravity of hand to wrist joint axis n inches.

If the extensor tendons were cut or denervated, the pronated hand would inevitably fall into flexion as shown in Figure 2. Without support extensor torque, an alternative (orthotic) form of support is required.

In most cases the paralyzed wrist can be supported with a static wrist-hand orthosis. As shown in Figure 3, the hand is supported with palmar and forearm components.

Experience with static wrist-hand orthoses suggests that there are three areas where pressure may become excessive. As shown in Figure 4, these areas include the volar forearm, P_1, palmar, P_2, and dorsal wrist, P_3 areas.

Volar Forearm Pressure (P_1)

To determine the volar forearm pressure, P_1, it is necessary to consider the force, F_1, between the proximal strap and

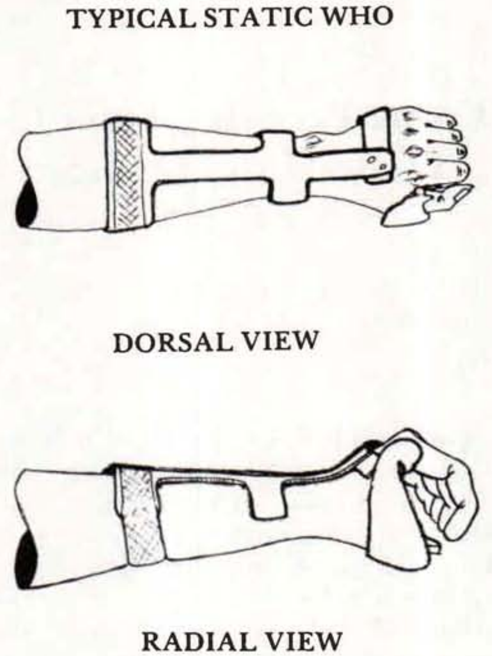

Fig. 3. Typical static wrist-hand orthosis.

volar forearm surface as shown in Figure 5.

The hand in Figure 5 tends toward flexion producing a demand torque (T_D) given by

$$T_D = W_H \cdot d_H \qquad (2)$$

The corresponding support torque (T_S) afforded by the orthosis is given by

$$T_S = F_1 \cdot d_F \qquad (3)$$

Where, F_1 = proximal volar forearm strap force n lbs.

d_F = length of forearm piece from proximal strap to wrist joint axis n inches.

When the wrist is adequately supported the demand torque is balanced by the support torque or

$$T_D = T_S \text{ or} \qquad (4)$$
$$W_H \cdot d_H = F_1 \cdot d_F$$

PRESSURE AREAS

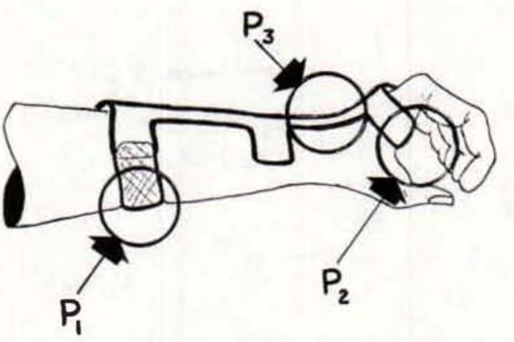

Fig. 4. Areas where excessive pressures are most apt to be found in a static wrist-hand orthosis. P_1 —volar forearm; P_2 —palmer surface; P_3 —dorsal surface of the wrist.

VOLAR FOREARM PRESSURE, P⅔

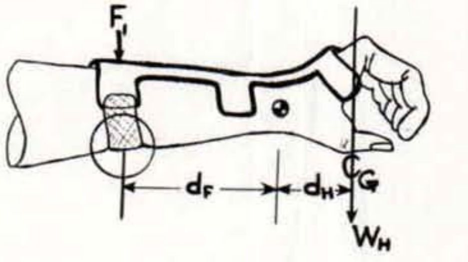

Fig. 5. Elements needed to determine volar arm force in a static wrist-hand orthosis; equation (5).

Rearranging equation (4) yields the following for the volar forearm force,

$$F_1 = \frac{W_H \cdot d_H}{d_F} \quad (5)$$

The volar forearm strap area is

$$A_{strap} = W_S \cdot L_S \quad (6)$$

Where, W_S = strap width n inches
L_S = strap length contacting volar surface n inches

Since mechanical pressure is defined as the ratio of force to area, the volar forearm surface pressure, P_1, is obtained from equations (5) and (6).

$$P_1 = \frac{F_1}{A_{strap}} = \frac{W_H \cdot d_H \text{ (num.)}}{d_F \cdot W_S \cdot L_S \text{ (den.)}} \quad (7)$$

The numerator of equation (7) contains hand weight (W_H) and its lever, (d_H) neither of which can be changed by the orthotist. However, the factors in the denominator forearm lever (d_F), strap width (W_S) and strap length (L_S) can be changed to reduce the volar forearm pressure, P_1.

The value of equation (7) to the orthotist can be realized by a practical example. Consider patients with hands that weigh 1 to 2 pounds (W_H) and each has a 3-inch lever arm (d_H) from the center of gravity of the hand to wrist joint axis. Assume the area of the volar forearm strap is 1/2 wide (W_S) by 3 inches long (L_S). The resulting volar forearm pressure produced as a function of the forearm lever is shown in Figure 6.

Before a value for forearm lever, d_F, can be selected from this graph, it is necessary to know the maximum allowable value for volar forearm pressure, P_1. The maximum volar forearm pressure can be obtained from the tissue tolerance curve shown in Figure 7.

Tissue tolerance can be expressed as a specific pressure applied for a maximum period of time. Any combination of applied pressure and length of time above the curve is unacceptable; values below the curve acceptable. According to this relationship for "pressure tolerance," it is necessary that less than 30 mmHG pressure exists before the orthosis can be worn continuously (8 hours or longer). Referring to the curve of P_1 versus d_F,

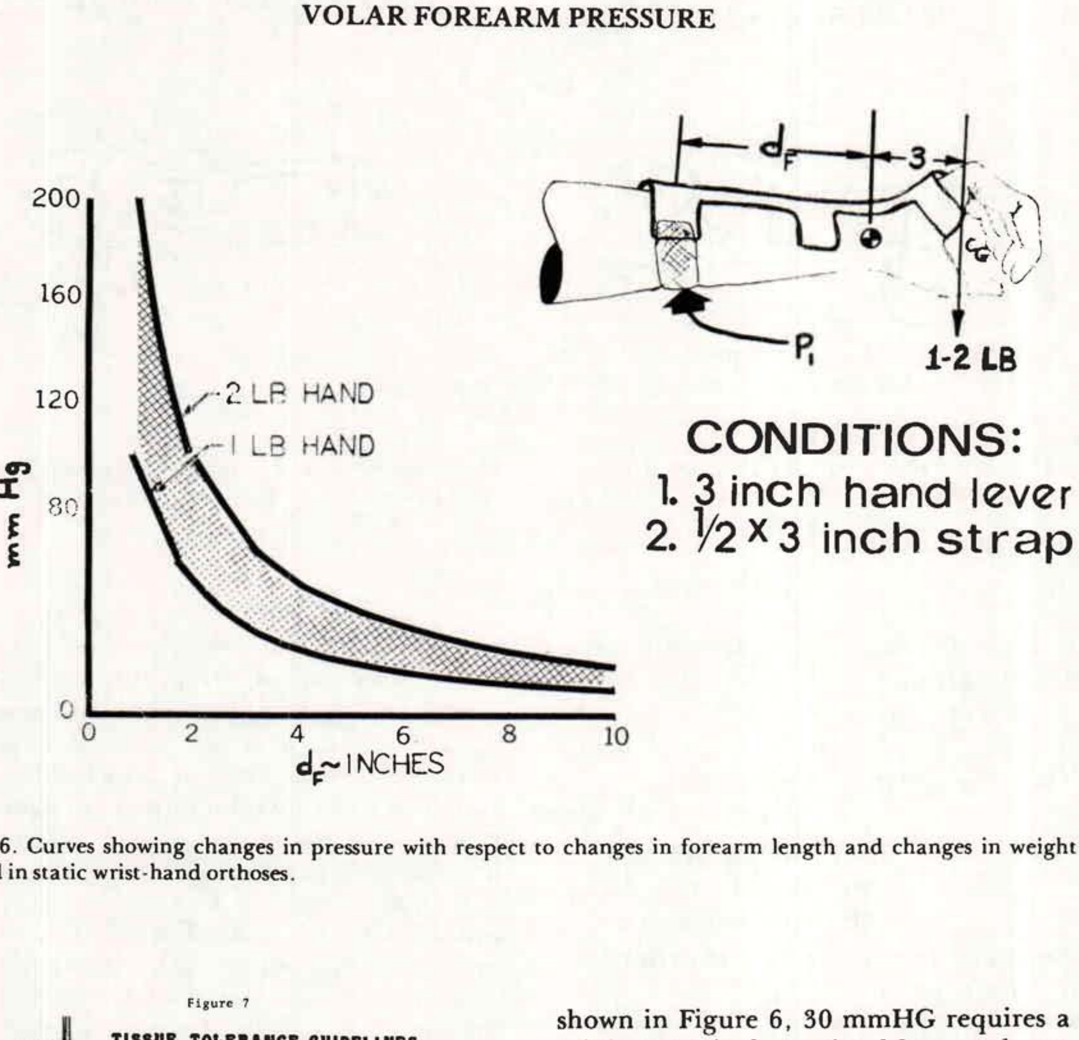

Fig. 6. Curves showing changes in pressure with respect to changes in forearm length and changes in weight of hand in static wrist-hand orthoses.

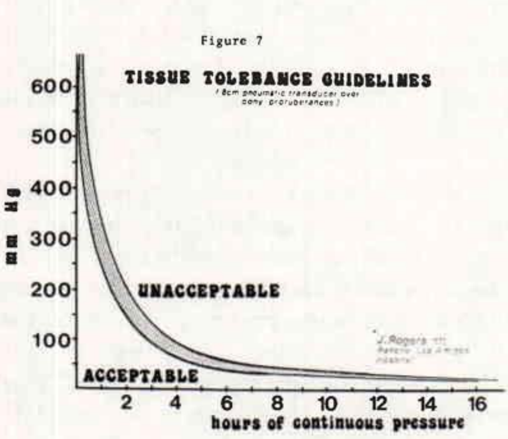

Fig. 7. Curves showing acceptable pressures on soft tissues with respect to time.

shown in Figure 6, 30 mmHG requires a minimum 6-inch proximal forearm lever. Therefore, the distance from the proximal extension of the forearm piece to the wrist joint axis should not be less than 6 inches to ensure that excessive pressure does not exist.

Palmar Pressure (P_2)

The palmar pressure, P_2, is due entirely to the ratio of the weight of the hand (W_H) and to the area of the orthosis in the region of the palm.

$$P_2 = \frac{W_H}{A_P} = \frac{\text{Weight of Hand}}{\text{Area of Orthosis in Palm}} \qquad (8)$$

The area of the orthosis at the palm is given by (see Figure 8).

$$A_P = W_{PE} \cdot L_{PE} \quad (9)$$

Where, W_{PE} = width of palmar extension inches

L_{PE} = length of palmar extension inches

Substituting equation (9) into (8) yields

$$P_2 = \frac{W_H}{W_{PE} \cdot L_{PE}} \quad (10)$$

This relationship for palmar pressure is shown graphically in Figure 9. In this case the palmar pressure, P_2, is compared with the width of the palmar extension, W_{PE}. The length of palmar extension, L_{PE}, in contact with the hand is assumed to be 3 inches. With the restraint that the

PALMAR PRESSURE

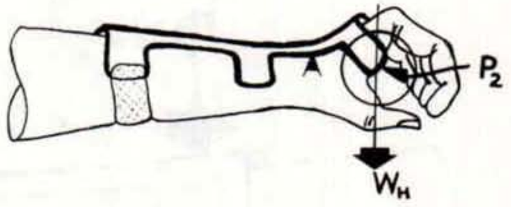

Fig. 8. Graphical presentation of palmar pressure, P_2.

PALMAR PRESSURE, P_2

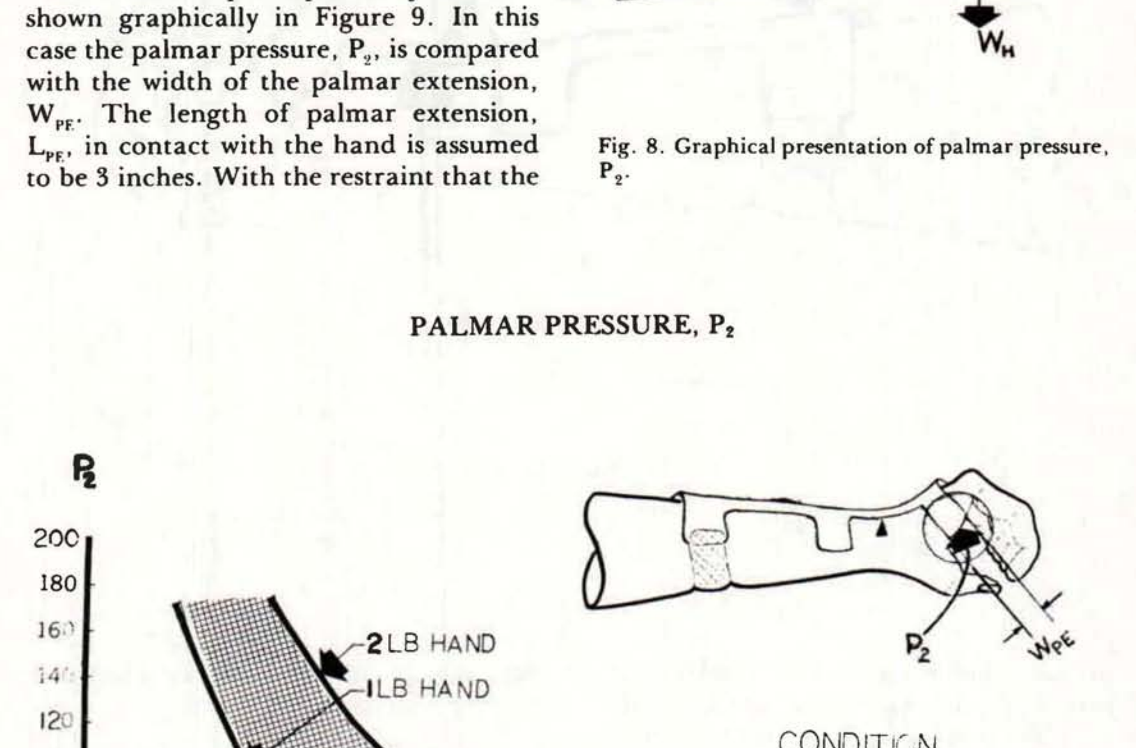

Fig. 9. Schematic of the determination of palmar pressure, P_2, and the effects of variations in hand weight and support width.

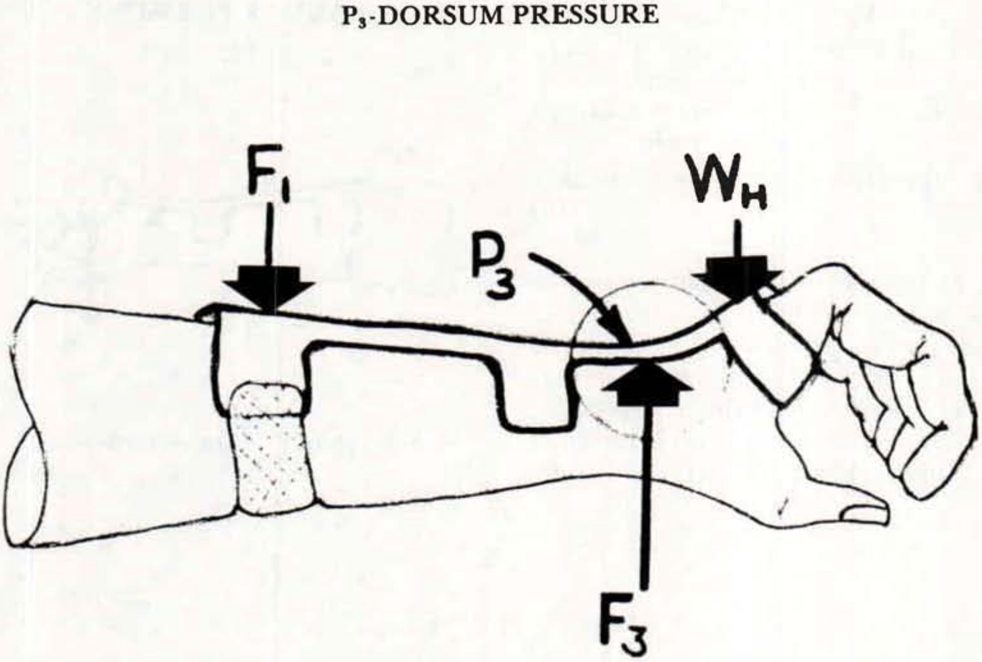

Fig. 10. Dorsum pressure, P_3.

pressure shall not exceed 30 mmHG continuously, the minimum width of the palmar extension is 0.7 inch as shown in Figure 9.

The size of palmar extension (3 x 0.7 inches) will ensure safe pressure but may interfere with rotation of the metacarpal-phalangeal joint. The distal edge of the palmar extension must be positioned proximal to the imaginary line formed by the second and fifth palmar creases.

Dorsal Pressure (P_3)

The dorsal pressure, P_3, is represented in Figure 10. This pressure is given by the ratio of the force, F_3, to the area of the dorsal piece of the wrist-hand orthosis making contact with the wrist.

$$P_3 = \frac{F_3}{\text{area of dorsal piece}} \tag{11}$$

The force F_3 is an equal and opposite reaction to the sum of the forces of the hand, W_H, and forearm piece, F_1.

$$F_3 = W_H + F_1 \tag{12}$$

The area of the dorsal piece is given by its length (L_{DP}) times width or W_{DP}.

$$A_{\text{dorsal piece}} = W_{DP} \cdot L_{DP} \tag{13}$$

Substituting equation (12) and (13) into (11) yields the following expression for dorsal pressure

$$P_3 = \frac{W_H + F_1}{W_{DP} \cdot D_D} \tag{14}$$

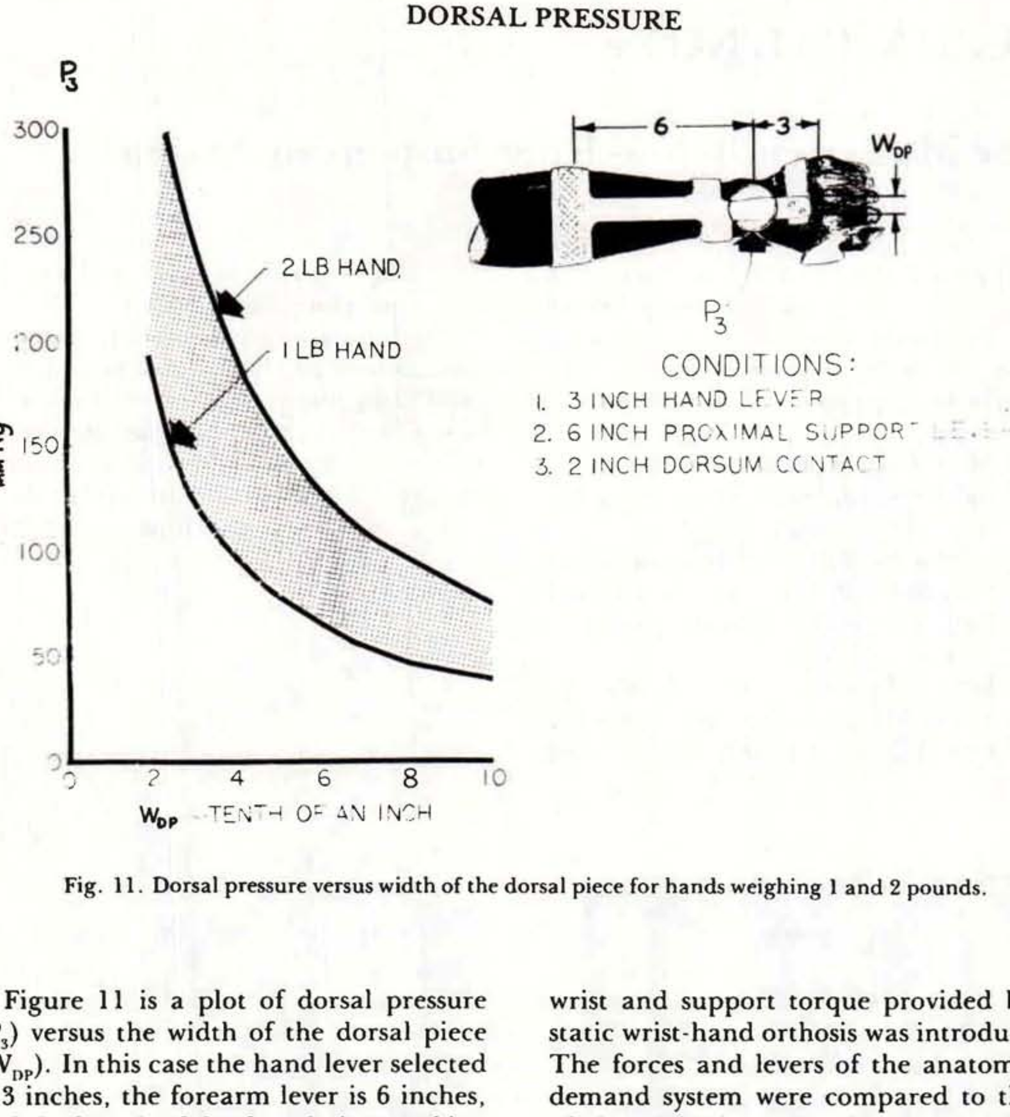

Fig. 11. Dorsal pressure versus width of the dorsal piece for hands weighing 1 and 2 pounds.

Figure 11 is a plot of dorsal pressure (P_3) versus the width of the dorsal piece (W_{DP}). In this case the hand lever selected is 3 inches, the forearm lever is 6 inches, and the length of the dorsal piece making contact with the wrist is assumed to be 2 inches.

For the dorsal pressure not to exceed 30 mmHG, the width of the dorsal piece must be a minimum of one inch.

Summary

Three areas of pressure produced by a static wrist-hand orthosis have been identified. The concept of demand torque produced by a paralyzed and flexible wrist and support torque provided by a static wrist-hand orthosis was introduced. The forces and levers of the anatomical demand system were compared to those of the orthotic supporting system. This information together with an estimate of the area over which the supporting forces occur allowed an estimate to be made of the pressure applied. The applied pressure was evaluated for tissue tolerance.

Footnotes

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Orthotics and Prosthetics, Vol. 32, No. 3, pp. 44-48, September 1978

TECHNICAL NOTE

The McFarlen Below-Knee Suspension System

From the time of the introduction to the Patella-Tendon-Bearing below-knee prosthesis, I have felt the need for a more adequate suspension system. The criteria for an improved suspension system are:

1. Maintenance of a comfortable residual limb position within the socket when the patient is sitting.
2. Minimum skin stress resulting from intimate contact between residual limb and socket when the patient is walking.
3. Both of these goals should be achieved without the use of a waist belt (Fig. 1) (I believe that a waist belt is uncomfortable and encourages a lordotic posture.)

After much experimentation, a suspension system has been designed that in most cases eliminates the need for a waist belt and achieves all the other design criteria (Fig. 2). In addition, it is interchangeable between left and right sides.

The McFarlen BK suspension System

Fig. 1. UCB system modified with belt, bilateral.

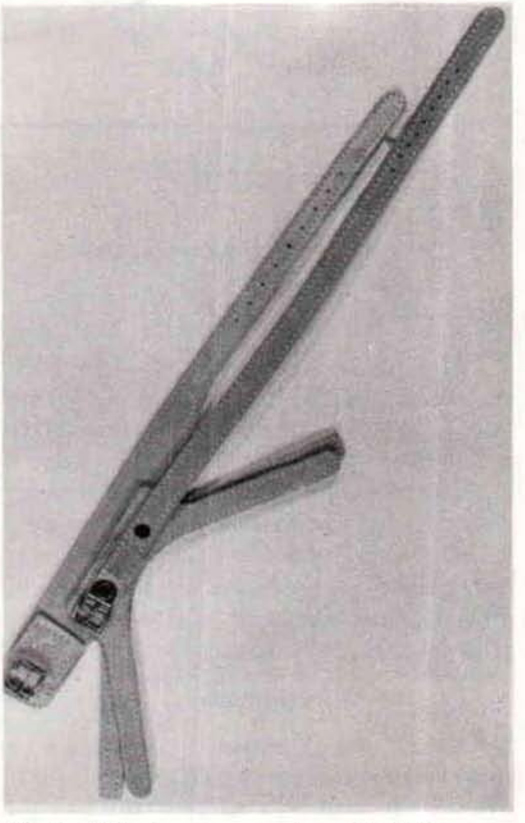

Fig. 2. McFarlen system overlay with UCB system.

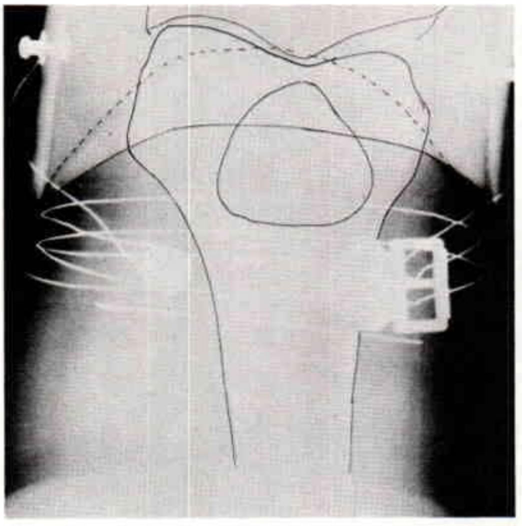

Fig. 3. X-ray anterior view, McFarlen system.

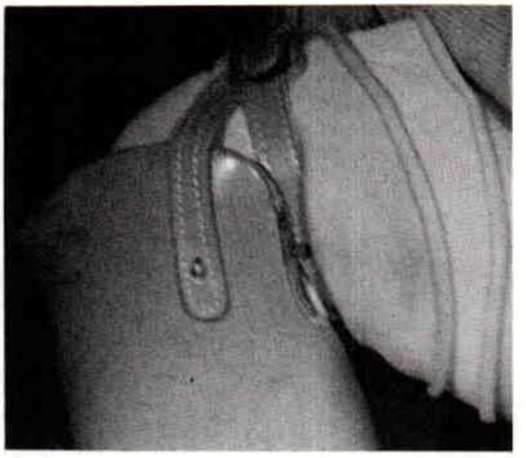

Fig. 4. Sitting, McFarlen system, medial view.

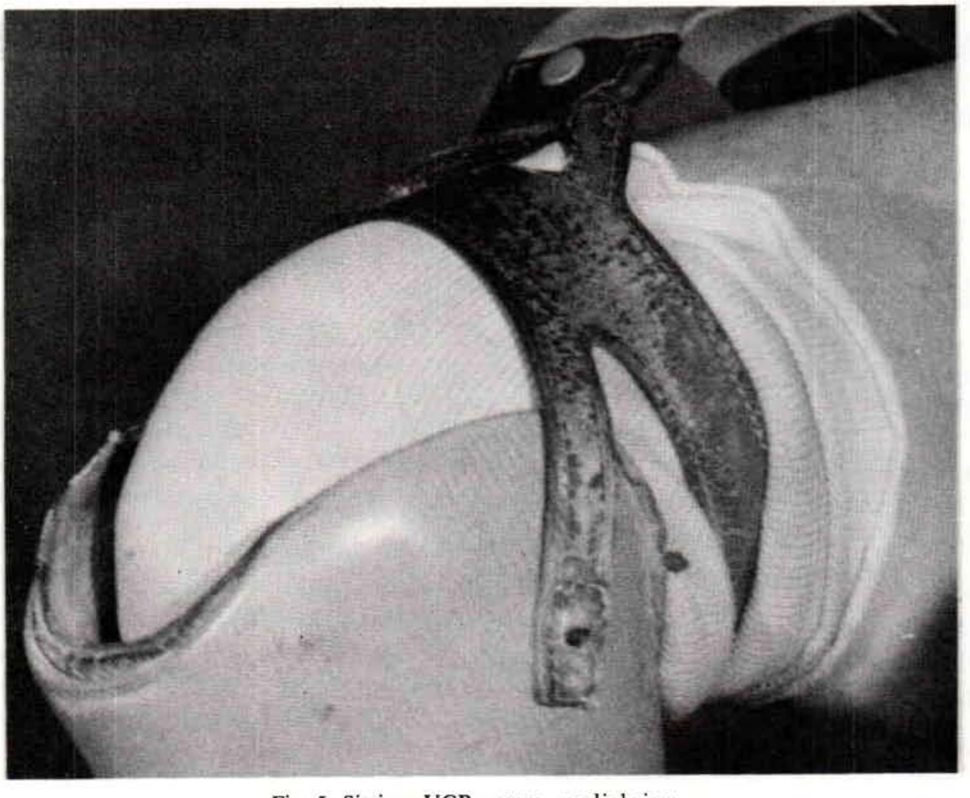

Fig. 5. Sitting, UCB system, medial view.

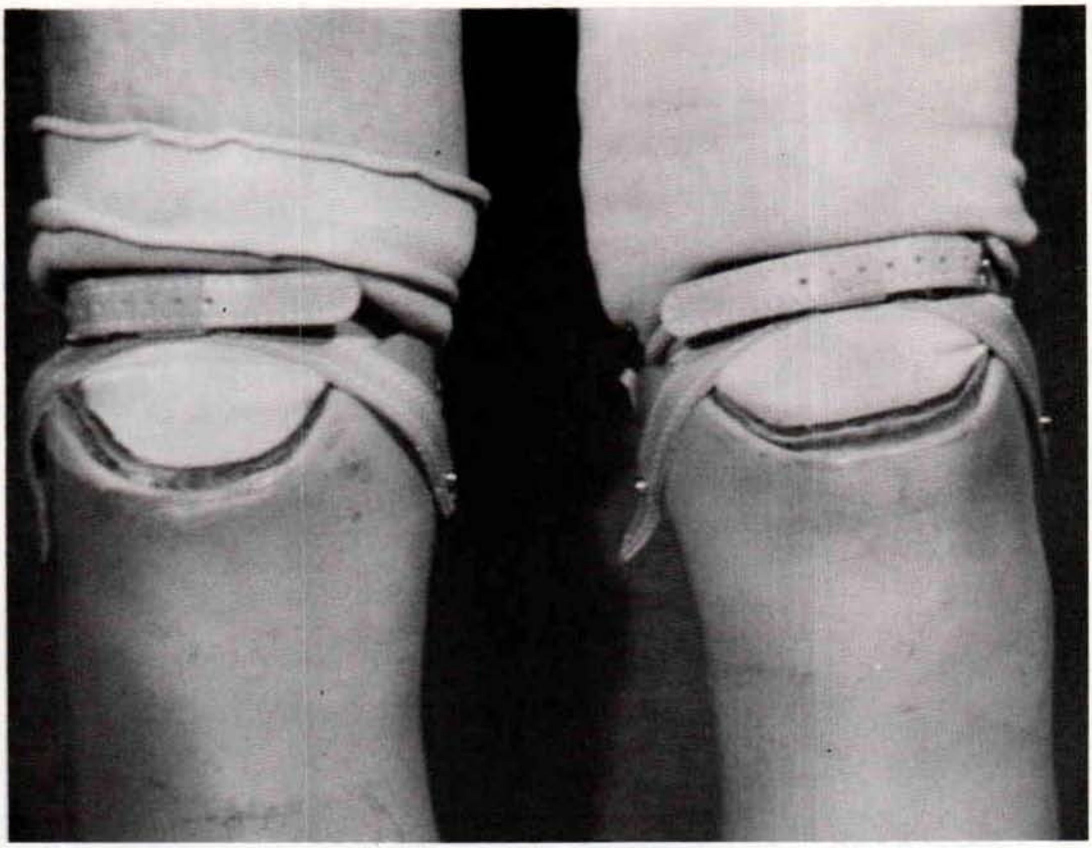

Fig. 6. Standing, anterior view, McFarlen system, bilateral.

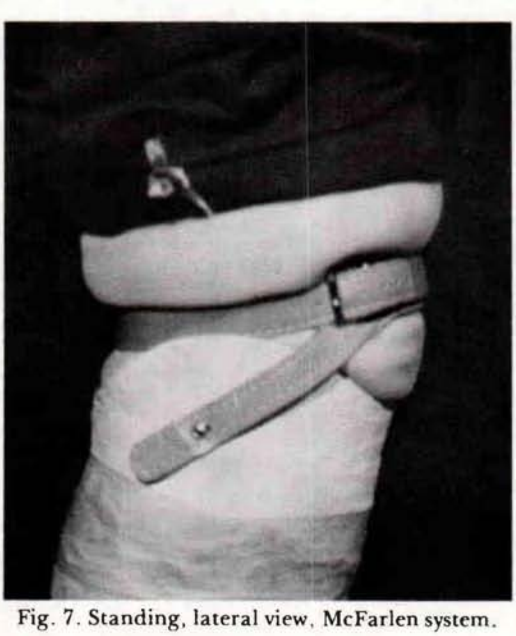

Fig. 7. Standing, lateral view, McFarlen system.

when located properly anteriorly is *at the proximal edge of the patella,* which I believe to be the most suitable position for the strap.

The strap when positioned in this manner requires a one to two cm. reduction in height of the medial and lateral trim lines to avoid "bridging." Because it is necessary to extend the socket walls only as far proximally as the condyles for stability, this reduction will have no effect on the medio-lateral stability of the prosthesis. Just proximal to the condyle is soft tissue where the strap can attain a good purchase on the femoral epicondyles. An X-ray view is shown in Figure 3.

When placed correctly, the strap upon knee flexion will come to rest on or near the posterior trim line of the socket (Fig. 4), thereby eliminating the common and

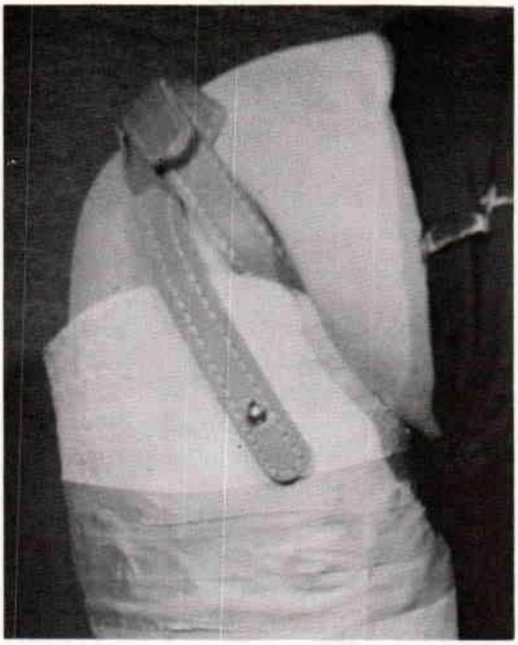

Fig. 8. Sitting, medial view, McFarlen system.

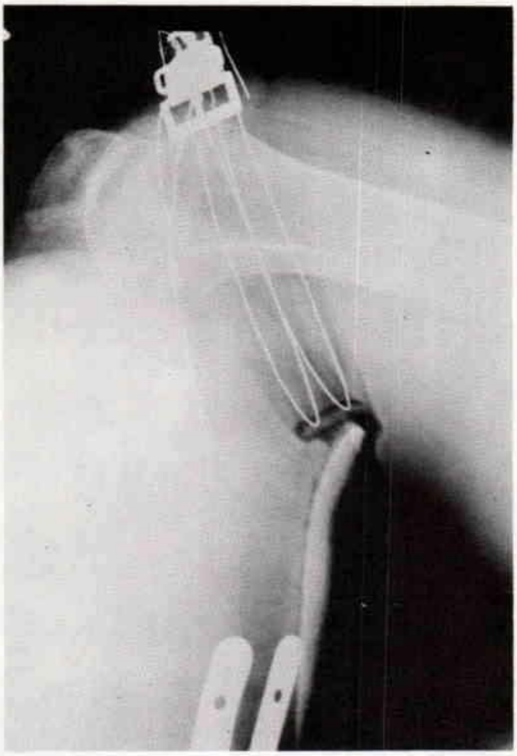

Fig. 9. X-ray, sitting, medial view, McFarlen system.

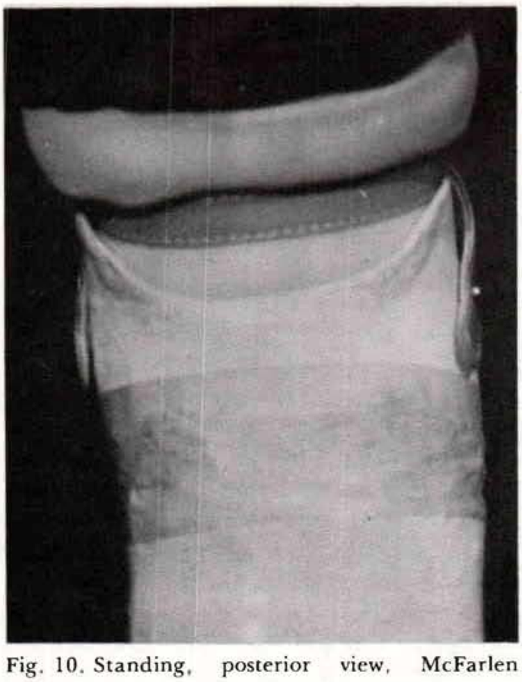

Fig. 10. Standing, posterior view, McFarlen system.

sometimes uncomfortable popliteal bulge (Fig. 5). Figure 6 illustrates the same patient standing with the McFarlen B/K Strap. It is interesting to compare this with Fig. 5, which shows the same patient and the UCB type suspension with waist belt. Note the popliteal bulge when the patient is sitting. Fig. 7 clearly illustrates a sagittal view of an active male patient (5'10", 210 lbs.) with a temporary plaster prosthesis, note the distal placement of the McFarlen BK Strap. Notice in Figures 8 and 9, two views of the same patient, that with knee flexion the strap actually disappeared into the posterior fold of the knee, thereby supporting the soft popliteal tissue. Figure 10 shows a posterior view and Figure 11, an anterior view of

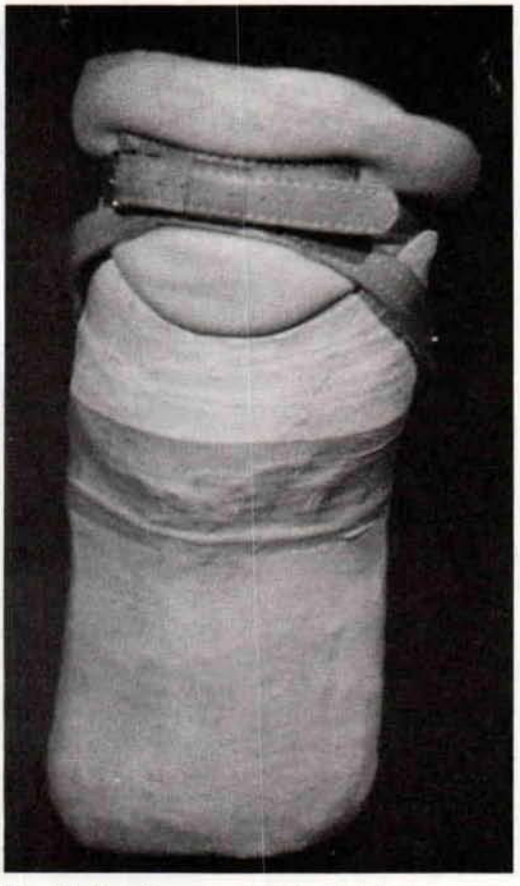

Fig. 11. Standing, anterior view, McFarlen system.

the same patient with the McFarlen Suspension System.

As seen in the illustrations, this suspension system allows for superior sitting comfort and suspension than that provided by any other supracondylar strap now available. Personally, I have used the system with great success on over 100 patient fittings since its original design in 1975.

The McFarlen B/K Suspension System, available through Pope Brace Company, is complete with four oz., top grade smoked elk, including buckle, rivets and keeper. It is adustable in length to 17¾" and can be assembled either right or left. This is a savings in itself by eliminating the need for excess inventories.

I want to thank Mark Hajost, C.P. and R.C. Mendrala C.P. for assistance in the structure of this paper.

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Orthotics and Prosthetics, Vol. 32, No. 3, pp. 49-55, September 1978

Metrication in the United States and Canada

EUGENE WAGNER

Metrication in the United States goes slower than in Canada. The big event in Canada in September 1977 was the change of all highway speed and distance signs to the use of metric units. While the actual change was done on the local and provincial levels within one month, it was coordinated with the Metric Commission in Ottawa.

Canadian weather reporting has been metric for many months, so motorists were not entirely unfamiliar with the metric terms when they appeared on highway signs.

The top speed limit on any Canadian highway is 100 km/h.

The province of Ontario has issued what is probably the first major all-metric highway map to be published in North America north of the Rio Grande. All distances shown on the map are only in kilometers. Included on the map is a graphical "Speed Conversion Chart" giving the miles per hour equivalents of kilometers per hour which are shown in increments of 10 km/h. The new map in conjunction with the new signs will do much to get Canadians accustomed to thinking metric.

Here in the States, according to the Metric Conversion Act of 1975, Public Law 94-168, a board of 17 members ought to be nominated by the President, to be confirmed by the Senate. The White House so far released 15 of those nominated. The two others are still under investigation. Following is the list of nominees with the category they represent as well as their backgrounds and metric experience if any:

Dr. Louis F. Polk, Dayton, Ohio, is a metrology expert and a retired vice president of the Bendix Corporation. He presently serves on the executive committee of the Fidelity Federal Savings of Dayton. He was chairman of the U.S. Department of Commerce's Metric Study from 1968 to 1971. Dr. Polk has been active in activities of the American National Standards Institute (ANSI) and is a former ANMC director.

Business

A.G. Weaver, Armonk, New York, is director of product safety for the IBM Corporation, and is an expert in engineering standards.

Standards

Sydney D. Andrews, Tallahassee, Florida, is director of the division of standards of the Florida Department of Agriculture. He is a past chairman of the National Conference on Weights and Measures and is chairman of the Florida Metric Council. Mr. Andrews is chairman of the ANMC Weights and Measures Sector Committee and also a member of the U.S. Metric Association. He has been actively promoting metrication for many years.

Members At Large

Dr. Paul Block, Jr., is publisher of the *Toledo Blade.* He has been a professor of chemistry at the University of Toledo since 1950.

Sandra R. Kenney, Owings Mills, Maryland, is continuity director for the Maryland Center for Public Broadcasting. She has taught art in Ohio and Baltimore and has been associated with instructional television since 1970.

Joyce D. Miller, New York City, is a vice president and director of social services for the Amalgamated Clothing and Textile Workers Union. Ms. Miller is a national president of the Coalition of Labor Union Women and serves on the AFL-CIO standing committee on civil rights.

Glenn Nishimura, Little Rock, Arkansas, is executive director of Arkansas Consumer Research, and he is vice president of the Consumer Federation of America.

The list of nominees has been sent to the Senate Commerce Committee who must confirm them individually for membership to the U.S. Metric Board.

Construction

Francis R. Dugan, Cincinnati, Ohio, is president of the Dugan & Meyers Construction Company. He has held official positions at local and national levels with the Associated General Contractors of America including membership on its metric committee.

Labor

Thomas A. Hannigan, Washington, DC, is assistant to the International Secretary of the International Brotherhood of Electrical Workers (IBEW). He served on the U.S. Metric Study 1968 to 1971. Mr. Hannigan is a member of the ANMC board of directors and its executive committee. He has a long record of opposition to national metrication dating back to 1970.

Dr. Henry Kroeze, Brookfield, Wisconsin, is chairman of the Department of Engineering and Computer Science at the University of Wisconsin-Waukesha. He is a member of the Engineers Joint Council Metric Commission, the ANMC, and the USMA. Dr. Kroeze is a native of the Netherlands and a long time promoter of metrication on the local and national levels.

Retailing

Dr. Satenig St. Marie, New York City, is a divisional vice president and director of consumer affairs for the J.C. Penney Company. She is a past president of the American Home Economics Association and a member of the ANMC consumer liaison committee.

Science

Dr. Edward Ginzton, Palo Alto, California, is chairman of the Board of Varian Associates, a company engaged in research and development in the microwave electronics field. He had been a professor of electrical engineering at Stanford University.

Small Business

Carl Beck, King of Prussia, Pennsylvania, is president of the Charles Beck Marine Corporation, who are manufacturers of machinery for the packaging and converting industries. He is active in the affairs of the National Small Business Association. Mr. Beck is a member of the

ANMC board of directors and its executive committee.

Roger Travis, Holbrook, Massachusetts, is president of Medi Inc., a manufacturer of disposable medical products. He is also president of the Smaller Business Association of New England.

State and Local Government

Dr. Frank Hartman, Lansing, Michigan, is a federal liaison representative for the Michigan State Department of Education in Washington. He has been a high school teacher, principal, and superintendent of two school districts.

The Governors Conference also took some measure. A representative for each State has been appointed to represent the Governors Conference in what they call the "Interstate Metric Committee". Here is a list of its members:

Alabama

Aubrey Dismukes
Division of Weights and Measures
Dept. of Agriculture & Industries
1445 Federal Drive
Montgomery 36130
(205) 832-6693

Alaska

Tony Motley, Commissioner
Dept. of Commerce & Economic Development
Pouch D, Juneau 99811

Arizona

Richard Harris, Asst. Director
Weights and Measures Division
Commerce Department
State Capitol, Phoenix 85007

Arkansas

Sam Hindsman, Director
Weights and Measures Division
Commerce Department
State Capitol, Little Rock 72201

California

Valerie Antoine, Vice President
U.S. Metric Association, Inc.
10245 Andasol Avenue
Northridge 91323
(213) 363-5606

Colorado

Jack Kinstlinger, Executive Director
Department of Highways
4201 East Arkansas Ave.
Denver 80222
(303) 757-9201

Connecticut

Graham Waldron, Director
Technical Services Division
Department of Commerce
State Capitol, Hartford 06115

Delaware

Dr. William J. Geppert
State Supervisor of Mathematics
Department of Public Instruction
Townsend Building
Dover 19901

Florida

Wayne C. Voigt, Asst. Director
Division of State Planning
State Capitol, Tallahassee 32304

Georgia

Rick Cobb, Deputy Commissioner
Division of Planning & Budget
State Capitol, Atlanta 30334

Hawaii

George Mattimoe, Deputy Director
Division of Weights & Measures
1428 S. King Street
Honolulu 96814

Idaho

NGA Interstate Metric Committee
Attn: Patricia Hawley
Office of the Governor
State Capitol, Boise 83720

Illinois

NGA Interstate Metric Committee
Attn: Sylvia Dennen
Office of the Governor
State Capitol, Springfield 62706

Indiana

Richard Wiley
Mathematics Consultant
State House, Indianapolis 46204

Iowa

Thatcher Johnson
Deputy Secretary of Agriculture
Des Moines 50319

Kansas

John L. O'Neil
National Conference on Weights & Measures
Department of Agriculture
P.O. Box 678, Topeka 66601

Kentucky

NGA Interstate Metric Committee
Attn: Frank Harscher
Office of the Governor
State Capitol, Frankfort 40601

Louisiana

Charles S. Johnson, Technical Administrator
Weights and Measures Division
Department of Agriculture
Room 315, 1237 Murphy Street
Shreveport, Louisiana 71101
(318) 424-6461

Maine

Arnold Johnson
Curriculum Consultant
Maine Education Department
State House, Augusta 04333

Maryland

Mrs. Audrey Buffington
Consultant in Mathematics
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444 North Capitol Street
Washington, D.C. 20001

Minnesota

Nathaniel Scott
Assistant Commissioner of Administration
208 Administration Building
St. Paul 55155

Mississippi

Dr. Charles E. Holladay
Superintendent of Public Education
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Puerto Rico

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Assistant Secretary
Department of Consumer Affairs
Box 41059, Minillas Station
Santurce 00940

Virgin Islands

NGA Interstate Metric Committee
Attn: Peter de Zela
Office of the Governor
Government House
Charlotte Amalie, St. Thomas 00801

Some states have taken actions in metrication on their own.

California passed a metric law. Formation of the California Metric Conversion Council was authorized with the passage of SB 1018 by the State Legislature. The bill, which was introduced by State Senator Alfred Alquist, was passed by a 33 to 2 vote in the State Senate and by a 70 to 7 vote in the Assembly. It automatically became law without the Governor's signature when he did not act upon it during the prescribed time limit.

The Council will consist of 10 members to be appointed by the Governor. The council will devise and carry out a broad program of planning, coordination, and public education in the use of the SI in California activities. Many California USMA (United States Metric Association)—members worked for the passage of the legislation.

GM Passes Halfway Mark

At late July and early August 1977 meetings of the General Motors Board of Directors and corporate executives, Mr. Richard L. Terrell, vice chairman of GM, observed, "General Motors is in the midst of an ongoing conversion to the metric system—a conversion which has been paced, and accelerated, by our unprecendented redesign program. Chevette was our first U.S. metric car, the 1977 B/C redesign was metric, and so is the 1978 midsize program—all in keeping with our plan of going metric as new parts and new designs are released. In fact, with the introduction of our new midsize cars, we will be past the halfway mark—we'll be more metric than inches and pounds. And by 1982 or so, the conversion will be virtually complete.

"Meanwhile, it is going very smoothly and essentially at little or no cost."

In accordance with General Motors metrication policy, the 1978 "A" type cars are predominately metric and thus join the "B" and "C" cars which became metric last year and the "T" Chevette, introduced two years ago.

The General Motors practice is to "go metric" on those new parts and assemblies which require new tooling. The above cars have been extensively redesigned to reduce mass and to improve fuel economy. Thus, the cars contain a predominance of new metric parts. The General Motors automotive products are now more metric than customary.

Postal Service Is Going Metric

Like other Federal units and private industry, the U.S. Postal Service (USPS) is gearing up to convert to the metric system of measurement. The "rule of reason" will apply to adoption of the SI in the Postal Service according to Deputy Postmaster General William F. Bolger. That is, the conversion will take place in an orderly manner, compatible with the voluntary conversion actions of postal customers.

In keeping with this policy, the USPS has committed itself to participate fully in the metric implementation efforts of the Federal government. The assistant Postmaster General for Research and Development, John F. Wise, is USPS's metric coordinator and chairman of the Postal Service's Metrication Board. That Board includes representatives from a number of Washington, DC, Headquarters organizations as well as a liaison person from each postal region.

Orthotics and Prosthetics, Vol. 32, No. 3, pp. 56-58, September 1978

Adapted Driver Education Publications

MENAHEM LESS Ph.D.
EDWARD C. COLVERD
GERALD E. DeMAURO
JUDY YOUNG

Despite the efforts of many vocational rehabilitation programs, employment of disabled people may be limited by the inability of graduates to travel freely from their homes to their now-found jobs. The need for improved public transportation is evident in the recommendations of the White House Conference of Handicapped Individuals, and for the expansion of existing facilities. Such a statement was necessitated by the inadequacies of present systems.

Commissioner Newman of the Rehabilitation Service Administration (1970) estimated that at least 100,000 disabled people are unemployed only because they lack transportation. Employment would bring these people $452,000,000 in annual wages as well as realize $39,000,000 in federal revenue.

The Human Resources Center in Albertson, New York, has successfully undertaken a series of state and federally funded initiatives in teaching people with a wide range of disabilities to drive. A most important objective of these programs has been to disseminate our experiences to the public.

Beginning in the fall of 1975, the adapted driver education unit of Human Resources Center commenced a long-range program in collaboration with the Nassau County Traffic Safety Board and the New York State Interdepartmental Traffic Safety Committee. In the last three years, the Center's driver education program has located 400 disabled potential drivers in Nassau County, New York. Evaluations were conducted of 241 of these who responded to preliminary inquiries. Training was initiated on 157 of these clients, and 61 were licensed to drive. Forty-six other clients are current trainees, and an additional 45 clients await installment of specifically designed equipment in the training van that will enable them to drive with disabilities that would otherwise preclude training. The entire training experience is documented in a manual entitled, "Teaching Driver Education to the Physically Disabled," which will include a teaching guide and evaluation mannual. This document will be published in 1978.

A manual is currently available which summarizes the Center's experience in vehicle modification for disabled drivers. "Hand Controls and Assistive Devices for the Physically Disabled Driver (1977) details the types of physical problems clients may have, the evaluation of the clients' driving potentials (including muscle assessment and in-car procedures), the prescription of mechanical compensatory devices, an evaluation of all such equipment currently available, and illustrations of equipment installment and use. This manual has been an enormous aid to driving instructors across the country. Included are 58 figures (22 photographs), a guide to the use of hand controls and assistive devices referenced to specific disabilities, and definitions of common terms relating to handicaps.

Hand Controls and Assistive Devices for the Physically Disabled Driver specifically outlines the uses of 39 mechanical compensations for functional disabilities. These are recommended by area of involvement, including upper and lower extremities, balance, neck and trunk rotation, and height deficiencies.

It is hoped that manuals, such as those described above, will enable innovative programs to benefit from the experiences of the Human Resources Center. Prospective program designers might avail themselves of the communication network that is rapidly developing within the rehabilitation field.

Manual on Management of the Quadriplegic Upper Extremity, Using Available Modular Splint and Arm Support Systems, Maude Malick and Christa M. H. Meyer, 228 pp. $15.00. Harmarville Rehabilitation Center, P.O. Box #11460, Guys Run Road, Pittsburgh, Pa. 15238 (Attn: Educational Resources Division)

Charles H. Pritham, CPO

As with her previous two efforts Mrs. Malick and her co-authors have produced another worthwhile contribution. While written principally for occupational therapists working without the close support of an orthotist expert in this very demanding area, as indicated on the front cover, all other members of the Rehabilitation Team will find this text interesting and informative. Of particular interest to the orthotist should be the side-by-side comparison of the various wrist-hand orthoses and arm support systems that are currently available.

The book opens with a thorough review of the involved anatomy, neurophysiology, and kinesiology that will be useful not only to the practitioner, but also to the student, and to candidates for certification. Three chapters are devoted to a description of orthotic systems, selection according to lesion level, and some relatively brief comments on measurement and assembly. While it would be impossible and, indeed, inappropriate to go into a thorough description of the fabrication procedure for each orthosis described, a fuller analysis and installation guide for the use of Balanced Forearm Orthoses would be most useful.

A lengthy chapter is devoted to functional management and general guidelines for the development of an occupational therapy program for the patient with an orthosis. The position of this book is well stated in the title and it sticks to the point. However, a comparison with the opposing school of thought concerning the use of universal cuffs would be most useful as would be a more thorough discussion of the prognosis for successful and continued orthotic use and the reasons for rejection. The book concludes with a brief description of Rehabilitation Engineering, Environmental Control Units, and powered wheelchairs in relation to Quadriplegia.

It seems picayune to quibble about such minor points when reviewing a text as well written as this one, but two points perhaps should be raised. The tone of the book would have been improved if the authors had consistently used the agreed upon orthotic nomenclature and eliminated the rather grating and belittling word splint. The two orthoses on pages 56 and 57 that are described as Rancho-style basic and long opponens orthoses are perhaps more accurately described as Warm Springs-style orthoses (the styles are virtually identical differing mainly in the attachment of the C-Bar). In comparison, only the most fulsome praise can be expressed for the high caliber of the illustrations. Whether it is the charts, diagrams, or photographs all are excellent and this volume can be considered as nothing less than the measure against which all others in this field will be compared.

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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		
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 $$°C = \frac{°F - 32}{1.8}$$

°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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    b. Photocopies

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6. Use the word "Figure" abbreviated to indicate references to illustrations in the text (. . . as shown in Fig. 14)

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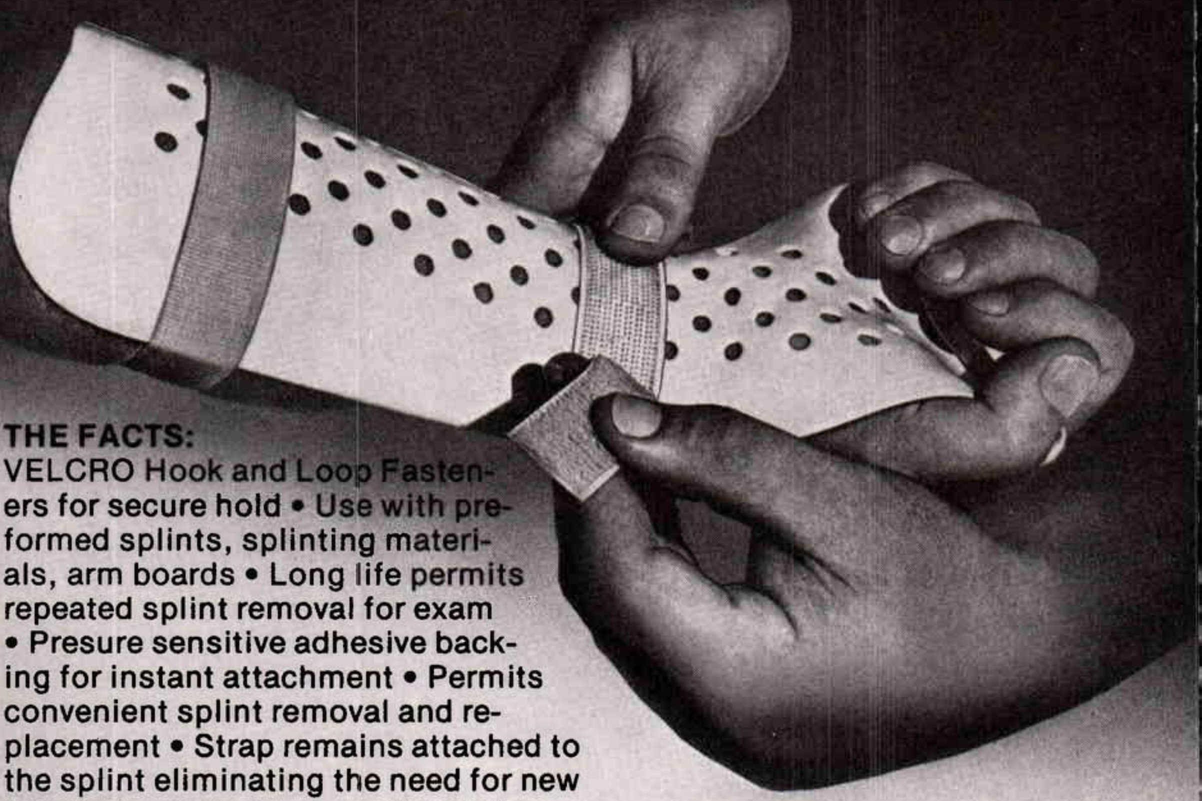

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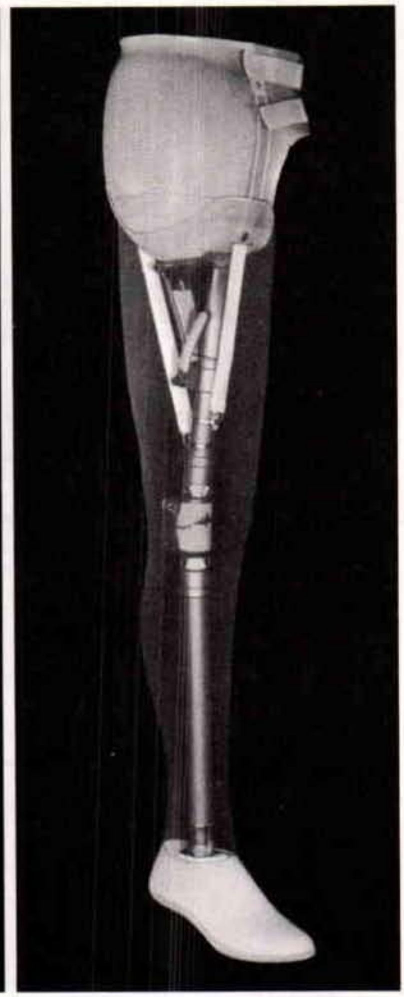

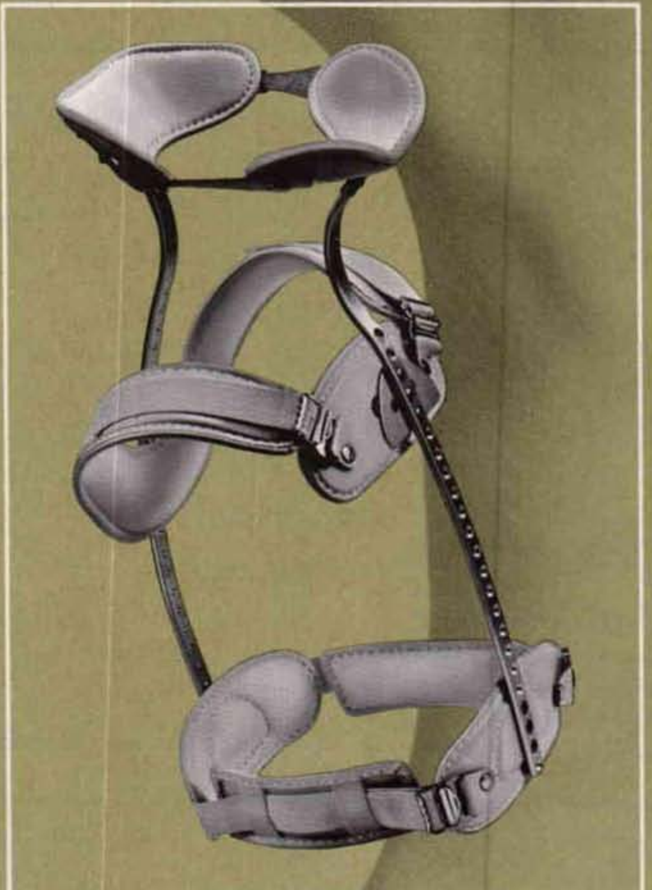

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