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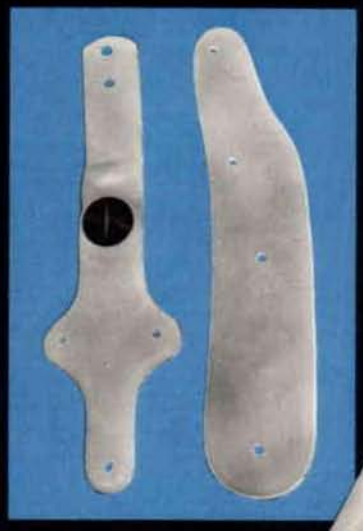

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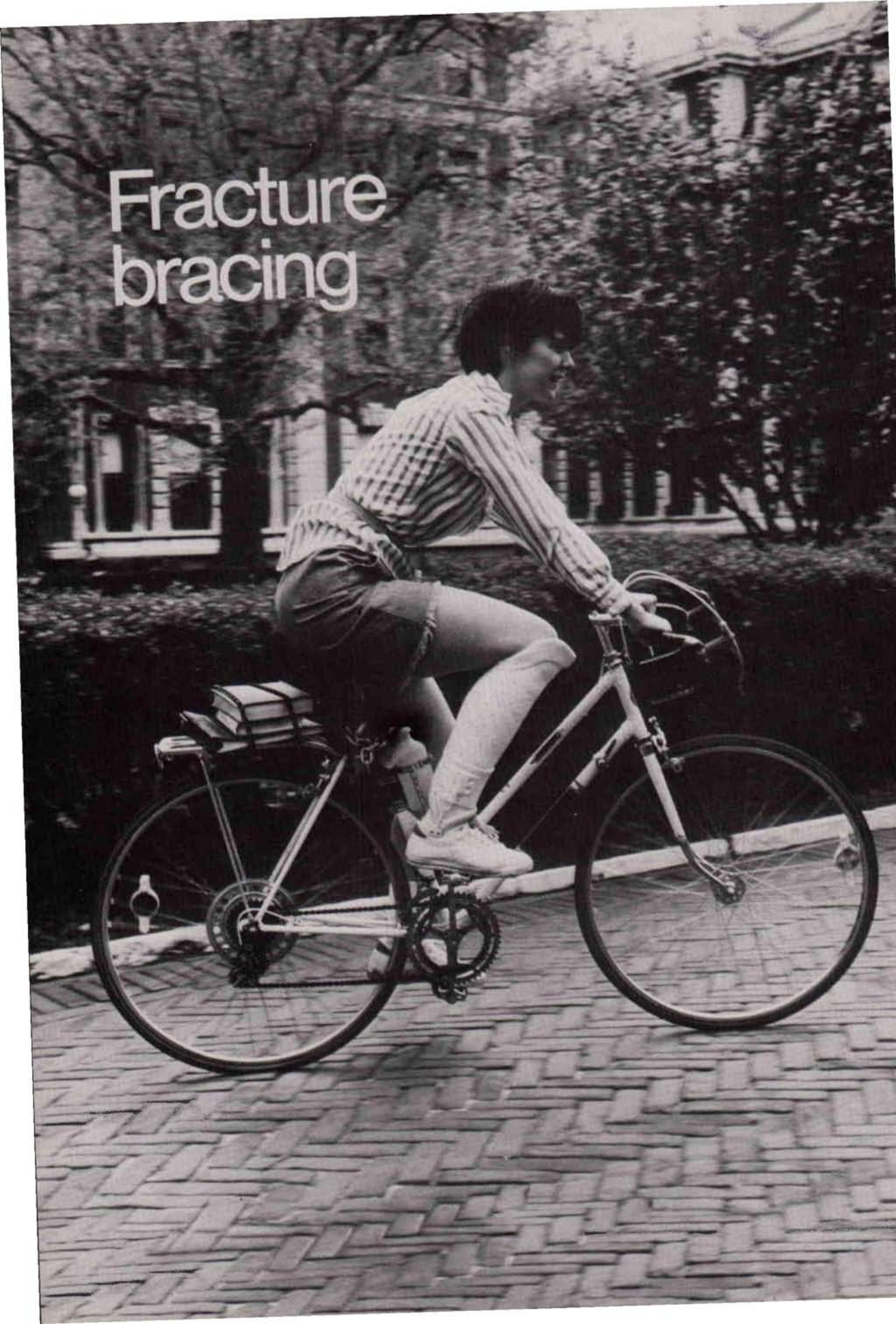
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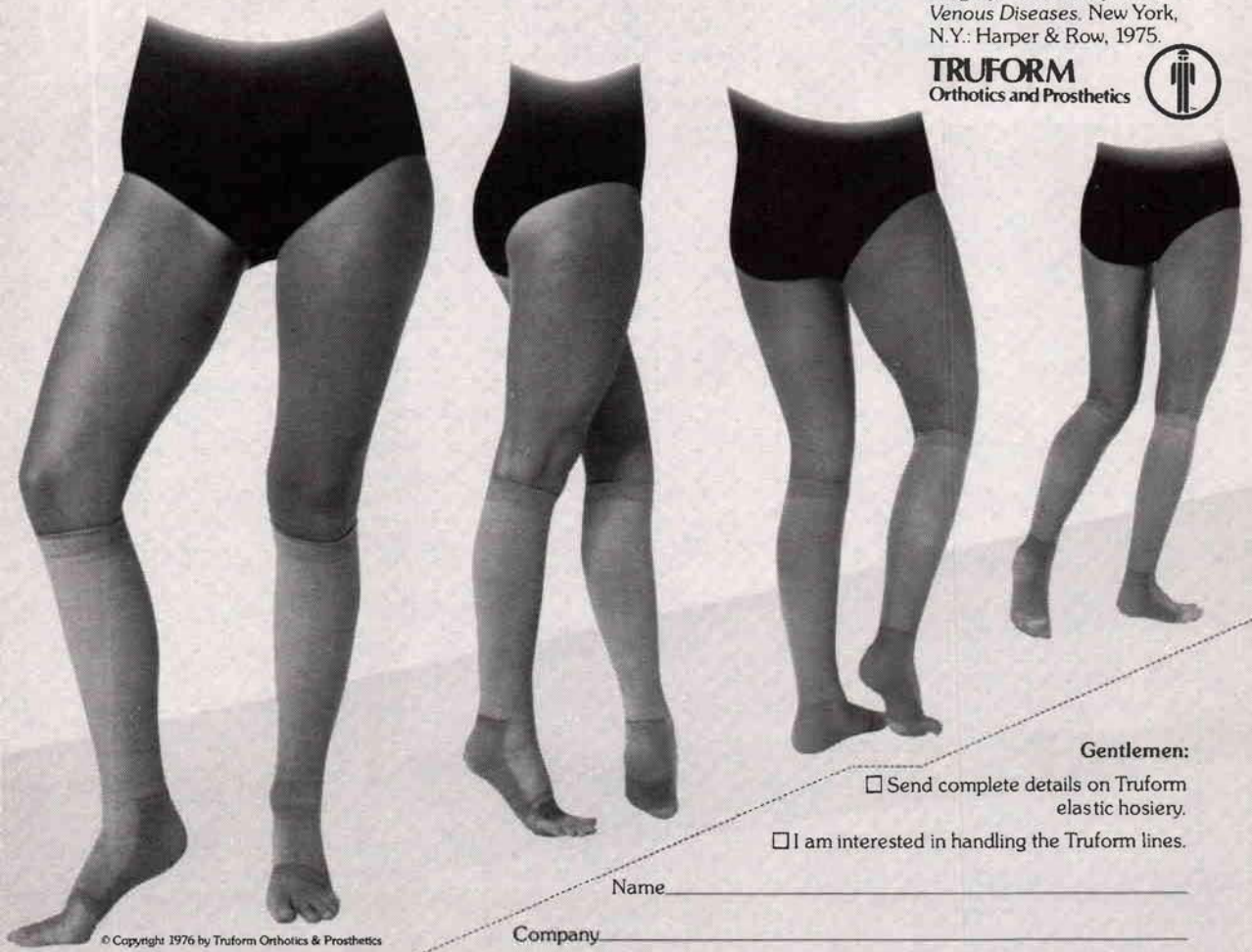

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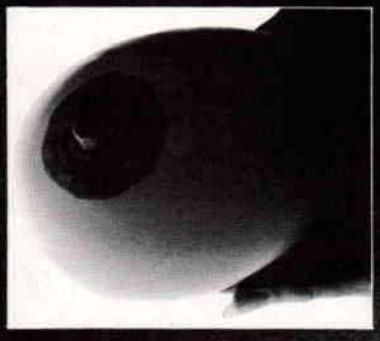

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Orthotics and Prosthetics, Vol. 31, No. 1, pp. 1–2, March 1977

THE ABC'S OF IT

When "splintmakers" and "limbmakers" were pushed into the future by a burst of technological and educational demands, the medical technocrats of the age renamed them Orthotists and Prosthetists. The new names did little to assist the general public in understanding exactly what one does with titles that are so long and difficult to pronounce.

The new names, however, did provide avenues for professional advancement and recognition never dreamed of by the original practitioners of orthotics and prosthetics.

Whenever recognition abounds in medically oriented circles, it brings its demands. The community in which you practice recognizes you by your credentials, your pedigree. What was required of you to become an orthotist-prosthetist? Did you "do-not-fold, -staple, -spindle, -or-mutilate (please print or type)" your name and address on a form, enclose a check for $10.00 and receive a certificate in the mail? Were you simply required to purchase your local "traders license" and hang out your neon sign? Preposterous postulations? Indignant indulgences? Yes, to you and me these are insulting thoughts and when certified orthotists and prosthetists are asked such questions, the response is often punctuated with righteous indignation. Yet, questions with similar veins of thought and background are being asked by federal and state governments every day. They are asking all professionals falling in the sphere of health care "Just what makes you, apart from anyone else, able to provide this service?"

The American Board for Certification has been actively involved in responding to H.E.W., state governments, agencies, and individuals involved in procurement of orthotic and prosthetic services. They ask why you, alone, are qualified. They point out the selfserving aspects of licensing and certification. They question if it is really necessary to have *any* qualifications.

We are fortunate. We can point to specific areas of practice that demand special qualifications. We were asked—we did not demand—to become professional members of our communities. We were invited. For nearly 30 years Certified Orthotists and Prosthetists have met the challenge of being recognized as a specialized entity.

Today, new agencies, new departments, new individuals are asking for information about us. How do we get to be who we are? We are obligated to respond, to educate those around us about the standards, and the rationale for those standards, within our profession. To fail to respond is suicidal.

We must make those around us aware of the need for our existence. Certified orthotists and prosthetists are an elite group of individuals. The process by which you have been awarded your credentials is the very finest available in health-care today. You have voluntarily submitted yourself to an arduous education on a professional plane. You have been trained within the university system. You have served a residency under the supervision of a certified orthotist-prosthetist following your formal education. You have been examined by your peers and orthopedic surgeons when you took your Board examinations. Your "boards" did not come easily. You were examined in three clinical areas; you were

examined in an oral interview; you successfully completed a comprehensive written examination.

You have obtained a formal education, learned a variety of skills, and have proven to your examiners that you are qualified to provide orthotic and prosthetic care to patients. You are Certified. "Just what makes you, apart from anyone else, able to provide this service?" Your education; your skill; your specialized body of knowledge; your credentials; your pedigree. The total is your personal achievement. That is also what ABC is all about.

CHARLES DANKMEYER, C.P.O.

Orthotics and Prosthetics, Vol. 31, No. 1, pp. 3-15, March 1977

A LIGHTWEIGHT ABOVE-KNEE PROSTHESIS WITH AN ADJUSTABLE SOCKET

George Irons, C.P.O.[1]
Vert Mooney, M.D.[1]
Sandra Putnam, R.P.T.[1]
Michael Quigley, C.P.O.[1]

In the late 1940's the suction socket prosthesis for above-knee amputees was introduced into clinical practice in the United States through the combined efforts of the American Orthotic and Prosthetic Association, the National Academy of Sciences, and the Veterans Administration. For nearly ten years the accepted practice was use of the so-called quadrilateral shaped cross-section, proposed by the Biomechanics Laboratory, University of California, Berkely, and a suction socket valve, but with a space distal to the stump. Further studies at the University of California indicated that if proper contact over the entire stump could be obtained the circulation in the stump of the above-knee amputee would be improved and thus many of the problems then besetting prosthetists and patients would be alleviated.

Initial experiments were with wooden sockets, but it was soon shown that it was easier to obtain the same or better results by laminating Dacron stockinet with polyester resins over a modified positive model of the amputation stump. Today, the total contact socket, with or without suction, is almost universally prescribed for the above-knee patient.

The armamentarium of devices for the above-knee amputee also includes sophisticated knee mechanisms that provide excellent control of the leg during the swing and stance phases of locomotion, ankle units that permit motion in three planes, and devices that reduce the shear stress about the stump during the stance phase.

Yet, there is one type of patient for which nearly every one of the recent advances in prosthetics offers no advantage — the geriatric, dysvascular amputee. Experience has shown that this type of patient with his limited energy, emotional lability, poor judgment, and stump with unstable volume often does poorly with modern prosthetic devices for the following reasons:

—Weight—Crustacean prostheses with pelvic belt suspension are normally heavy and therefore the prosthesis is difficult to control and the patients tire more readily.

—Instability — Knee units, even braking knees, are difficult for the patient to adjust to, and therefore much training is needed. Patients will often reject the prosthesis because they feel unstable. The manual locking knee is an exception.

—Donning — Suction sockets, as we know them, require more energy and skill to don than most geriatric amputees have. Even the standard pelvic belt suspension can cause problems due to the rigidity of the system.

—Socket Fit — Edema problems and weight changes are always present. These patients often cannot adjust for volume differences because they do not understand how to add or subtract prosthetic socks. Discomfort leads to either constant visits to the pros-

[1]Rehabilitation Engineering Center at Rancho Los Amigos Hospital, County of Los Angeles, University of Southern California, Downey, California 90242, The Rehabilitation Engineering Center — Rancho Los Amigos Hospital — Los Angeles County — University of Southern California is one of a group of National Centers funded and supported by The Rehabilitation Services Administration, Department of Health, Education and Welfare, United States Government. Financial support is also derived from: The Veterans Administration, The National Institutes of Health, The National Aeronautics and Space Administration, and certain Industrial Corporations.

thetist for adjustments, or rejection of the prosthesis.

A new system of management for the geriatric patient has been developed at Rancho Los Amigos Hospital using a polypropylene adjustable socket, an endoskeletal structure, and a manually locked knee (Fig. 1). This design incorporates the following advances over previous designs:

—Lightweight — Polypropylene socket and endoskeletal structural members permit the fabrication of a prosthesis that weighs about 50 percent less than the crustacean type designs commonly used. (The prosthesis is designed for light duty, and is not intended for use on extremely active patients.)

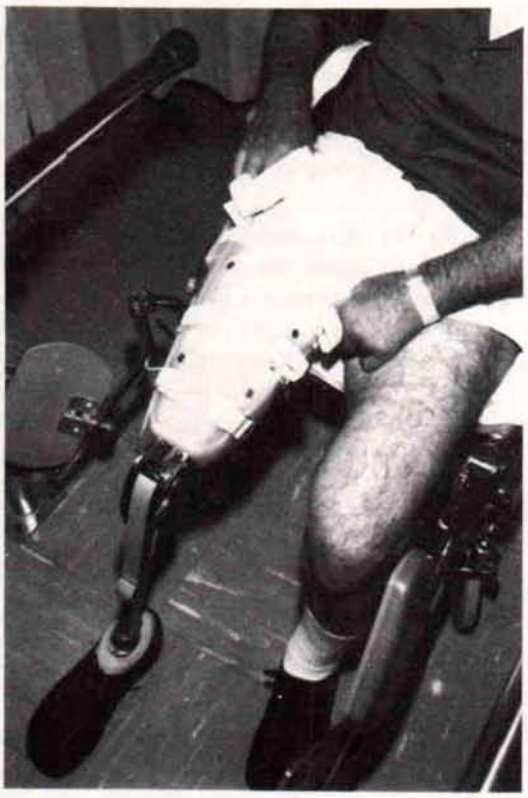

Fig. 1. Patient donning the prosthesis. Note the adjustment straps that compress the anterior and posterior socket panels.

—Stability — A manual locking knee is used to provide knee stability although the patient's gait is less cosmetic than with an active knee. However, elimination of the possibility of the knee buckling outweighs this disadvantage.

—Adjustability — The socket can be tightened or loosened to allow for volume changes, proximal weight-bearing tolerance, and suspension. Only one prosthetic sock is needed because the socket can be adjusted for volumetric changes, resulting in more comfort, more total contact, less donning training, and fewer adjustments.

—Comfort — The proximal brim can be made more flexible than is the case with thermosetting plastics, and is therefore more comfortable.

—Early Patient Training — Patients may be fitted with a prosthesis before volume changes are complete, therefore allowing earlier patient activity and training and a reduction in overall rehabilitation time.

HISTORY AND DEVELOPMENT

Although adjustable AK sockets have not been in common use since the leather socket went out of vogue, a number of notable attempts have been made to develop adjustable sockets. The most widely known unit is on the "Cosmevo" prosthesis, invented by Cosmo Invidiato of Paterson, New Jersey, which is an "off-the-shelf" type of AK prosthesis that incorporates length and alignment adjustments as well as having air bladders in the socket to provide for a snug fit. The "Cosmevo" prosthesis has been used for both definitive and temporary use.

Three different types of adjustable AK sockets have been used on temporary, or training, prostheses. In 1964, Foort (2) reported on an "Instant Prosthesis for Thigh Amputees" that merged his work at the University of California Biomechanics Laboratory with that at Manitoba Rehabilitation Hospital, and resulted in three socket sizes that could be attached quickly to an

adjustable pylon for temporary use as a prosthetics training and evaluation device. In 1965, Magato and Rosenberg (*4*) reported on an adjustable training leg that had been used on 23 patients. A polyester laminated quadrilateral socket with screw adjustments and an Otto Bock Safety knee with a SACH foot were used. Training time was decreased from five to three weeks. The prosthesis was not used definitively. Brownsey and Fillauer (*1*) used a polyester socket with an adjustable anterior wall on a pylon structure with an offset knee joint and a metal-and-tire-tread foot. All but two of the 21 patients in the study planned to progress to a conventional prosthesis.

It was apparent that adjustability in the socket was a key element contributing to the success of the three types of adjustable training prostheses.

Silastic bladders have also been tried in AK sockets by Sinclair (*6*) and Horiuchi (*3*) in order to provide volume adjustments, but fabrication and leakage problems eventually caused disfavor with this technique.

Both the air bladder and the Silastic techniques were tried at Rancho Los Amigos Hospital in the late 1960's. Four air bladders were placed in the proximal brim of the socket, one on each wall. Two serious problems existed; the pressure from the bladders eventually deformed the patient's residual limb into a square cross-section, and there were leakage problems almost constantly. The laminated Silastic air cushion AK socket was meant to apply constant total contact and partial weightbearing forces. Unfortunately, upon use the patient was "pumped out" of the socket.

The advent of thermoplastic materials and vacuum forming techniques in the early 1970's (*5, 8*) provided new possibilities for adjustable AK socket designs. In early 1975, the present design of the adjustable socket was developed. When used in conjunction with an endoskeletal structure and a manual locking knee, the prosthesis has proven to be useful to a great number of geriatric patients who could never master the more conventional types of prostheses.

To date, over 70 definitive lightweight AK prostheses have been fitted at Rancho Los Amigos Hospital, and over 100 more have been fitted by private practitioners in Southern California. In many cases, prosthetists have called in geriatric patients who had previously been functioning at a marginal level with a conventional prosthesis, and explained the new design. Very often the patient decided to change over to the lightweight AK prosthesis with an adjustable socket.

PRESCRIPTION CRITERION

Potential patients for the above-knee prosthesis are evaluated by all members of the rehabilitation team to determine their functional goals and potential for prosthetic use.

The patient's prior and present functional levels are assessed by the physical therapist to determine his potential for ambulation with a prosthesis. If a patient cannot stand, balance, or walk with a walker without a prosthesis, it is most likely that he will not be able to balance or walk with a prosthesis. If a patient has remained in a wheelchair and not walked for the past six months, he is usually considered to be a questionable candidate for a prosthesis.

Range of motion is assessed to determine if any significant contractures are present. For example, if a patient has a hip flexion contracture of 30 deg. his potential for functioning successfully in a prosthesis is considered to be limited. Strength of all limbs is tested manually. The strength of the upper limbs must be functional to enable the patient to don the prosthesis and use crutches or a walker. The residual limb must also have adequate strength, especially in the hip extensors and abductors, in order to control the prosthesis during ambulation, particularly if the prosthesis is to include a safety knee rather than a manually locked knee. The sound limb must also have adequate strength and tolerance for weightbearing.

Sensation of the upper and lower limbs is evaluated in order to identify any impairment which may interfere with the wearing or control of a prosthesis.

Decreased ability to feel in the fingers and hands can affect a patients ability to don the prosthesis. Hypersensitivity to touch on a residual limb can affect a patient's tolerance to socket pressures, and impaired proprioception in the sound foot can result in gait deviations (Fig. 2).

Each patient's heart rate and blood pressure are monitored while walking without a prosthesis to determine his physiological response to exercise. This allows the therapist to determine if the patient has sufficient cardiovascular reserve to allow him to tolerate the additional demands of prosthesis use.

The patient's cognition and motivation are assessed to determine if he has sufficient understanding and judgment to handle a prosthesis safely and if he will be cooperative and interested in participating in an active rehabilitation program.

Fig. 2. Evaluation of the sound limb and foot to determine sensitivity, proprioception vascularity, and strength is of utmost importance with dysvascular patients.

The patient's social history is also reviewed. If the patient has a history of social problems such as alcoholism or has no one at home to look after him, it is likely that his rehabilitation with the prosthesis will be that much more difficult.

Following evaluation by all members of the team, a decision is made as to whether or not the patient is a candidate for a prosthesis; what his long term functional goals will be; and if a candidate, the type of prosthesis that would best suit his needs.

FABRICATION

It is necessary to have a vacuum-forming table in order to fabricate the adjustable socket. An oven that is capable of producing 400 deg. F. of evenly distributed heat is also required. The following materials are necessary:

1 ea. 13-in. x 13-in. piece of ¼-in. thick polypropylene,

1 ea. 13-in. x 13-in. piece of ⅜-in. thick polypropylene,

1 ea. 3-in. x 3-in. piece of ½-in. thick Lexan, polypropylene, or other strong plastic,

2 ea. nylon stockings,

3 ea. cotton-webbing-backed Velcro straps with "D" rings,

1 ea. 4-in. x 4-in. piece of 1 ¼-in. thick T-foam or RTV Silicone foam,

A cast of the patient is taken in the customary manner. When filling the cast, a removable pipe or mandrel is used. During the cast modifications, the desired flexion and adduction angles and proximal cast contours are established. The length of the cast is checked and reliefs are added where necessary. The circumferences are checked and the cast is modified to make the circumferences the same as that of the patients. "Tension" should not be added to the cast.

A 1 ¼-in. plaster buildup is added to the distal end of the cast. The size of the buildup should correspond to the size and shape of the attachment plate on the endoskeletal knee unit. The surface of the buildup must be parallel to the ischial seat in the frontal plane and parallel

Fig. 3. Aligning the surface of the distal buildup to be parallel with the ischial seat and medial wall. This will ensure that the socket will be level when attached to the knee unit. See Fig. 4 also.

Fig. 4. Aligning the surface of the distal buildup to be parallel with the ischial seat and medial wall. This will ensure that the socket will be level when attached to the knee unit.

to the medial wall in the sagittal plane (Fig. 3 & 4). Straight edges should be used on the buildup and the socket brim to help make the two areas parallel. The edges of the buildup should be contoured to blend in with the mold.

The mandrel is removed and the mold is placed on the vacuum table. Suction holes are drilled through the mold to the hollow interior of the mold at the Scarpa's Triangle, medial, and posterior walls.

To make the flexible anterior portion of the socket, a ½-in. thick piece of plastic is placed on the distal buildup and a nylon stocking is pulled over the mold (Fig. 5) to allow the

Fig. 5. After vacuum holes are drilled, ½-in. thick plastic piece is placed on the distal buildup and a nylon hose is pulled over the mold.

vacuum to pull under the entire length of the mold. The 13-in. x 13-in. piece of ¼-in. thick polypropylene is locked in place in a 12-in. square metal frame and placed on a stand in a 400 deg. F. oven in a manner that allows the plastic to sag without contacting any other material. When the plastic sags to a point about two-thirds of the length of the mold it is

removed from the oven, turned 180 deg. so that the sag is above the mold, and then pulled carefully over the mold (Fig. 6), all in one fluid motion. Vacuum is applied slowly after the plastic has made contact with the plinth on all sides and until the plastic is in contact with the mold in all areas. When the plastic has cooled, the excess is cut away at the base of the mold.

To make the more rigid posterior and medial walls it is necessary that a piece of ⅜-in. thick polypropylene be molded over the ¼-in. thick piece.

The mold with the ¼-in. thick polypropylene is left on the vacuum stand and holes are drilled through the plastic to open up the original vent holes. Another piece of nylon should be pulled over the mold and plastic and the vacuum forming procedure repeated, this time using the ⅜-in. thick polypropylene.

The trim lines are designed to allow adjustability at both the proximal and the distal ends of the socket, although the distal end is less flexible. The ¼-in. thick polypropylene covers the entire anterior wall of the socket and extends 2 ½-in. over the medial and lateral walls. The ⅜-in. polypropylene covers the entire posterior wall and extends to the medial wall 1-in. from the adductor longus channel. Laterally, the ⅜-in. thick polypropylene extends around to the anterior wall (Fig. 7).

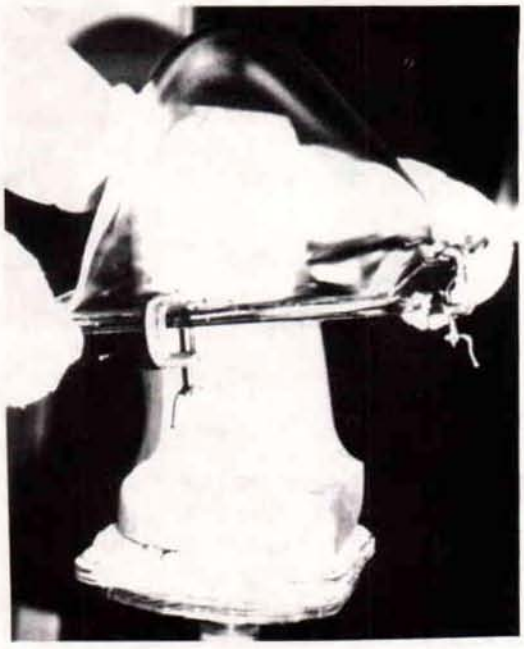

Fig. 6. After the ¼-in. piece of polypropylene turns clear and sags, remove it from the oven, invert it and pull it over the mold.

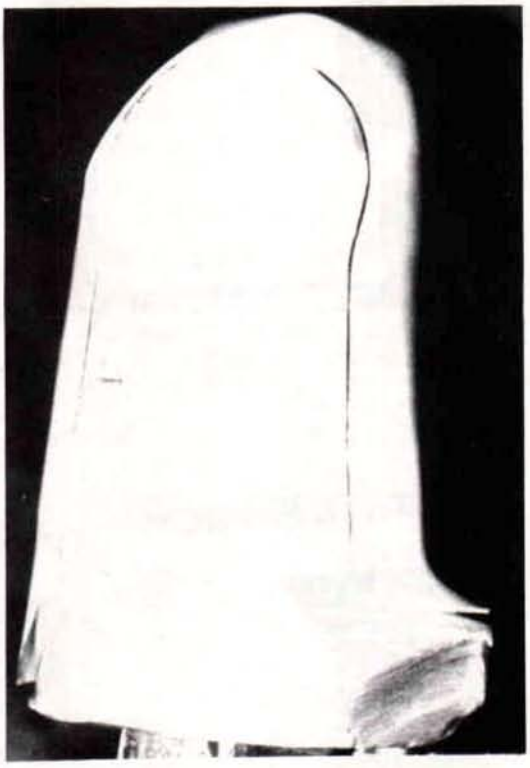

Fig. 7. The anterior trim line.

The trim lines must be determined before removing the plastic from the cast (Fig. 8). The trim line is laid out for the ⅜-in. thick polypropylene as follows:

1. A line is drawn from the medial wall from a point 1-in. posterior to the adductor longus channel down to a point two-thirds of the length of the cast.
2. A line is drawn on the anterior wall 1-in. medial to the lateral wall and extended down to a point two-thirds of the length of the cast.

Fig. 8. The trim line shows the overlap between the two panels. Note that both panels overlap at the distal end.

3. The trim line is moved posteriorly about 1-in. at the distal one-third of the mold, in order to provide more flexibility in this area. A flowing line should be made when extending this line. Distally, the trim line is ½-in. proximal to the plastic attachment plate.

A cut is made carefully along the established trim line, the posterior wall is removed, the trim line is smoothed, and the socket is replaced on the mold. The posterior wall is removed again, a grease pencil is used to trace the trim line on the ¼-in. thick polypropylene. The trim line is 1 ½-in. posterior to the traced lined, and is flared to the distal end. Along the 1 ½-in. mark, a cut is made, but the distal end is left attached anteriorly. The ¼-in. thick polypropylene is placed on the anterior wall over the ⅜-in. thick polypropylene posterior wall and the trim lines are rechecked.

The knee, shin, and foot are set up to the correct height and alignment, and the attachment plate is leveled on the knee unit. In the case of a short socket, an extension tube is used to connect it to the knee unit. Often, however, a space of from 1-in. to 3-in. is needed between the socket and the knee unit in order to provide the correct length of the prosthesis and the proper knee-center height. In these instances, the plaster mold is built up before forming the socket so that it will be that much longer. The additonal space in the socket is filled with foam. However, it is recommended that an extension tube be used whenever possible because the lengthened sockets may fatigue easier.

Endoskeletal components are used with the adjustable socket. For geriatric patients that are marginal candidates for a prosthesis, a lightweight foot and manually locked knee is recommended. Other knee mechanisms can be used at a later date when a patient's functional potential indicates the need.

The socket is placed on the knee unit attachment plate, the line of progression, flexion, adduction and M-L position are checked, and the border of the attachment plate on the bottom of the socket is traced. The bolt holes are marked, and holes are drilled through both sections of the socket and the ½-in. thick piece of plastic (Fig. 9).

The cotton-webbing-backed Velcro straps are riveted or screwed to the lateral wall of the posterior section of the socket, and the "D" rings are attached to the medial wall of the posterior section of the socket. One strap is placed at the ischial level, one at the distal third of the socket, and one midway between these two (Fig. 10).

The socket is bolted to the knee unit and the cable for the knee lock is taped to the lateral wall of the socket. The prosthesis is now ready for fitting.

FITTING

The patient is instructed how to don the prosthesis properly, and when it is donned correctly it is checked for proper fit. Fitting the prosthesis is essentially the same as for any

Fig. 9. The socket is aligned on the knee unit attachment plate.

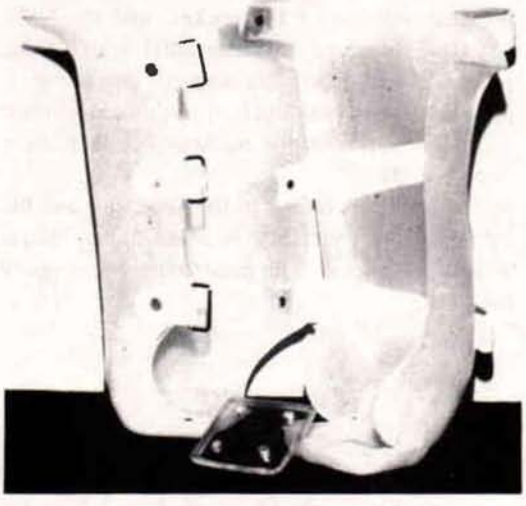

Fig. 10. The completed socket. Note the trim line at the distal one third of the socket.

other AK prosthesis. The ischial tuberosity is checked to see if it is resting on the ischial seat. The length of the prosthesis is checked. When a manual locking knee unit is used, the prosthesis should be ½-in. shorter than the sound limb in order to provide toe clearance during swing phase. When a safety knee unit is used, the limb lengths should be equal.

The patient should be able to distinguish when he is on the ischial seat, and he is instructed in the use of the adjustment straps to maintain ischial weightbearing. He should also be taught to use the manually locked knee properly, and to test the knee each time he stands to be sure it is locked (Fig. 12).

Fig. 12. Lateral view of the prosthesis with the cover pulled down. Note position of the knee lock cable.

Generally, no alignment changes are necessary. If slight alignment changes are needed, a wedge between the socket and the attachment plate can be used.

Sitting comfort is of great importance. Check the trim lines and ischial seat while the patient is sitting, and make any necessary modifications.

FINISHING

The prosthesis is finished with a cosmetic foam cover, which is shaped to match the patient's sound leg and extends to the distal third of the socket. When a manually locked knee unit is used adequate space must be left in the cosmetic cover for operation of the locking lever, because if it comes in contact with the cosmetic cover it may stick in an unlocked position. The cable and control knobs for the manual lock knee should be attached to the anterior lateral aspect of the socket in order to provide easy access to this control for the patient. The entire prosthesis is then covered with cosmetic hosiery (Fig. 11).

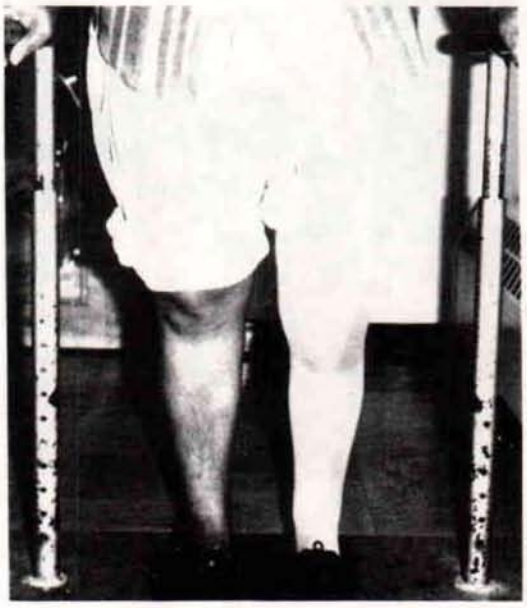

Fig. 11. The completed prosthesis with a foam prosthetic cover.

PHYSICAL AND FUNCTIONAL TRAINING

Once a patient receives his above-knee prosthesis, he is admitted to the hospital and is placed on an intensive physical therapy program consisting of physical and functional training based on the patient's specific needs. For example, if the patient needs strengthening of the upper limbs for ambulation with crutches, the depressor muscles may be strengthened by progressive resistive exercises. All patients participate in a daily mat class to strengthen the muscles of the residual limb including the adductors, abductors, and hip extensors (Fig. 13). Lying prone on the mat for a short period is also included to maintain extension range in the hips.

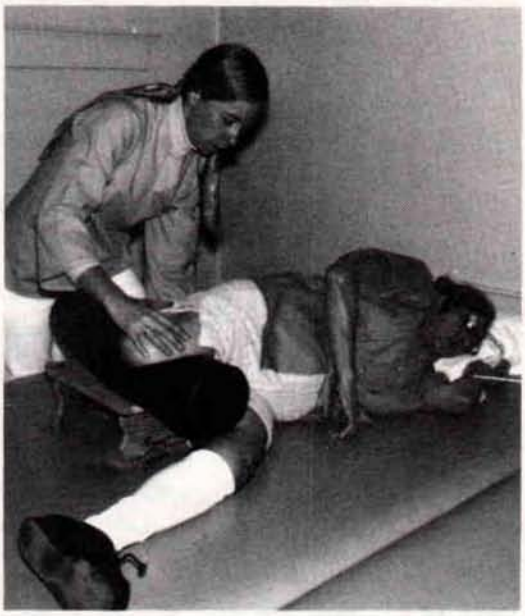

Fig. 13. Daily mat classes are held to strengthen hip muscles. Proning and resistive exercises are also used.

Patients are also trained in transfers and ambulation with a walker or crutches without their prosthesis in order to enable them to go to the bathroom at night without putting on the prosthesis. Most patients will need to use a wheelchair for some activities, so training in

wheelchair handling and transfers is provided (Fig. 14).

As part of the patient education program, the patient is instructed in care of his residual limb and remaining foot. He is told to inspect his skin carefully and is instructed to have red or open areas cared for immediately. The use of proper defensive foot wear is stressed and appropriate shoes are ordered for patients with potential foot problems. Shoes with firm but flexible soles and soft leather uppers are often used. The patient is also instructed in the care of his prosthesis. He is taught to clean the socket of the prosthesis daily with a damp cloth and to return to the prosthetist for any necessary adjustments.

Although the initial instructions about donning the prosthesis are given by the prosthetist, the physical therapist continues the donning training and practice until the patient fully understands how to don and doff the prosthesis correctly (Fig. 15). Close coordination between the therapist and prosthetist is essential for successful fittings.

Fig. 14. Most patients who are candidates for the prosthesis must also be able to use a wheelchair, and therefore transfer techniques need to be taught.

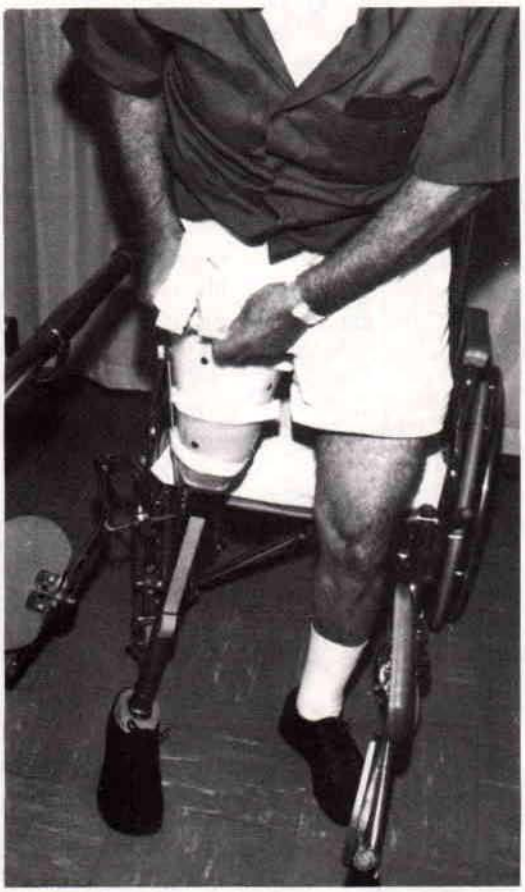

Fig. 15. Patients are trained proper donning procedures and strap adjustments.

The patient is instructed to don one 5-ply prosthetic sock first. The patient then dons the prosthesis in a sitting position with the Velcro straps loose and the plastic hip joint out of the way. He fastens the waist belt, stands and locks the prosthetic knee and adjusts the sock properly by pulling it down snugly. The Velcro straps then are pulled snug and fastened. When the cosmetic cover is added to the prosthesis, the patient is given additional instructions in the management of the cover and stockings. A major advantage of the adjustable socket is that only one 5-ply sock is needed. When volume changes occur, the patient simply adjusts the Velcro straps.

Once donning is understood, preambulation activities begin with the patient standing in the parallel bars. Emphasis is placed on standing balance, shifting weight from one leg to the other, minimum use of hands for support, and use of hip abductor and extensor muscles during weightbearing.

The patient progresses from preambulation activities to gait training in the parallel bars. Short frequent training sessions are used because the amount of concentration required by the patient during training makes the activity very fatiguing. During gait training, emphasis on the use of hip abductor and extensor muscles is continued, especially when the patient has a safety knee on his prosthesis. Less training time is required for patients with manually locked knees because the patients do not need to learn the same degree of hip control.

When the patient has become independent in ambulation, he is trained to do all necessary functional activities wearing the prosthesis, including transfers, and negotiation of stairs, curbs, ramps, and uneven surfaces. Each patient also participates in an occupational therapy program for training in functional activities, such as self-care, homemaking, and community skills with the prosthesis in order to increase the patient's functional abilities in a home-and-community environment. If problems in the home environment are anticipated a home visit is made by all team members to ensure safety and carry-through of function after discharge.

The average training time required for a patient with a locked knee unit is from two to two and one-half weeks. When a safety knee unit is used, four weeks are generally required. Patients usually do not need further training as an out-patient, but are followed at regular intervals in the out-patient clinic.

FOLLOW-UP DATA (TABLE 1)

The first fourty-four patients who were fitted with the adjustable AK sockets were interviewed by a physical therapist either in the out-patient clinic or by telephone two to twelve months after the discharge from the hospital. The purpose of the follow-up interviews was to determine the long term use of the prosthesis by patients, because our past experience with geriatric patients using a conventional above-knee prosthesis with a safety knee has been poor. The majority of dysvascular geriatric patients who were fitted with a conventional AK prosthesis with a safety knee discontinued using the prosthesis because of the weight and difficulty with controlling the knee unit. Energy-cost studies carried out in the Kinesiology Laboratory at Rancho Los Amigos Hospital on vascular above-knee amputees using conventional AK prostheses (7) have shown that it takes more energy for a patient to walk with crutches and a prosthesis than it does for him to walk without the prosthesis using only crutches. We were therefore interested to learn the patient utilization of the lightweight adjustable prosthesis.

The average age of the 44 patients interviewed was 61 years. Ten of the patients were given a safety knee; 34 patients were given a manually locked knee. Of the 34 patients who received the manually locked knee, seven of them might have been considered for another design of prosthetic socket, but 27 of them by our criteria would not have been a candidate for any other type of prosthesis. The patients seemed to fall into two groups: those receiving safety knee units (ten patients) which allowed the knee to swing freely; and those receiving

manually locked knee units (34 patients). Patients that received the manually locked knee units were further divided into two categories; those who would have been a candidate for any other prosthesis; and those who were a candidate for a lightweight prosthesis only.

PATIENTS WITH SAFETY KNEE UNITS

The average age of the ten patients in this category was 53 years, or eight years less than the average for the total groups. These patients would have been a candidate for any prosthesis. Of the ten patients, two reached the level of virtually unlimited distance walking in a community using crutches, and eventually received standard crustacean prostheses. Five patients became able to walk a limited distance in the community with crutches or a walker but required a wheelchair for long distances. One patient used the prosthesis for walking in his home only, and used a wheelchair out of doors. Two patients discarded the prosthesis because of medical problems not associated with prosthetic wear.

PATIENTS RECEIVING MANUALLY LOCKED KNEE PROSTHESIS

Seven patients who would have been considered for a conventional prosthesis received the lightweight prosthesis with the adjustable socket because of other complicating orthopedic problems. The average age for this group was 57 years. One of the patients became a community ambulator, and eventually was fitted with a crustacean type of prosthesis. The other six patients became limited community ambulators.

The average age for the remaining 27 patients who received a prosthesis with a manually locked knee was 66 years. By the evaluation criteria used at this hospital it was determined that these patients would not have been candidates for any type of conventional prosthesis. The follow-up data from these patients indicated that none of them became community ambulators; that is, having the potential for unlimited walking in the community. Ten of the patients became limited community ambulators, with crutches or a walker, ten patients became household ambulators, one patient died, and six stopped using the prosthesis. Of the six that stopped using the prosthesis, other unrelated medical complications were the reasons in four cases, the remaining two patients were simply dissatisfied with the prosthesis.

SUMMARY

The first 44 patients fitted with an adjustable lightweight AK prosthesis were interviewed two to twelve months following discharge from Rancho Los Amigos Hospital.

It was found that the adjustable prosthesis was used for three groups of patients. One group of moderately active geriatric patients with good muscle control were able to walk in the community when given a lightweight prosthesis with a safety knee. The adjustable socket prosthesis with a manually locked knee was also of benefit as an early training device for patients with multiple orthopedic involvement who had inadequate strength to use a heavier prosthesis.

The largest group of patients fitted with the adjustable prosthesis with a manually locked knee were those geriatric patients who by our criteria would not have been fitted with a conventional prosthesis. The decreased weight, ease of adjustability, and manually locked knee contributed to the successful fitting of those patients who would not have otherwise walked.

CONCLUSION

Although the durability, long term functional use, and energy cost of the use of this type of prosthesis must still be determined, our experience has shown that the prosthesis has adequate strength and durability to withstand the relatively light stresses that geriatric and other marginal prosthetics patients place upon it.

TABLE 1
FOLLOW-UP DATA

Total number of patients interviewed	44
Average age of patients:	61 years
Patients receiving safety knee units:	10
Average age:	53years
Functional results:	
Community ambulator	2
Limited community ambulator	5
Household ambulator	1
Discontinued walking*	2
Patients receiving manually locked knee units who might have functioned in other prostheses:	
Average Age:	57 years
Functional results:	
Community ambulator	1
Limited community ambulator	6
Patients receiving manually locked knee units who *could not* have functioned in other prostheses:	27
Average Age:	66 years
Functional results:	
Community ambulator	0
Limited community ambulator	10
Household ambulator	10
Discontinued walking*	4
Rejection	2
Expired	1

*Due to other medical complications.

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PLASTIC SPIRAL RETENTION CLIP FOR FES ELECTRODES

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The principles of functional electrical stimulation (FES) are well established (*1, 2, 3*), and both skin-surface electrodes and implanted electrodes have been used in recent years. However, both of these systems have produced problems.

The implants require surgery and, occasionally, post-surgical complications such as infection and peripheral nerve damage have occurred.

Non-surgical transcutaneous stimulation through the use of skin electrodes is an effective and useful approach, but it has had a major drawback. The electrodes are held in position customarily by an elastic knee cuff which is pulled over the knee and adjusted by the patient after a period of instruction and trial. The problem here is related directly to the tendency for the cuff to slip repeatedly and, thus, displace the electrodes as the patient walks. Frequent adjustment is required throughout the day, and unless the electrodes are repositioned properly the apparatus will not provide the function intended.

The authors have developed a plastic spiral electrode retention clip which eliminates the problem of slippage. The spiral retention clip (Fig. 1) is flexible and can be positioned easily by the patient without assistance. The manner of fabrication permits the patient to spread open the spiral and snap it into place on the limb and the electrodes will stay over their designated contact points. The clip does not cause constriction or discomfort to the patient. Figure 2 shows the Liberson Brief Pulse Stimulator [3] (*3*) with the Spiral Retention Clip for FES electrodes in place on a patient.

The distinctive features of this clip are:

1. It is simple to apply and position.
2. It does not slip.

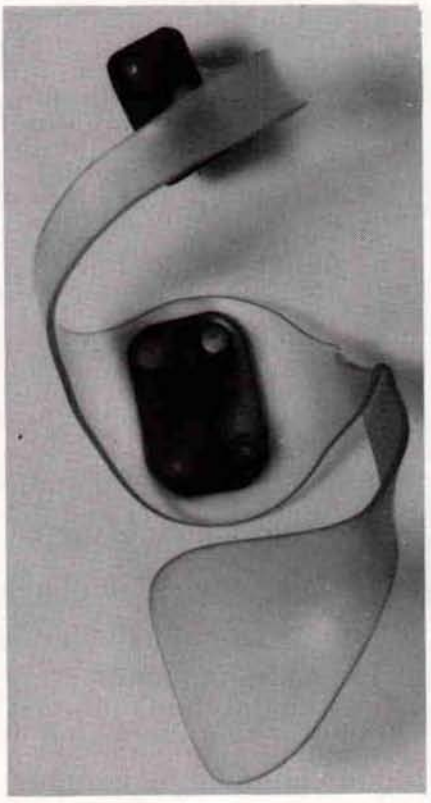

Fig. 1. The plastic spiral retention clip with electrodes in place.

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[3]The Liberson Brief Pulse Stimulator, referred to here, differs from other FES systems in that it employs simultaneous and balanced stimulation of both muscle (m. anterior tibialis) and nerve (n. superficial peroneal), to achieve optimum dorsiflexion and eversion of the foot during swing phase of walking.

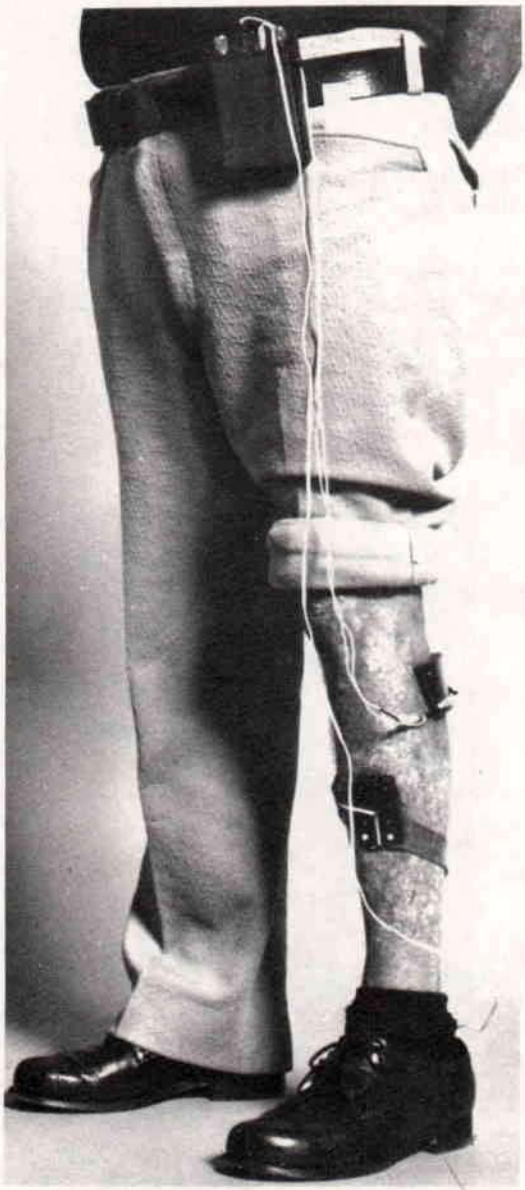

Fig. 2. The Liberson Brief Pulse Stimulator in use with the plastic retention clip.

CASTING

POSITIONING OF THE ELECTRODES

Position the smaller electrodes (overlying the superficial peroneal nerve) ½-in. distal and anterior to the head of the fibula and hold it in place with an elastic strap (Fig. 3). In the same manner secure the larger electrode (overlying the anterior tibialis muscle) ¾-in. lateral to the tibial crest at approximately the mid-shank level. The electrodes should be coated with conductive electrode gel.

Before connecting the electrode lead to the control module, set OUTPUT TIME to zero, and OUTPUT CONTROL to minimum. MODE SWTICH should be in center position. Connect electrode lead to OUTPUT-CHARGE plug. The system is then ready for checking.

The patient should be seated with the knee flexed to 90 degrees. Support the affected limb so that the foot is free to dorsiflex and plantarflex (Fig. 3). Set MODE SWITCH to TIMED position and OUTPUT TIME to approximately 3 seconds. Increase OUTPUT CONTROL gradually while observing the patient's reaction. The foot will begin to dorsiflex at ½ to ¾ of maximum output. If the foot is everting while dorsiflexing, shift the peroneal electrode slightly distal to the initial position. If sufficient dorsiflexion is not attained at maximum output setting, move the anterior tibialis electrode distally and laterally until optimum reaction is observed.

After the proper positions have been determined, trace the contours of the electrodes directly onto the patient's skin with an indelible marker (Fig. 4).

LOCATION OF THE DISTAL END OF THE SPIRAL

The most distal portion of the spiral should fall approximately 2 to 3 inches distal to the anterior tibialis electrode, and its anterior margin should fall just anterior to the medial midline of the shank. The clearance between the electrode and the distal end of the spiral should be as great as possible to facilitate donning the device, but at least 1 ½-in. superior to the medial malleolus. The distal end of the spiral should be between 1 ½ and 2-in. square. The positioning is marked as shown in Figures 3, 4, and 5.

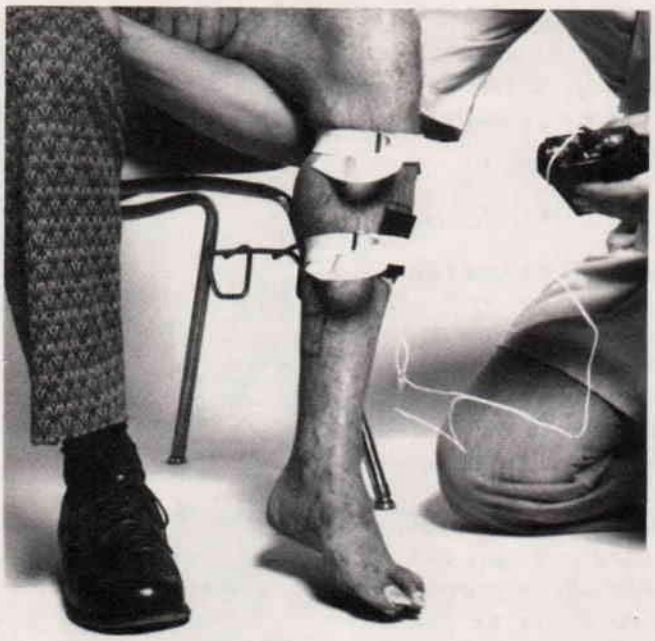

Fig. 3. Positioning the two electrodes on the surface of the leg.

Fig. 4. Outlining the positions of the electrodes.

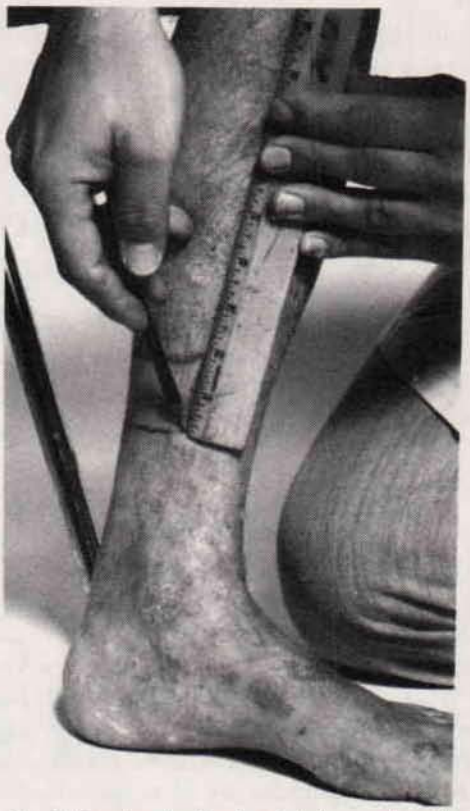

Fig. 5. Locating the distal end of the retention clip.

Mark the tibial crest and any other prominent areas, including any scar tissue or unusually pressure sensitive areas, so that contact of these areas with the clip can be avoided.

WRAPPING THE NEGATIVE MOLD

The patient is seated with the knee in 90 deg. of flexion.

A thin stockinet, i.e., elastic perlon tricot, tube gauze, or the equivalent, should be used as a separator, and should extend from a level just proximal to the patella to a level 1 or 2-in. inferior to the position marked for the distal end of the spiral.

Surgical tubing or Dacron tape inserted under the stockinet may be used to protect the patient while the cast is being cut for removal. Care must be taken in positioning the protective strip, so as not to obscure any of the indelible marks.

Four-inch wide elastic plaster bandage should be used for the initial wrap. It should be reinforced with a roll of four-inch wide ordinary plaster bandage before removal.

The wrap is begun distally and should continue proximally. The orthotist should mold an impression of the distal portion of the popliteal area posteriorly (Fig. 6).

Fig. 6. Making an impression of the shank to obtain a negative mold.

The negative mold is removed (Fig. 7), and after it has been determined that the indelible markings have been transferred, the mold is sealed and filled. A pipe should be inserted to facilitate cast modification and fabrication.

CAST MODIFICATION

The negative wrap is stripped, and the indelible markings on the positive mold are touched up (Fig. 8). Excess plaster in the area of the protective strip is removed. Care must be taken not to distort the contours of the cast during this procedure.

To prepare the electrode sites, retrace contours of the electrodes on the positive model, mark off a perimeter ¼-in. outside of the electrode marks, and remove approximately ⅛-in. of plaster from this area, following the parasagittal contours of the shank. If electrode marks have become obliterated, retrace contours.

Starting from the center of the posterior border of the peroneal electrode site, moving posteriorly and spiraling around the positive mold, draw a line connecting the centers of the two electrode sites. Continue the spiral postero-inferiorly from the posterior midpoint of the anterior tibialis electrode site to the distal end of the spiral already marked. Mark off a ¾-in. distance on each side and along the entire length of the connecting line (Fig. 9).

Remove ⅜ to ½-in. of plaster in the area delineated in the preceeding step (Fig. 10).

Fig. 7. Removal of the plaster wrap, or negative mold.

Retrace contours of the distal site.

Mark off a perimeter ¼-in. distance around distal end of spiral.

Remove plaster in this area to form a concavity with an apex ¼-in. deep.

Finish all modified areas with a fine sand screen.

Fig. 8. The indelible markings transferred from the stockinet need be touched up to ensure transfer to the positive model.

FABRICATION

PATTERN

Cut templates as shown in Figure 11 from cardboard.

Tape the cardboard templates for electrode sites in place on the positive model.

Tape the templates for the proximal spiral arm to the cast and to the electrode templates for the proximal spiral arm to the cast and to the electrode templates. Be certain that the templates are aligned intimately to the contours of the model (Fig. 12).

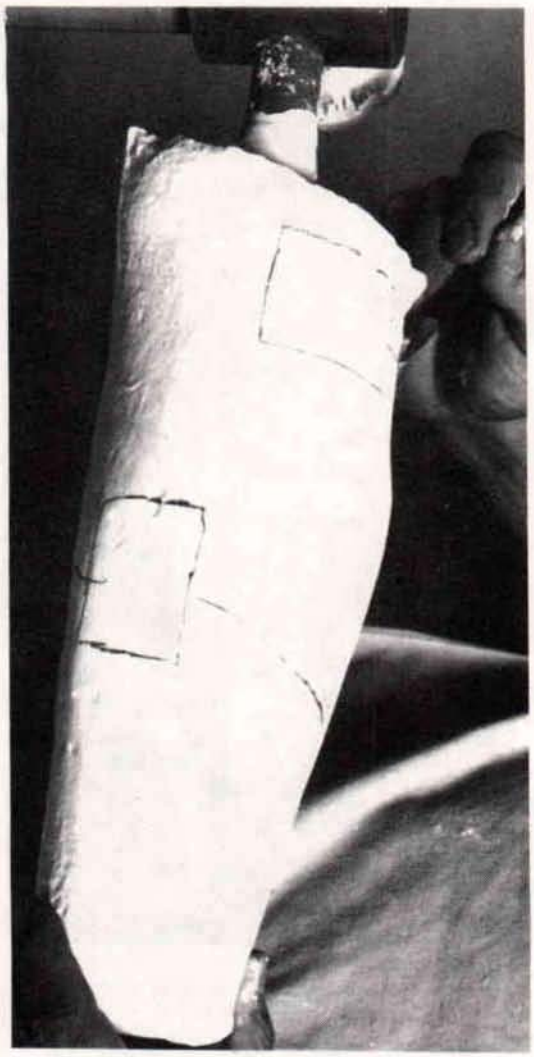

Fig. 9. Markings on the positive model to guide in the formation of the spiral retention clip.

Follow the same procedure for the distal spiral arm. The center of the distal end of the spiral should fall in the center of the concavity at the marked position at the distal end of the spiral.

Remove the pattern and transfer its outline onto cardboard. Round off the junctions between templates for electrodes and spiral arms to create a smooth flowing transition between all sections of the spiral, and cut out.

Use rubber cement to adhere the modified pattern to a piece of ⅛-in. thick Nyloplex, and cut along the edges. Smooth and polish all edges carefully.

MOLDING

Preheat the oven up to, but not exceeding, 215 deg. F. A heat gun may be used if no oven is available.

Place the Nyloplex in the oven for approximately 5 minutes, or heat until the entire piece is flexible.

When the plastic is ready for molding, lay the sheet on the model, being certain that the electrode pads correspond to electrode sites on the positive model.

Wrap an elastic bandage securely around the entire model, particularly over the channels for the spiral arms.

After the plastic cools remove the bandage.

Using a heat gun, spot heat and remold any area that is not intimate with the model. Particular attention should be given to transitional areas between the spiral arms and the electrode pads.

The orthosis is now ready for fitting.

FITTING

The design of the spiral clip is such that proper fit can be achieved in only one position on the limb.

After placing the cuff in position the skin should blanch uniformly under the entire length of the cuff except for the area over the tibial crest. Re-modify the positive model and spot heat the cuff to achieve intimate and uniform contact with the leg.

The electrodes may now be secured to the cuff using ⅜-in. non-metallic screws. Drill a ⅜-in. diameter hole in the center of both electrode sites to allow exit for the lead wires.

Connect electrode and foot switch leads to the control module. Place foot switch on inside heel pad of patient's shoe. Set MODE CONTROL to FOOT SWITCH and OUTPUT

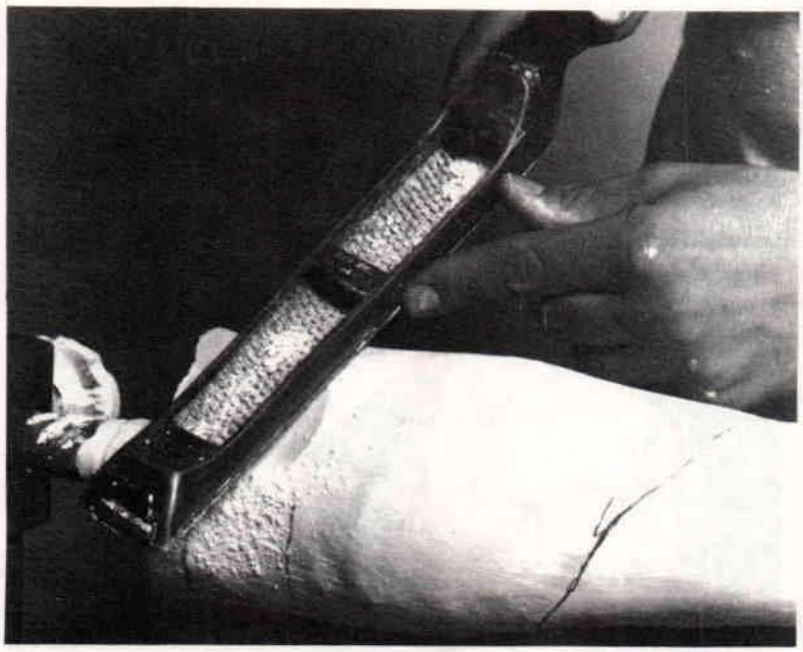

Fig. 10. Removal of plaster from the positive model.

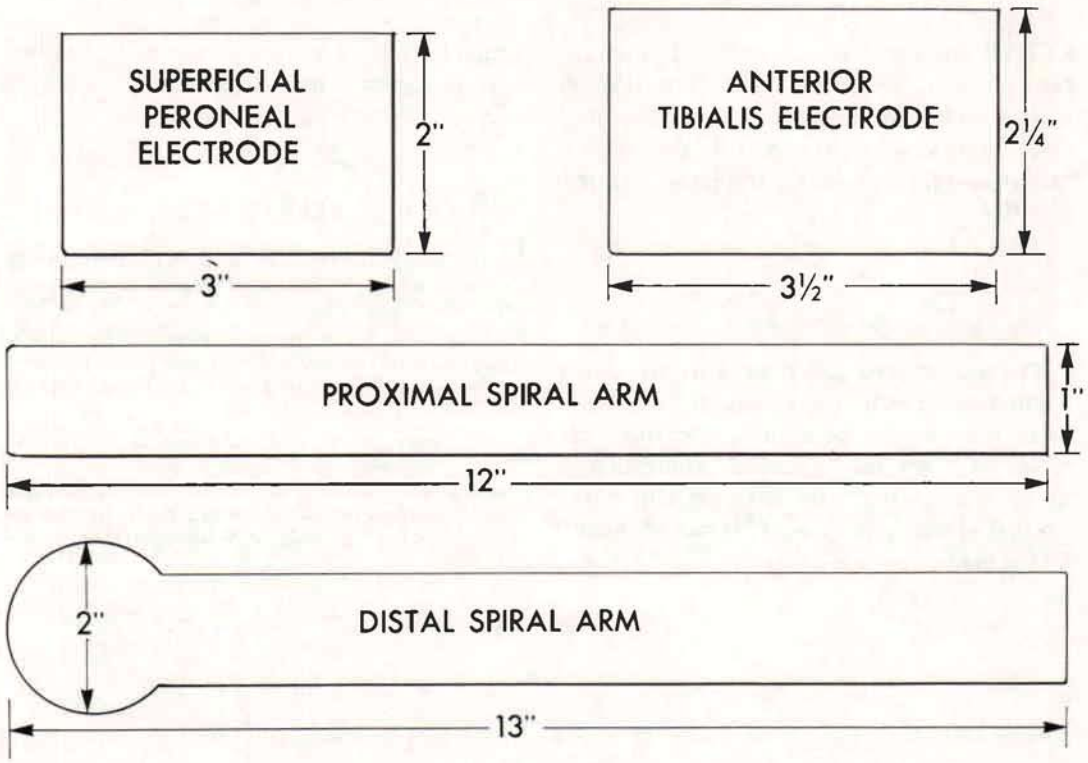

Fig. 11. Dimensions of templates for use in fabrication of the spiral retention clip.

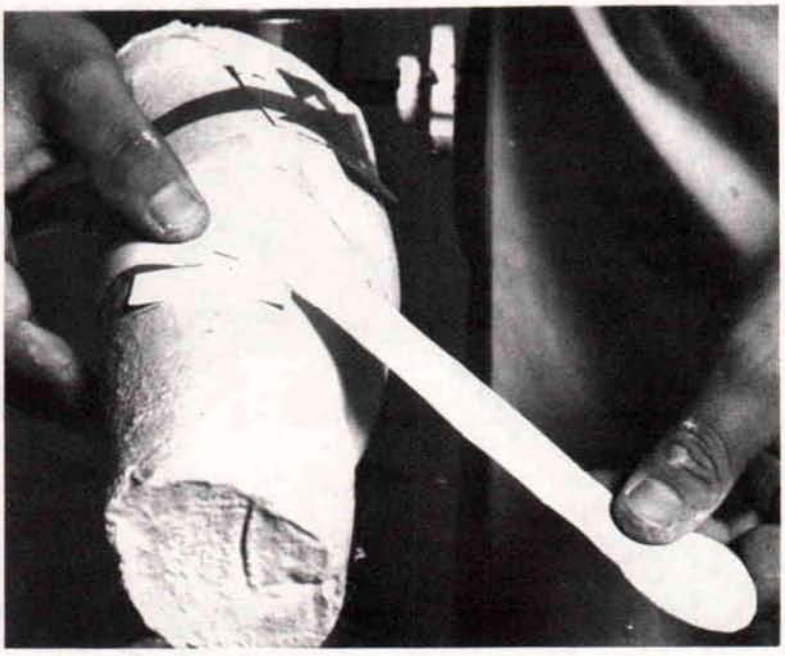

Fig. 12. Application of the templates to the positive model.

CONTROL to position determined during casting. Allow patient to ambulate. From heel-off to heel-strike the patient's foot will be in a dorsiflexed position. At heel-strike the circuit is broken and the foot is free to plantar flex into foot-flat.

SUMMARY

The authors have described a simple, easily applied device which will retain the electrodes in position on the lower-limb when the technique of functional electrical stimulation is used. The spiral plastic retention clip is not uncomfortable to the wearer. It can be donned by the patient without assistance; it is hygienic, requires little or no maintenance, is flexible, and in contrast to the previously employed elastic cuff method, does not slip.

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MAXILLOFACIAL PROTECTIVE HEADGEAR

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Recently we treated a patient for maxillofacial injuries sustained from falls while experiencing convulsive seizures. Because of the repeated episodes of trauma to the patient's head and face and his intractable seizures, a protective headgear was designed and fabricated. Because the patient desired to wear the headgear at all times, special consideration to the construction was necessary to allow the patient as much comfort and freedom as possible while still providing adequate protection. To date the patient has been very satisfied. He has fallen on his head and face while wearing the headgear and no injuries have occurred.

There has been little published on protective devices for the head and neck of individuals suffering from seizure disorders (*1*, *2*). This paper describes the design and construction of the protective headgear and the results of its use.

CASE REPORT

A 25-year-old white male was seen in the emergency room at St. Joseph's Hospital in Marshfield, Wisconsin for treatment of severe maxillofacial injuries which resulted from falling while experiencing a convulsive seizure. Examination revealed severe facial and oral lacerations, nasal bone fracture, mandibular symphysis fracture, maxillary anterior alveolar process fracture, and coronal fractures of several teeth.

The patient's past medical history was essentially unremarkable with the exception that a major seizure disorder had been diagnosed in 1970. Different medications and dosages were tried without good control of the seizures. Unfortunately, the seizures occurred without warning which resulted in many severe falls and injuries.

After consulting with the patient's neurologist, it was decided that hospitalization would not be necessary and definitive treatment of the maxillofacial injuries was completed under local anesthesia on an outpatient basis. The treatment consisted of closed reduction of the nasal bone fracture, closed reduction of the maxillary alveolar process and mandibular fractures with establishment of intermaxillary fixation and closure of the multiple oral and facial lacerations.

The patient was evaluated weekly for the following five weeks. When he returned after the fifth week, the fracture appliances were removed. On the way home, the patient experienced a seizure and fell again sustaining severe maxillofacial injuries. He was brought to the Emergency Room and appropriate treatment rendered. It was decided to admit the patient to the hospital so that he would be in a controlled environment. Because the patient was a military veteran, he was transferred to a Veterans Administration Hospital.

Upon the patient's return to the Marshfield area, the injuries had healed satisfactorily. At that time it was suggested that a protective headgear be designed to prevent further injuries. The patient was quite receptive and a maxillofacial protective headgear to provide protection as well as comfort was designed and constructed by the Orthotic and Prosthetic Department at the Marshfield Clinic. To date the

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patient has been very satisfied with the headgear. He and his relatives state that while seizures have continued, the headgear has prevented further maxillofacial injuries.

The problem in fitting a patient with a conventional all-plastic helmet is that they tend to be heavy and uncomfortably warm. Since the patient had a tendency to fall in the sagittal plane in either an anterior or posterior direction, a helmet had to be designed which would be light in weight and rigid enough to protect the frontal and occipital regions, the nose, and the mandible.

FABRICATION OF HELMET

A prefabricated protective helmet was obtained from the J. A. Preston Corporation (71 Fifth Avenue, N.Y.). This helmet has felt padding on the inside with strap leather on the outside (Fig. 1). It has an adjustable chin strap and can be obtained in circumferences from 18-in. to 25-in. in half-inch increments. It is recommended that the circumference measurement be taken just above the level of the ear. To reinforce the helmet and provide strength, Orthoplast (Johnson & Johnson, 501 George St., New Brunswick, N.J. 08903) was used. Because the patient had a problem with anterior falls, a face shield was also indicated. In addition the shield had to protect the patient's eyeglasses from impact while still permitting him to don the glasses easily. It was also important that his vision was not impaired by such a shield. After heating the Orthoplast to 160–170 deg. F. with a heat gun, it was wrapped circumferentially around the helmet, and corrugated slightly (Fig. 2). The Orthoplast

Fig. 1. Prefabricated helmet obtained from J. A. Preston Corporation. Reprinted by permission of © J. A. Preston Corp., 1974.

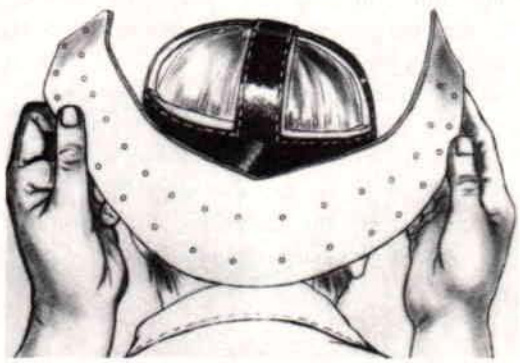

Fig. 2. Posterior view. The first shaped piece of heated Orthoplast being applied to the leather helmet.

was bonded to itself with a nonflammable spot remover. The helmet became rigid when it cooled. The occipital portion was brought low enough so that rigid support could be achieved. The rigid Orthoplast was molded to the helmet, and riveted in place. The impact of a fall on a specific point on the Orthoplast is spread throughout the whole ring of the Orthoplast, thus distributing the result of the impact over a broad area.

Another consideration was the protection of the mandible. An inferior bar had to be placed so that the mandible was protected against any impact that it received (Fig. 3). It had to be constructed in such a fashion that the jaw would

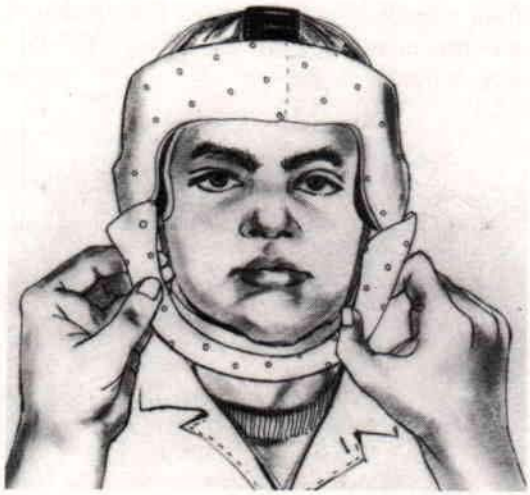

Fig. 3. Application of the corrugated Orthoplast® for protection of the mandible. Dotted line on the Orthoplast marks point where the first piece of Orthoplast was overlapped and sealed.

have full range of motion and permit the patient to eat without interference from the shield.

To achieve these results, two strips of Orthoplast, rolled in circular bars to give them strength, were attached to the Orthoplast covering the helmet's circumference. The superior bar was placed so that the patient had full visibility and at the same time full protection to his eyeglasses and nose (Fig. 4). The bars were attached to the helmet with heat, spot remover, and rivets. To some degree the exact locations and dimensions of protective bars will vary with the size and shape of the anatomy of the facial features.

Since the patient has had the helmet (Figs. 5 & 6) he has experienced falls, and was well

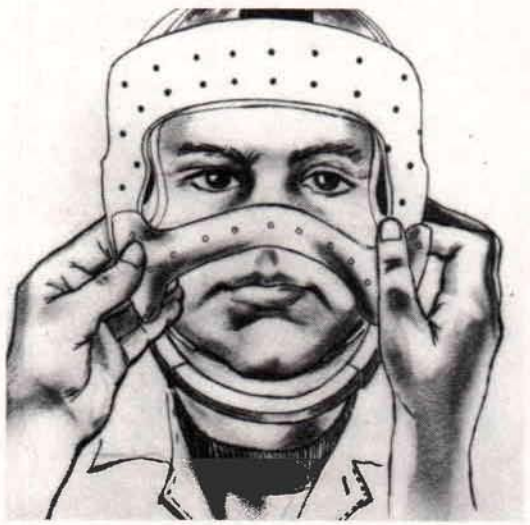

Fig. 4. Application of corrugated Orthoplast to protect face.

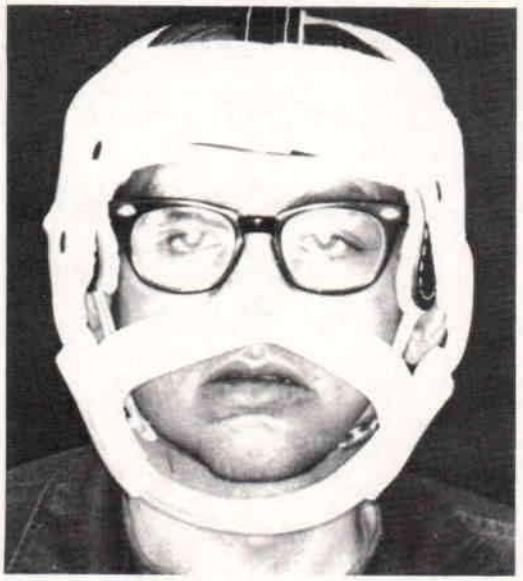

Fig. 5. Frontal view of patient wearing protective headgear showing superior and inferior bars.

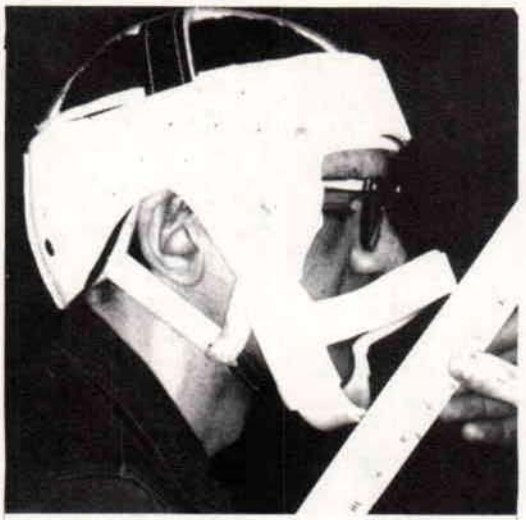

Fig. 6. Side view of patient showing relationship of the frontal protective bars.

protected from the impact by the protective headgear. To date, he has suffered no trauma to his head or face.

Reaction of the patient to the helmet has been very favorable. He has it by his bed, and near his person at all times so that he can put it on whenever he moves to the vertical position.

In summary, this helmet is light in weight, reinforced with Orthoplast, and with added face shield has protected this patient from injuries from anterior or posterior falls. Corrugation of the Orthoplast is helpful in achieving a satisfactory degree of rigidity.

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EVALUATION OF THE ORTHO-WALK TYPE B PNEUMATIC ORTHOSIS ON THIRTY-SEVEN PARAPLEGIC PATIENTS[1]

PREFACE

The evaluation of the Ortho-Walk Pneumatic Orthosis was requested by the Veterans Administration (VA) and the Rehabilitation Services Administration (RSA), Department of Health, Education, and Welfare. The Veterans Administration originally became interested in pneumatic orthoses after contacts with the French developers of the Ortazur Orthosis, the forerunner of the Ortho-Walk.

Dr. George Morel of Berck Plage, France, introduced the Ortazur Pneumatic Orthosis in 1965. Although the orthosis was originally used quite successfully on children with osteogenesis imperfecta, Dr. Morel later used it on a three-year-old child with traumatic paraplegia. The orthosis was used still later with positive results by a number of French physicians to stand patients with Duchenne Dystrophy, cerebral palsy, and paraplegia. In most cases, the primary goal of these physicians was to support the knee and hip joints in order to bring the patient to an erect position, with a secondary goal of ambulation.

In March 1973, the vice president of the Aerazur Company, manufacturer of Ortazur in France, and four other staff members visited the Castle Point VA Hospital in New York and fitted three patients with the pneumatic orthosis. A fourth orthosis was fitted subsequently to another patient at this hospital, and all patients were asked to provide feedback to the Veterans Administration Prosthetics Center concerning the utility of the orthoses. This informal evaluation demonstrated that the high paraplegic may be able to use the orthosis for standing, although ambulation was impractical.

A study of both the Ortho-Walk and the Ortazur pneumatic orthoses on 11 patients at Bird S. Coler Hospital, New York, by Maurycy Silber, M.D. (*14*), identified several positive physiological outcomes from regular use of the pneumatic orthoses, and underscored the need for a large scale, formal evaluation of the Ortho-Walk pneumatic orthosis on paraplegic people.

The ILC Dover Company[2] obtained an exclusive license to manufacture and distribute the pneumatic orthosis in the United States, and first introduced a modified version of the Ortazur Pneumatic Orthosis, called the Ortho-Walk, in October 1973 at a combined meeting of the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation in Washington, D.C. ILC Dover is the Division of ILC Industries, Inc. that was the sole designer and manufacturer of the space suits for Project Apollo and Skylab.

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[1]The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

This study was supported by Contract V101 (134) P-350 between the Veterans Administration and the National Academy of Sciences, and Contract SRS 500-75-0001 between the Social and Rehabilitation Service, HEW, and the National Academy of Sciences.

[2]ILC Dover Company, 350 Pear Street, Dover, Delaware 19901.

National interest in this new orthosis was high, not only because of the large amount of publicity it was given, but also because the Type B Ortho-Walk Pneumatic Orthosis appeared to be of real benefit to people with paraplegia, since it stabilizes the knee, hip, lower spine, and to some extent, the ankle.

The Veterans Administration recognized the possible benefits for the 20,000 paraplegic and quadriplegic patients under its care and requested the Committee on Prosthetics Research and Development (CPRD), National Research Council, to conduct a large structured evaluation of the Ortho-Walk Type B Pneumatic Orthosis on people with paraplegia in VA and other hospitals.

MICHAEL J. QUIGLEY, C.P.O.
Committee on Prosthetics Research
and Development

THE POPULATION OF PEOPLE WITH PARAPLEGIA

The National Center for Health Statistics (NCHS) report "Prevalence of Selected Impairments — 1971" states that in the civilian noninstitutionalized population there are approximately 1.4 million people with paralysis, complete or partial. Of this number, about 102,000 people have paraplegia, or 0.5 people per 1,000 persons. Since many paraplegics are institutionalized, the estimate is probably low. Assuming that about 10 percent of the paraplegic population was institutionalized or in a noncivilian status at the time of the 1971 survey, there would be about 112,000 persons with paraplegia in this country at that time. In 1975, there are probably from 120,000 to 140,000 persons with paraplegia in the United States.

According to Peter C. Hofstra, M.D. (*4*), Chief of the VA Spinal Cord Injury Services, the population of spinal-cord-injured people is increasing by 10,000 to 20,000 persons per year. The highest incidence of spinal-cord injury occurs in young males between the ages of 15 and 35 years. Approximately 50 percent are paraplegics and 50 percent are quadriplegics.

PRESENT USE OF ORTHOSES FOR PERSONS WITH PARAPLEGIA

The history of the orthotic treatment of paraplegia does not go back much further than World War II, since previous to that time about 90 percent of the spinal-cord-injured persons died from genitourinary infections. The development of antibiotics to combat these infections reversed the fatality rate shortly after World War II (*4*).

The physiological benefits of standing persons with paraplegia were first mentioned by Abramson (*1*) in 1948, who stated that an hour of standing each day will prevent osteoporosis in the lower limbs and helps to prevent urinary calculi and genitourinary infections. In 1964, Rusk (*12*), stated that "circulation and nutrition, as well as morale, are also aided by keeping the patient in the upright position for several hours each day."

Rusk also recommended that the tenth thoracic vertebra be used as a landmark when prescribing orthoses; lesions at or superior to this level are usually given double-bar long-leg orthoses with a pelvic band and Knight spinal attachment (current terminology is LSHKAFO, or lumbo-sacral-hip-knee-ankle foot orthosis); lesions inferior to this level are provided with the same orthoses without the spinal attachment, and lesions inferior to L_1, are fitted without the pelvic band.

Hahn (*3*), Scott (*13*), Edberg (*2*), and Warren *et al.*, (*15*), do not advocate the use of the pelvic band on paraplegic patients. Edberg feels that the pelvic band must apply excessive pressure against the skin to be effective, that it causes difficulty in donning the orthosis, limits flexibility and adds excessive weight. Hahn and Scott state that the two most important considerations for orthotic design for paraplegics are ease of donning and control of ankle dorsiflexion, hence the so-called Craig-Scott design KAFO has no pelvic band, only one thigh band, and a fixed but adjustable ankle joint.

Another method of providing standing mobility to paraplegic people is by using standing frames. Motloch (*7*) has demonstrated success with the "parapodium," a jointed standing frame for spinal-cord-impaired children. Prast (*9*) is working on an adult version of Motloch's parapodium, which will provide standing stability and allow "pivot walking," which is a combination of rotating and sliding the base of the device in the desired direction. A "mobile, portable, collapsible set of standing bars" is the way Peizer and Bernstock (*8*) described another device, called the "Stand-Alone."[3] In an evaluation of the device on 32 patients, the Stand-Alone proved to provide "hand free" independent standing and mobility on level and slightly sloped surfaces for most paraplegics up to the level of T_8, providing the person could tolerate the standing position.

[3]Stand Alone, Corporation for Medical Engineering, 8472 East Garvey Ave., San Gabriel, California 91771.

Despite the various orthotic designs available, and the philosophies that accompany each design, the majority of paraplegic persons will either reject their orthoses or not have them prescribed. There are many reasons for this, the main one being the excessive energy expenditure needed to ambulate in an orthosis. The donning procedure for most orthoses is difficult and time consuming, and once the orthoses are on the patient they often interfere with transfer activities. In addition, crutches are needed for stability while standing and ambulating, which limits the use of the hands and arms. Other problems with standing ambulation for paraplegic patients are the lack of bladder control while standing and the obviously abnormal walking pattern.

Hussey and Stauffer (*5*) studied the ambulatory function of 164 spinal-cord-injured patients and stated that "no patient achieved any form of functional ambulation without pelvic control[4] and there appeared to be no effective method of bracing patients to overcome this deficit." The nerve supply for the pelvic control muscles is affected by a thoracic lesion.

Rosman and Spira (*11*) reported similar problems in ambulating patients with thoracic lesions. In a study of 35 patients with lesions from the T_1 to T_{11} level who were fitted with orthoses for ambulation, only one patient was ambulating out of the hospital, and five used the orthosis for standing only. The report concluded "that there is an essential difference between the 'occupation' of walking in the non-pressured rehabilitation environment and walking when faced with the problems of everyday life." It further concludes that "some disabled persons with unusual strength, willpower, and motivation for walking will successfully overcome the difficulty, effort, and social strain involved in the continuous use of braces," but that "most will eventually relinquish these goals because the effort proves too great."

[4]The Term "pelvic control" used here refers to the ability of the abdominals to move the pelvis when body weight is on the crutches.

Initial studies on pneumatic orthoses showed promise, espeically for patients with thoracic lesions. Silber (*14*) reported on 11 patients, nine of them with lesions at T_{12} or superior, in 1975. All patients in the study were inpatients. He stated that all patients could transfer independently, all but one patient could don the orthosis independently, and all could stand and ambulate, although not always independently. Of the six patients who also received conventional metal orthoses, five could not don the orthosis independently. However, after about two weeks training with the pneumatic orthosis, all of them could don it without help. All patients felt that the pneumatic orthosis was more comfortable than the conventional orthosis, and found that it made activities-of-daily-living (ADL) functions much easier. Silber used both the Type A Pneumatic Orthosis which stabilizes the knee only, and the Type B, which stabilizes the trunk, hip, and knee in his study. He also used both the French Ortazur style and its American counterpart, the Ortho-Walk.

Ragnarsson *et al.*, (*10*), at the Institute of Rehabilitation Medicine, New York University Medical Center, studied 14 patients using the Ortho-Walk and the French Ortazur pneumatic orthoses. Eleven of these patients were also fitted with conventional metal orthoses. Energy consumption of three patients may have been less with pneumatic orthoses than with conventional orthoses, although it is not clear that the devices were evaluated on comparable tasks. Patients could, however, ambulate further and for a longer time in the pneumatic orthosis. However, only one of ten patients preferred the pneumatic orthosis over the conventional orthosis because of inadequate support at the knees and hips, zipper failures, and most of all, inflation problems. The study concludes that for many reasons the pneumatic orthosis is especially suitable for early ambulation training, but severe mechanical problems limit its usefulness for community ambulation.

In summary, many designs of orthoses are presently prescribed for paraplegic adults but in nearly every case, when a thoracic level lesion

is present, the orthoses prove to be impractical and are rejected. Wheeled standing frames are being used successfully on children, and are beginning to gain acceptance with adults. Initial results with pneumatic orthoses were promising, and therefore an evaluation of this orthosis has been conducted.

DESCRIPTION AND FITTING OF THE PNEUMATIC ORTHOSIS

The Ortho-Walk Type B Pneumatic Orthosis (Fig. 1) is available in six standard sizes. Each orthosis has three pneumatic beams on the anterior and posterior aspect of each leg. A model with four pneumatic beams on the anterior and posterior aspect of each leg is also available and is recommended for people weighing over 160 pounds. The garmet is made of nylon, and the pressure bladders in the pneumatic beams are polyurethane. The orthosis incorporates values for inflation and deflation, a series of straps and laces for fitting and adjustment, zippers for donning and doffing, and toe lifter straps, which attach to the shoes.

The size of the orthosis needed for a particular patient is determined by relating ten measurements of the patient to a sizing chart, and then choosing the size that most nearly corresponds to the measurements. Custom orthoses are available for people who do not fit into the standard-size range due to obesity, excessive height, etc. The manufacturer recommends that long cotton underwear be worn under the orthosis. Regular clothes may be worn over the orthosis.

Two types of air compressors are available, an AC compressor and a DC compressor. The AC compressor is used as a stationary item, generally used in the household. The DC compressor is termed "portable," and comes with a carrying case, 12-volt battery, and charger. It may also be operated from an automobile cigarette lighter. Other types of inflation techniques, such as small compressed gas cartridges and pumps, have proved to be impractical, although larger cylinders similar to scuba tanks, may be used.

Fitting of the orthosis is generally done by an orthotist, preferably on a waist-high bed or tilt table. The zippers covering the adjustment laces and straps are opened and the orthosis is spread out on the table. The patient (wearing shoes and long underwear) is then positioned supine on the orthosis and the heel straps are secured around his shoes. The position of the patient on the orthosis is then checked, as is the length of the orthosis. The posterior pneumatic beams are aligned in a straight line; then long and short zippers are closed.

The orthosis is inflated to straighten the pneumatic beams and the laces and straps are adjusted to maintain this alignment (Fig. 2). The zippers covering the adjustment straps and laces are then closed and the toe lifter strap is fastened to the shoe and tightened until the ankle is held at approximately 90 degrees.

A final alignment check is made when the patient is standing, and two or three additional fitting and adjustments are usually required before an acceptable fitting is obtained.

Wearers of the orthosis may then don it by positioning themselves over the outspread orthosis, attaching the heel straps and closing the long- and short-leg zippers and the abdominal zipper (Fig. 3). They then turn on the air compressor, which should be positioned close to the patient, and clamp the inflation hose to the corresponding valve on the orthosis. Once the orthosis is inflated to the recommended pressure of 32 pounds per square inch (psi), as noted on a guage on the compressor, the inflation hose is removed. The patient can then push himself to the end of the bed and uses crutches to push up to a standing position (Fig. 4). An alternate technique is to inflate the orthosis while in a sitting position and pull up to a standing position by grasping parallel bars (Fig. 4). A "drag-to", "swing-to", or "swing-through" gait can be used. A four-point gait is difficult, if not impossible, to achieve.

In order to deflate the orthosis the wearer positions himself ready to sit in a chair or lay on

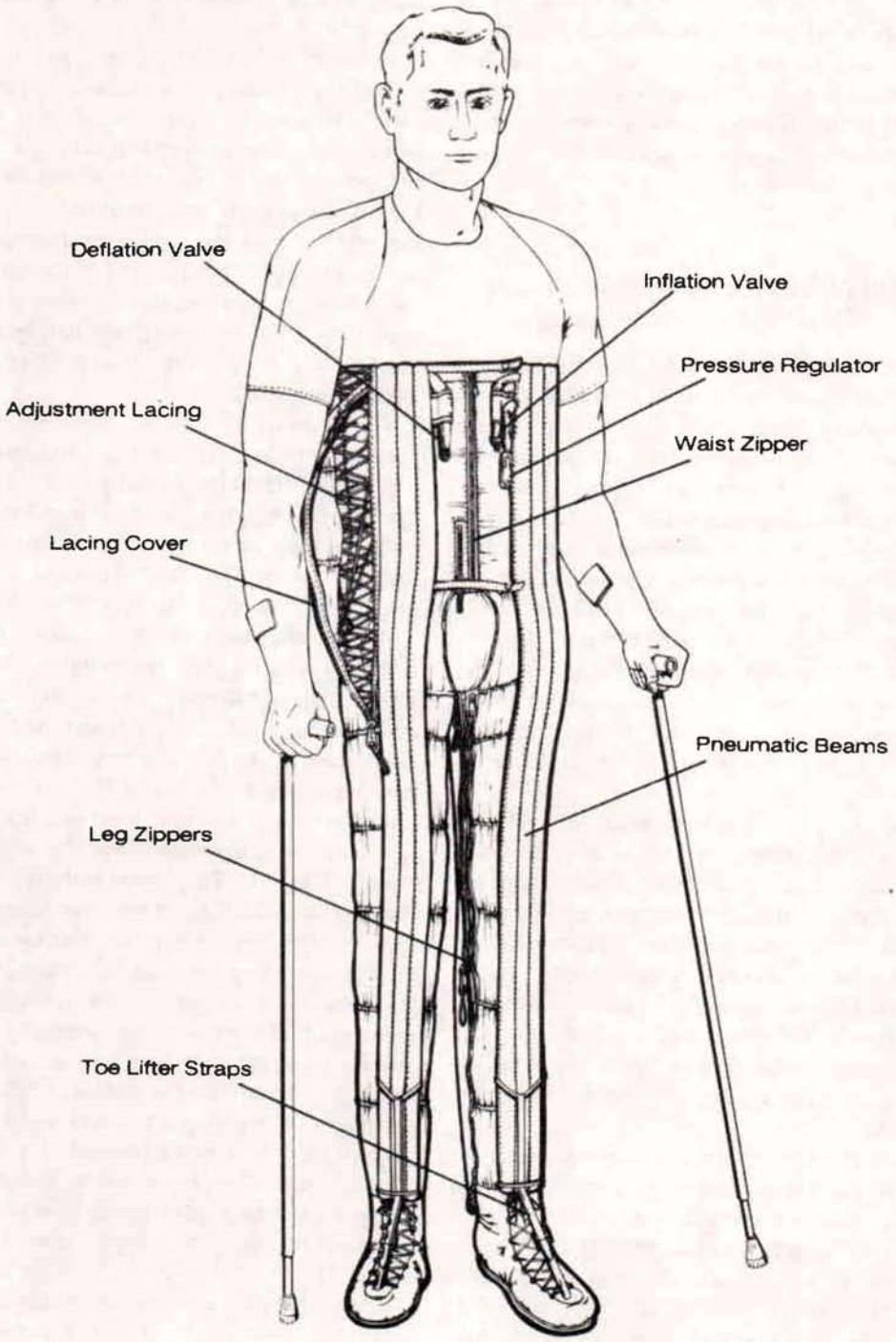

Fig. 1. Ortho-Walk Type B Pneumatic Orthosis. The pneumatic beams on the anterior and posterior aspect of each leg support the knees, hips, and trunk.

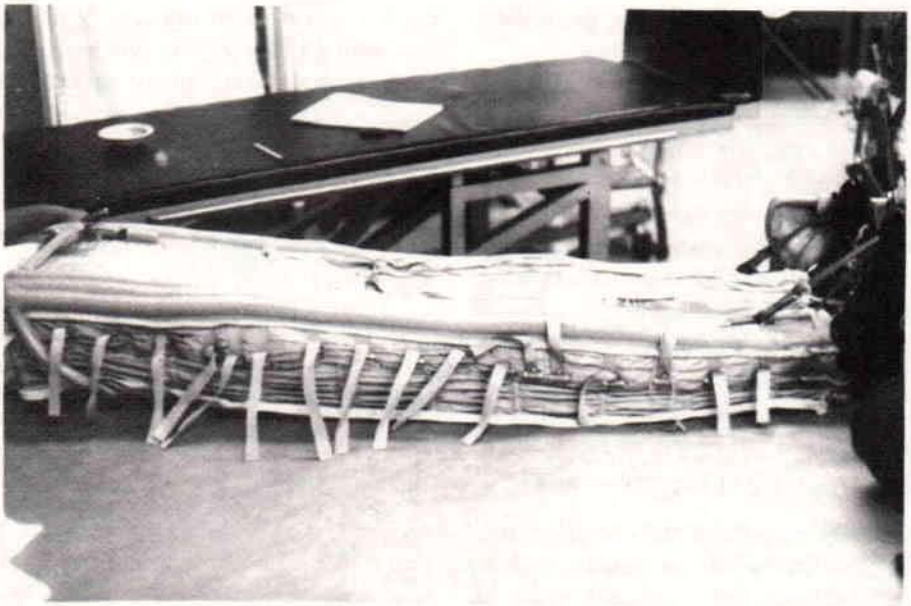

Fig. 2. Adjustment straps individualize the fit of the orthosis. Usually, these straps need to be readjusted about three times after the initial fitting.

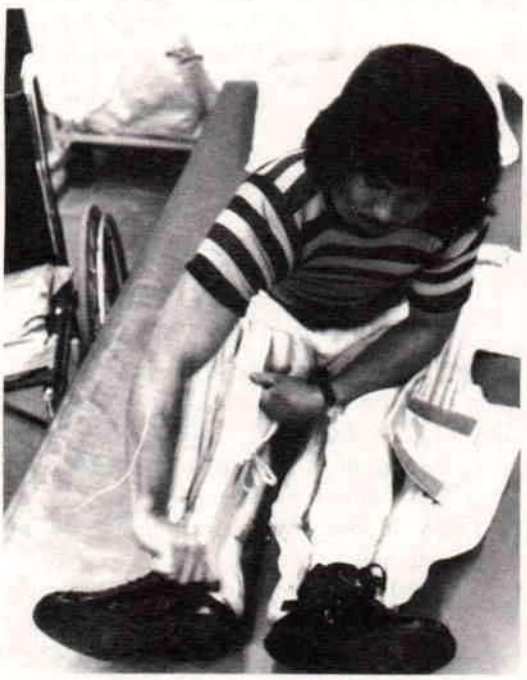

Fig. 3. Patient donning the orthosis. The orthosis is first spread out on a bed and then the patient positions himself over it.

Fig. 4. Patient transferring from a sitting to a standing position during inflation by pulling himself up using the parallel bars and one crutch.

a bed, opens the deflation valve, and slowly lowers himself.

The orthosis may be worn deflated in a sitting position for the entire day.

Wearers of the pneumatic orthosis are cautioned to avoid burning the material, and to keep sharp objects away from the material.

The orthosis may be washed by hand using a mild detergent, and should be inspected periodically for tears, broken stitches or abraded fabric. The orthosis is mailed back to the supplier whenever repairs are needed.

THE PURPOSE AND ORGANIZATION OF THE EVALUATION

The primary purpose of the clinical evaluation was to determine the indications, training needs, advanatages and disadvantages of the pneumatic orthosis in the hospital, home, and community. The results of the study are to be used by the Veterans Administration and the Department of Health, Education, and Welfare to determine policy, by educational institutions as instructional material and by medical and paramedical practitioners as a guide for patient management.

A steering committee was formed which met in New York on May 1, 1974. The members of the committee were Heiner Sell, M.D., Assistant Director, and Meg McGarrity, Physical Therapist, Institute of Rehabilitation Medicine, New York; Maurycy Silber, M.D., Director of Rehabilitation, and Nancy Hivry, Physical Therapist, Bird S. Coler Hospital, New York; Thomas Pirrello, Jr., Orthotist-Prosthetist, Veterans Administration Prosthetics Center, New York.

At the steering committee meeting the evaluation participants were chosen, the protocol and timetable were set, and other logistical matters were discussed.

EVALUATION CENTERS

The evaluation was a cooperative effort between VA and civilian hospitals. Centers were chosen for various reasons, e.g., past cooperation with CPRD or VA, proximity to another participating hospital of the opposite category (i.e., VA and civilian), or, simply, expression of interest in the study.

The centers were:

VA Spinal Cord Injury Services

Miami VA Hospital	Jorge Jacobi, M.D. David Dupree, C.P. Evelyn Carrasquillo, P.T. Betsy Powers, C.C.T.
Richmond VA Hospital	Charles Lamb, M.D. Hallie Ratliffe, Orthotist Daniel Kahsar, R.P.T.
Hines VA Hospital	David Stern, M.D. Wilbur Pearson, C.O. Helaine Hull, R.P.T.
Palo Alto VA Hospital	Inder Perkash, M.D. Maurice LeBlanc, C.P. Deborah Wilson, P.T.

Civilian (non-VA) Evaluation Centers

University of Miami (Jackson Memorial)	Jerry Enis, M.D. William Sinclair, C.P.O. Robin Smith, R.P.T.
Northwestern University (Rehabilitation Institute of Chicago)	Bupend Agrawal, M.D. David Thullen, C.O. Steve Huber, R.P.T.
Craig Rehabilitation Hospital	Harry Hahn, M.D. Alton Scott, C.P.O. Joan Polack, R.P.T.

PROTOCOL

Both specific and general guidelines for patient selection were made.

Specific Criteria:

1. Patients had complete spinal-cord lesions.
2. The etiology was trauma.
3. The lesions were between the T_1 and T_{12} vertebral levels.
4. Severe deformities of the limbs (over 20 degrees) were contraindications.
5. Patients were selected for size and weight to fit the standard-size Ortho-Walk.
6. Patients were inpatients while being fitted and trained.

General Criteria:

1. A sample of patients should be ready for discharge during the study so an evaluation in both the hospital and home setting is possible.
2. A sample of patients who have had previous experience with conventional metal orthoses would be desirable.

Number of Fittings

The Veterans Administration was to provide up to 35 pneumatic orthoses for evaluation. A pair of orthopaedic shoes, an AC, and a DC compressor were provided with each orthosis. Each of the seven clinics was therefore allowed up to five orthoses. In cases when a patient would not be using his orthosis, other patients could be fitted with it. A minimum of 35 patients were to be evaluated.

Orientation Session

All participants of the evaluation met in New York on July 1–2, 1974. The guidelines were explained to the group, and a final draft of the evaluation form was made. The orthotists and therapists were then taught fitting and training by Dr. Silber, Nancy Hivry, and Melvin Bailey of Bird S. Coler Hospital, and Meg McGarrity of the Institute of Rehabilitation Medicine. The facilities and patients at Coler Hospital were used for the training sessions.

Clinical Trials

The first patients were fitted approximately six weeks following the orientation session. Site visits were made to each center by the CPRD staff, and in two cases by the staff of ILC Dover.

It was apparent that the protocol was too rigid for some of the centers since they were not able to recruit patients. In one spinal-cord-injury center with 160 beds, over 100 patients were quadriplegic. Of the remaining number of paraplegics, over half were hospitalized for pressure sores and most of the remainder were in for urinary problems, surgery, or would soon be moving to a distant city. Only three patients could be recruited in this center during the first few months of the evaluation, despite the fact that it had more beds for spinal-cord-injured patients than the other centers. The protocol was relaxed in order to allow outpatients who could come in for daily therapy to be included.

An interim meeting was held in Miami, Florida, on December 15, 1974. One participant from each center attended this meeting. At this time, six and one-half months into the evaluation, 35 patients had been fitted. Many problems and misunderstandings were taken care of and the date of the final meeting was set.

DATA ANALYSIS

In February, 1974, all centers were requested to send in the completed evaluation forms. The data was then tabulated and prepared for the final meeting.

Number of Patients		Total 37
VA Spinal Cord Injury Centers		patients
Miami		5
McGuire (Richmond)		5
Hines (Illinois)		6
Palo Alto		7
	Total	23
Civilian (non-VA) Rehabilitation Hospitals		patients
University of Miami		5
Northwestern (Chicago)		5
Craig (Denver)		4
	Total	14
Sex		
Males	31	
Females	6	
Height		
Average	5 feet 9 ½-inches	
Range	5 feet 3 inches–6 feet 2 inches	
Weight		
Average	144 pounds	
Range	98 pounds–185 pounds	
Age		
Average	31.6 years	
Range	18 years–58 years	

Age of Injury

Time from date of injury to fitting with the pneumatic orthosis.

Average	38 months
Average excluding three oldest injuries	19 months
Range	1 month–27 years, 9 months

Lesion Level

T-1	3 patients	T-7	0 patients
T-2	1	T-8	3
T-3	3	T-9	3
T-4	4	T-10	6
T-5	2	T-11	3
T-6	4	T-12	4

No response - 1

Etiology

Trauma	34	
Gunshot wounds		11
Auto accidents		8
Motorcycle accidents		2
Tractor accident		1
Explosion		1
Fall		1
Not specific		10
Total traumatic		34
Tumor		1
Multiple Sclerosis		1
No response		1
Total non-traumatic		3

Decubitus Ulcers (Present before fitting)

Gluteal fold	2
Sacral	1
Sacral and Ischial	1
Coccygeal	1
Total	5

Medication (Valium and/or Dantrium)

Total using daily medications - 17 patients

PHYSIOLOGICAL EFFECTS

Blood Pressure and Pulse Rate

Each center was requested to take blood pressure and pulse rate measurements with the patient supine and standing, without the orthosis and then with the orthosis. Three patients were not able to reach an upright position on the tilt table without the pneumatic orthosis, before orthostatic hypotension would cause dizziness and an average blood pressure of 92/75. However, with the orthosis on, all three patients were able to reach a 90-degree upright position with a stable blood pressure averaging 113/79 with no sign of dizziness. On one patient the pulse rate decreased by 20 pulses per minute when the orthosis was worn, but the change was inconsequential on the other two patients.

On 17 patients the blood pressure, with the orthosis on in a standing position, rose an average of 4 mm Hg when compared to the readings taken in the same position with the orthosis off. The averages were 117/79 mm Hg with the orthosis off and 121/84 mm Hg with the orthosis on. Average pulse rate on the same 17 patients decreased from 89 to 87 pulses per minute when the orthosis was worn. The comparative blood pressure and pulse rate data was consistent throughout the evaluation, i.e., the blood pressure increased slightly with the orthosis on, and the pulse rate remained stable.

Decubitus Ulcers

Five patients with decubitus ulcers were fitted with the orthosis. There were no complaints concerning retarded healing or aggravation of these ulcers, and no indication that they healed faster in the orthosis. No ulcers were caused by the pneumatic orthosis during the evaluation, even though redness over the knee was noted on many occasions.

Bowel and Bladder Function

Clinics were requested to make general observations concerning bowel and bladder function and catheterization attributable to the orthosis. The orthosis seemed to have no effect on bowel or bladder movements, or on the type of catheterization used.

Pain

One patient could not wear the orthosis because it hurt her back, and another complained of bruises acquired while wearing it. All but three of the other patients felt that the orthosis was immediately comfortable. How-

ever, these three patients felt that the orthosis was comfortable after wearing it from 15 to 30 minutes. For two patients with back pain, the orthosis offered considerable relief; one also had scoliosis, so the trunk support was of great benefit.

Spasticity

Two patients reported relief from severe spasticity while wearing the orthosis, although they also stated that the spasticity recurred in a greater than normal amount after the orthosis was removed. In two cases excessive spasticity caused the patients to reject the pneumatic orthosis. Adduction contractures in another patient could not be adequately controlled. Spasticity of the hip flexors kept a second patient off balance to such an extent that he was exhausted after ambulating only ten yards. In general, patients felt that their spasticity was slightly decreased while wearing the orthosis.

Heat

One patient rejected the orthosis because he felt it was "too hot." Another preferred to wear it only on cool days. Five complaints concerning heat retention were made.

ORTHOTIC INFORMATION

Fitting and Adjustments

All orthoses were the Ortho-Walk Type B, three-tube standard suits. The length of time to measure patients for the orthosis ranged from 15 to 30 minutes, and averaged 20 minutes. Fitting times ranged from 20 minutes to two hours, and averaged 50 minutes. Three readjustments are usually needed, and can be done by either the therapist or the orthotist. The average time needed per adjustment is 20 minutes, or a total of 60 minutes for all three. However, some patients needed no readjustments while others needed up to five, and in one case three hours and 20 minutes were spent readjusting the laces.

The reasons readjustments are needed are usually 1) the patient was fitted while supine and the fit changes when he stands, and 2) the laces and straps are new, and "give" slightly when stressed. The most common clinical indication that a readjustment is needed is bending at the knees and/or hips, which can be corrected by either tightening the laces and/or placing special pads in the area of the instability.

Equipment

In all cases but one, the orthoses and compressors were received from the manufacturer in excellent condition. In one case, a suit was returned because of a leak, although the manufacturer stated he could not find the leak. In two other cases, at different clinics, a slow loss of pressure (5 psi lost in 10 minutes) was reported. A possible cause for the pressure problems was the high altitude, since most of these problems occurred in Denver. Another patient caused a leak after burning through the fabric of the orthosis with a cigarette. In no instance did a loss of pressure occur so suddenly that the safety of the patient was jeopardized.

The most common and most serious equipment failure concerned the zippers. In five cases the seam attaching the zipper to the nylon fabric failed. In one case the zipper came off track. The zipper failures were sudden and caused one patient to fall. Another patient had a zipper give way while he was training to descend stairs. The therapist fortunately caught him.

Equipment repairs were made by ILC Dover. All repairs were made satisfactorily, but the length of time required for shipping the orthosis back and forth and for repairs ranged from two to four weeks. Two patients lost interest in the evaluation while their suits were being repaired.

Previous Orthotic Experience

Twelve patients were using metal orthoses prior to the evaluation. Five patients were ambulatory and the remaining seven used them for standing only. Patients wearing orthoses spent from eight to ten hours daily in bed, from two and one-half to three hours standing, and the remaining time sitting. Patients who had not been fitted spent an average of 15 hours daily in bed and nine hours in a chair.

Four patients had an inadequate range of motion. One patient who had bilateral 15-deg. knee-flexion contractures and a 10-deg. limitation of ankle dorsiflexion was fitted and did well in the orthosis. Another patient with a 30-deg. hip-flexion contracture could not stand independently in the orthosis and could ambulate only at great energy expense, but kept the orthosis as a therapeutic device.

THERAPY INFORMATION

Inflation, Standing, Transfers

Seventeen patients preferred to inflate the orthosis while they were in the supine position, and then push themselves over the edge of the bed until their feet contacted the floor. They then grab one crutch, push themselves upright, and pick up the second crutch.

Sixteen patients preferred to inflate the orthosis while they were sitting and either pull themselves up by grasping parallel bars or push themselves up by turning around in front of the wheelchair and pushing up from the armrests. Three patients were brought to 90 degrees on the tilt table before inflating the orthosis.

Joint Stability

Three patients did not receive enough trunk support, and 11 patients did not have enough knee stability (Fig. 5). The normal posture in the pneumatic orthosis differs considerably from the extended posture seen with metal orthoses. The trunk and hips are in a neutral position in the Ortho-Walk, rather than extended, and the knees stay slightly flexed. This different type of posture undoubtedly caused many to think that inadequate stability was provided.

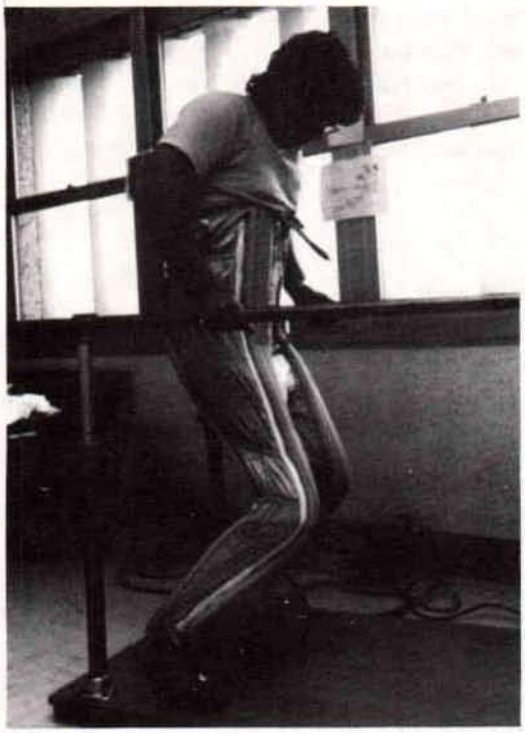

Fig. 5. Instability of the knees and hips. Although only two or three patients had this much instability, 11 patients cited this as a major problem. The addition of pads, readjustment of laces, or use of a four-tube suit may help to correct this problem.

Seven patients thought the lack of ankle stability was a problem. The Ortho-Walk prevents plantarflexion by having an anterior strap extend to the shoe laces, but allows free dorsiflexion.

Time and Distance

Patients wore the orthosis for an average of 20 minutes a day deflated, and 30 minutes a day inflated. The average distance traversed was 54.0 yards in 24 minutes, or 6.75 feet per minute. One patient, however, covered 300 yards in 45 minutes, which is a rate of 20 feet per minute. This patient was 5 feet 11 inches

tall, weighed 160 pounds, 26 years of age and was able to press 260 pounds when weightlifting.

Donning and Doffing

Twenty-three patients were able to don the orthosis independently; seven needed major assistance and three needed minor assistance. The time needed to don the orthosis ranged from eight to 60 minutes and averaged 25.5 minutes.

Twenty-seven patients could doff the orthosis independently; two needed major assistance and five needed minor assistance. The average time needed was nine minutes and ranged from three minutes to 20 minutes.

Fifteen patients could independently don clothes over the orthosis; three needed assistance.

Transfers, Stairs, Recoveries

Transfers from a sitting position to a standing position were made independently by 18 patients. Fourteen needed assistance. Approximately five therapy sessions of 30 minutes each were needed before patients could transfer independently. All but six patients could deflate from a standing position independently. Patients were able to achieve this after about four therapy sessions of 20 minutes duration.

No patients were able to climb stairs independently, although seven could climb them with assistance. Six patients could handle a six-inch step or curb independently.

Eight patients attempted to learn fall recoveries, but only one could recover independently. He achieved this by first unfastening the abdominal zipper of the orthosis, then jacknifing and climbing his walker.

Gait Patterns

The most commonly used gait pattern was the "swing-to" pattern, which 17 patients adopted. Nine preferred to "drag-to" and nine used the "swing-through" pattern (Fig. 6).

ACCEPTANCE

Fourteen of the 37 patients chose to accept the orthosis for regular, if in some cases limited, use. The remaining 23 rejected it.

All of the patients accepting the Ortho-Walk were males. The average age of this group was 34 years, whereas the average age of those rejecting the orthosis was 30 years.

The height and weight of the patients accepting the orthosis averaged 69.6 inches and 141.5 pounds. Four of the patients were described as having normal body builds, four were listed as

Fig. 6. Patient learning the "swing-through" gait pattern at Coler Hospital, New York.

thin and six were muscular. All three patients who were considered obese rejected the orthosis. The average height of patients rejecting the orthosis was one-half inch less than those accepting it, and the average weight of those who rejected it was four pounds greater.

The age of injury (time from date of onset of paraplegia to fitting with the Ortho-Walk) for patients who accepted the pneumatic orthosis was two years less than those who rejected it (23 months versus 47 months).

The average lesion level for patients who accepted the Ortho-Walk was T_8–T_9, whereas the level of those who rejected it was T_5–T_6.

The follow-up time for all patients was from one month to eight months. Two of the patients who were only followed for one month were listed as accepting the orthosis.

Of the 23 patients who rejected the orthosis, the most common reasons for rejection were excessive energy consumption and inadequate stability at the knees, hips, and ankles. Two patients needed to have their ankles bound together in a "hobble" to prevent their legs from abducting excessively (Fig. 7); lack of motivation rated next as the reason for rejection. The motivational problems generally occurred once the patient realized the amount of effort required for standing and ambulation. Four patients started out highly motivated, but were listed as having poor motivation when they rejected the orthosis.

Poor cosmesis was listed as the reason for rejection by three patients, who stated that the thoracic section was too bulky, and that wearing clothes over the orthosis was impractical (Fig. 8).

Six patients preferred their metal knee-ankle-foot orthoses (KAFO'S) to the Ortho-Walk, and in three cases the reverse was true. Of the six preferring the metal KAFO'S, three patients used the Craig-Scott (*6*) design orthosis and three used conventional designs.

Three patients listed donning problems as one reason for the orthosis being rejected. These patients had higher lesions (T_4) and it took them from 25–60 minutes to don the orthosis independently. With assistance, the donning time was considerably shortened.

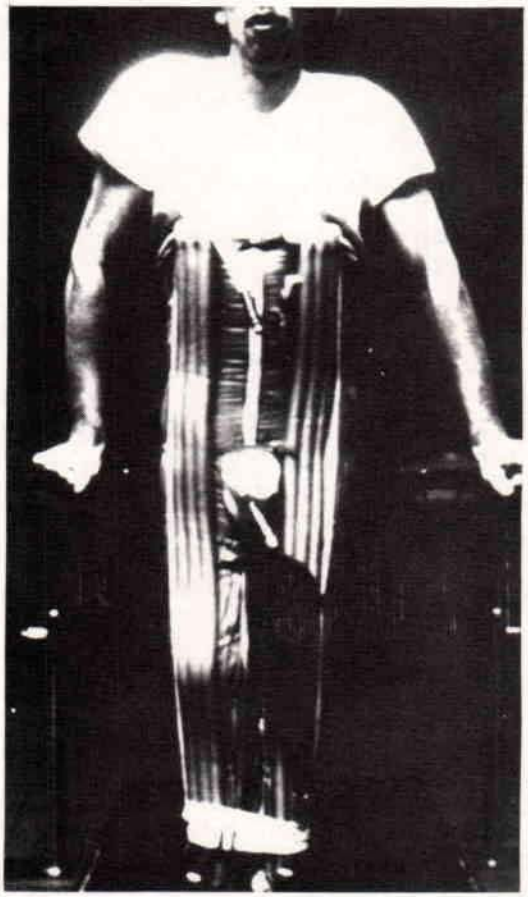

Fig. 7. A "hobble" around the ankles was needed on two patients to prevent the legs from spreading apart an excessive amount.

Ten patients took the orthosis home. Of these ten patients, two use it daily outside of the household, for school, work, and social activities. Three of these patients use the orthosis daily for household ambulation. Of the remaining five patients who took the Ortho-Walk home, one uses it two to three hours a week in the kitchen; another uses it one hour a day for exercise; one patient uses it once a week for 30 minutes of exercise, and two patients use it rarely, i.e., about once a month.

In summary, patients who accepted the Ortho-Walk pneumatic orthosis were those in good physical condition with thin to muscular builds. A positive attitude towards standing and

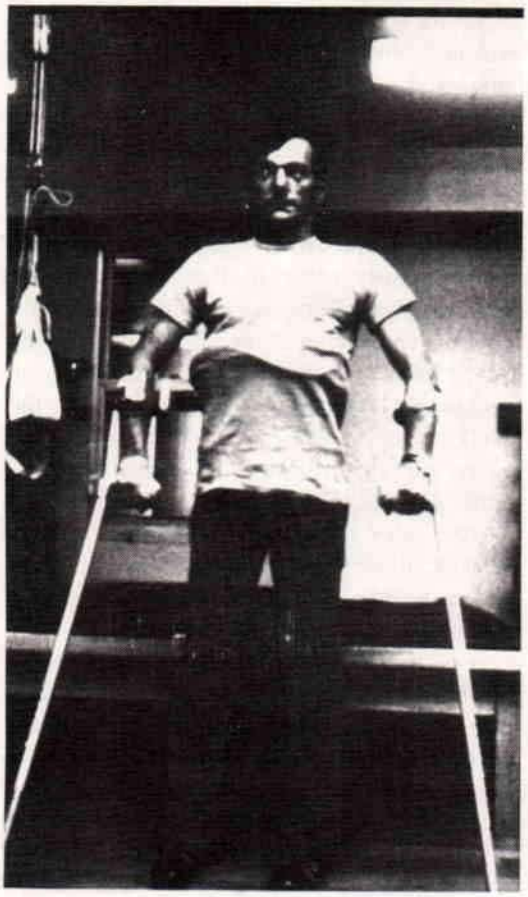

Fig. 8. Patient wearing clothes over the Ortho-Walk. Three of the patients who rejected the orthosis complained about the cosmesis.

ambulating, combined with good motivation, also appeared to underlie acceptance. Perhaps these patients experienced a significant psychological boost from being upright, which justified for them this relatively inefficient technique of standing and ambulating.

It should also be noted that only those patients who fitted into the standard Ortho-Walk-size range were selected for the study. If a random selection process had been used, a larger number of patients would have fallen outside the average height and weight range (69.6 inches and 141.5 pounds) of those patients accepting the orthosis; and, therefore, a higher rejection percentage would have resulted.

COMPARISON BETWEEN VA AND NON-VA PATIENTS

The average age of VA patients in the study was 8.8 years greater than that of non-VA patients (35.6 years vs 26.8 years), mainly because there were five VA patients who were 45 years of age or older, with injuries incurred a number of years previously. None of the non-VA patients were of this age. Ages of injuries were also highest in the VA groups, averaging 51 months vs 11 months for non-VA patients. Older patients with "long-standing" injuries were more prevalent in the VA population because they generally kept in closer contact with the local VA hospitals, were aware that the study was going on, and requested to be participants.

Ten of the 23 VA patients, or 43 percent, accepted the pneumatic orthosis for the trial period, while only four of the 14 non-VA patients (28 percent) accepted it. The probable reason for the slightly higher acceptance rate at VA hospitals lies in the longer period of training they provided and their general tendency to be freer with their time. The private hospitals had problems justifying financially long training sessions over many weeks. Also, a few of the VA patients who were listed as accepting the orthosis were still in training at the end of this study, and may have rejected it later. In general, the private hospitals provided less training and discharged patients earlier than VA hospitals.

CONCLUSIONS

On March 17–18, 1975, all participants of the evaluation met at Craig Rehabilitation Hospital in Englewood, Colorado, to discuss the results of the evaluation (Appendix E). The participants met in a plenary session, then divided into three groups: physicians, therapists, and orthotists, to draw conclusions and make recommendations from the evaluation.

No age limit was set for patients who wish to use the orthosis, but the height and weight were

determined to be crucial factors. The participants agreed with the manufacturer that patients taller than six feet and in excess of 160 pounds require a four-tube suit instead of the standard three-tube design. Patients who are obese will have a minimal success rate and should have a custom suit designed if a good fit and proper support are to be expected. Patients with thin to muscular body builds have the best chance to achieve functional standing and walking.

People who work or study seem to make more use of the Ortho-Walk because of their desire to be active. Lack of accessibility to wheelchairs on a job, or employment requiring a standing position are both indications for lower-limb orthoses, including the Ortho-Walk design.

Patients who need to be very mobile, i.e., in and out of cars, planes, different businesses, will generally be hampered by lower-limb orthoses. The Ortho-Walk is contraindicated for these people due to the problems with inflation, deflation, and transfers.

Previous orthotic experience does not seem to affect the acceptance of the pneumatic orthosis, as six patients who wear metal KAFO'S preferred them to the Ortho-Walk, but the reverse was true for three patients. All patients who use the Ortho-Walk outside of the hospital should also be wheelchair independent. It was recommended that patients having success with previous orthoses are doing well enough and should not be encouraged to change to the Ortho-Walk.

The etiology of the lesion did not affect the results in the orthosis, nor did the level of the lesion. In fact, of those who accepted the orthosis, the three patients with the highest lesions were among the most successful users. More experience during the medical stabilization phase is needed with patients with high lesions before any conclusions can be made about the use of the orthosis in this situation.

A small study at the Miami VA Hospital indicated the Ortho-Walk did aid venous return and increased the blood pressure and volume to the kidneys. Therefore, cardiovascular conditions do not contraindicate the use of the orthosis for standing, but these patients should be watched closely, especially if ambulation is attempted.

The Ortho-Walk did not impair the respiration of any patient, and aided one patient in this respect.

Spasticity is not a contraindication to using the Ortho-Walk. In most cases, patients stated and therapists observed that the severity of spasticity was decreased or eliminated shortly after the application of the pneumatic orthosis.

The presence of decubitus ulcers does not necessarily contraindicate use of the Ortho-Walk. Five patients with decubiti in areas covered by the orthosis did not have any problems, and healing continued at a normal rate. On the other hand, there were indications of substantial increases in pressure under the suit, and (as noted earlier) reddening in several areas was observed after use.

A positive attitude of both the patient and the rehabilitation team is of utmost importance. A negative attitude towards standing or towards the different type of orthosis by the members of the team will quickly pass on to the patient, and the chances of functional standing and ambulation will be decreased.

The orthotists concluded that there were no problems with the recommended measurements, that the range of standard sizes was adequate and that the initial fitting procedure was good. No mechanical problems were encountered with the pneumatic beams, the AC and DC compressors, or the inflation valves. It was recommended that the deflation valve be redesigned so it can be left open, thereby freeing up the patient's hands while the suit is deflating. This would also allow air to continue escaping while the wearer is seated.

Miniaturization of the inflation mechanism was recommended. The portable compressor in the present system is too bulky and heavy to be carried by a paraplegic while he is standing, and the user must have a compressor available any time he wishes to stand. Small CO_2-type cartridges have been used in the past with minimal success, and it is recommended that a similar approach to inflation be perfected.

The donning procedure proved to be one of the major problems with the orthosis. Patients who could don the orthosis independently were often too exhausted to transfer, stand, and ambulate. No solution to this problem could be found during the evaluation.

The lack of a dorsiflexion stop at the ankle caused a few patients to feel unstable, and made it necessary for patients to use crutches when standing. Patients who expect to use the orthosis outside of the hospital for functional standing should also receive ankle-foot orthoses to provide anterior stability at the ankles.

PRACTICALITY FOR THERAPEUTIC USE

The Ortho-Walk pneumatic orthoses are practical for therapeutic use in the medical stabilization and rehabilitation phases of patient care in spinal injury when standing and ambulation are desired goals. Certain temporary psychological advantages seem to be offered, and it provides the rehabilitation team with one method of evaluating a patient standing before any further orthotic prescriptions are made. The adjustability and modularity of the suits allow them to be used on many patients. A stock of three to six suits can be fitted to most patients.

It is recommended that, whenever possible, any patient who may be a candidate for the Ortho-Walk receive a minimum of 40 hours of physical therapy in a stock suit of the correct size before a suit is ordered specifically for him.

PRACTICALITY FOR HOME AMBULATION

The Ortho-Walk Type B pneumatic orthosis has no real advantages over conventional orthoses in functional ambulation. The advantages of light weight is offset by the inconvenience of inflation and deflation, and the added difficulty of climbing stairs and recovering from falls. For use on level surfaces in the home, the Ortho-Walk has proved to be practical.

PRACTICALITY FOR COMMUNITY AMBULATION

The Ortho-Walk pneumatic orthosis has no real advantages over conventional orthoses for community ambulation. In the community, the disadvantages of the inflation system and of cosmesis are more apparent than in the home. The user must either have a number of compressors strategically located in the home, car, office, or school, or have an assistant carry a compressor with him. The noise of the compressor when inflating and of air escaping when deflating has drawn attention to the user of the orthosis in public places.

SUMMARY AND RECOMMENDATIONS

Based upon data collected from seven hospitals and 37 paraplegic patients with thoracic lesions, the following conclusions and recommendations were made concerning the Ortho-Walk Type B pneumatic orthosis:

ADVANTAGES

- Less weight than conventional orthoses.
- Temporary positive psychological reaction.
- Cost is reasonable when used as stock item on many patients.
- Adjustability and adaptability allows rapid application in the early treatment phase.
- Possible energy expenditure savings during ambulation.
- Adequate trunk support.

DISADVANTAGES

- Difficult and time-consuming to don.
- Inflation-deflation system is impractical.
- Provides less support to lower limbs than conventional orthoses.
- Cosmesis is poor, especially for women. Conventional orthoses are more cosmetic.

- Mobility is decreased. Stair-climbing and transfers are more difficult than with conventional orthoses.
- Maintenance and repairs must be made by the manufacturer, necessitating long waits due to mailing time.
- Cost is higher than conventional orthoses when used for one patient only.

RECOMMENDED IMPROVEMENTS

1. Improvement of the inflation-deflation system by miniaturizing the pressure source. An alternative solution may be the addition of knee and hip joints.
2. More ankle stability be provided, specifically to prevent dorsiflexion.
3. Ventilation of the suit.
4. The color of the suit (blue) is not cosmetic and could be improved.

RECOMMENDATIONS FOR FUTURE STUDIES

1. A study of the pressures at the interface between the pneumatic suit should be made. Redness usually occurs over bony areas when the suit is worn and clinicians are fearful that long-term standing may lead to skin breakdown.
2. More basic bioengineering is needed if pneumatic orthoses are to be made practical and be universally accepted.
3. Evaluation of other systems of mobilizing paraplegic patients should be made, such as that undertaken by Lehman *et al.* (*6*) on the Craig-Scott design knee-ankle-foot orthosis, which is used successfully in the Denver area. A quantitative study would be useful to compare pneumatic orthoses with standard knee-ankle orthoses used in paraplegic ambulation.
4. A careful study should be done to verify and document reported psychological and physiological benefits accruing from the use of various orthoses.

CONCLUDING STATEMENT

The concluding statement of the participants in the evaluation was that the Ortho-Walk Type B pneumatic orthosis has the potential for being a tool in the early rehabilitation of spinal-cord-injured patients. Its relative adaptability and ease of use in the early rehabilitative phase has the advantages of a temporary psychological lift, early screening of potential candidates for orthoses, and possibly aiding and improving the physical status of these patients. When considering candidates for the pneumatic orthosis, individualization of patients is a must, just as with conventional orthoses.

This study has shown that, as with all new ideas, the Ortho-Walk is not a panacea. Many improvements must be made before it can equal the merits of conventional metal orthoses. The idea of pneumatic splinting for paralyzed people is a feasible one, but it still needs much work. The fact that a private manufacturer can research, develop, and market such an innovative device without outside support is an accomplishment in itself. Ideas such as the Ortho-Walk can stimulate research teams in different disciplines to work jointly for the ultimate goal of better care for the spinal-cord-injured patient.

ACKNOWLEDGMENTS

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APPENDIX

TABLE I: PATIENTS ACCEPTING THE ORTHO-WALK PNEUMATIC ORTHOSIS

	Initials	Sex	Age	Height	Weight	Age of Injury	Level of Injury	Previous Orthotic Experience	Comments
1	J.A.	M	25	68"	--	5 mos.	T 12	None	Only followed one month, good progress
2	S.B.	M	58	68	165	5 mos.	T 9	None	Therapeutic use in hospital
3	T.C.	M	26	73	158	5 mos.	T 6	None	Household ambulator, good motivation, provides good trunk control. Zippers pulled apart.
4	L.D.	M	36	72	138	7 mos.	T 10	New KAFO'S	Household ambulator, complains of heat. Needs feet tied together to prevent abduction.
5	L.B.	M	36	72	117	14 mos.	T 12	KAFO'S ambulatory	Prefers Ortho-Walk to metal KAFO'S. Alleviates back pain, more ambulatory. Uses in home one hour/day for exercise.
6	O.W.	M	28	71	156	5 mos.	T 8	None	Spasticity, back pain decreased. Ambulatory with walker. Four tube suit required. Prefers "Stand-Alone device."
7	J.C.	M	39	65	120	58 mos.	T 3	KAFO'S, 2 years ambulatory with standing assist	Therapeutic use in hospital. Decreases spasticity. Needs assistance. Difficult donning. Better trunk stability. Prefers metal KAFO'S
8	R.F.	M	44	66	130	42 mos.	T 10	None	Highly motivated. Psychological advantage to standing. Household ambulator.
9	B.B.	M	26	71	160	18 mos.	T 11	None	Impractical for ambulation due to excess energy expenditure. Therapeutic & psychological advantages standing. 30° hip flexion contractures. Uses once a week for 30 minutes.
10	R.J.	M	25	71	145	36 mos.	T 4	None	Positive attitude. Good trunk support. Independent ambulator with crutches. Wears it to school and socially.
11	E.D.	M	57	74	185	149 mos.	T 4	Metal KAFO'S for 5 yrs., then lost trunk musculature. Out of orthosis for 12 yrs.	First orthosis to provide adequate trunk support. Good attitude. Uses at home and office daily.
12	B.S.	M	21	74	180	12 mos.	T 6	KAFO'S used only once.	Dependent with suits. Prefers the metal KAFO'S. Heterotrophic bone formation at hips. Zipper pulled apart. Rarely uses suit.
13	R.M.	M	20	69	150	1 mo.	T 4	None	Uses only once a month. Difficulty donning. High energy cost.
14	F.N.	M	37	70	157	3 mos.	T 8	None	Zipper pulled apart, problems donning. High energy cost. Uses 2-3 hours a week, mainly in the kitchen.

TABLE II: PATIENTS REJECTING THE ORTHO-WALK PNEUMATIC ORTHOSIS

	Initials	Sex	Age	Height	Weight	Age of Injury	Level of Injury	Previous Orthotic Experience	Comments
1	S.J.	M	23	73"	135	7 mos.	T 4	None	Adductor spasms, 15° hip flexion contractures.
2	M.O.	M		70		14 mos.	T 1	None	Not functional. Emotional problems, committed suicide.
3	W.D.	M	45	73	158	21 yrs. 6 mos.	T 6	KAFO'S for exercise	Easier than metal KAFO'S. Patient not motivated to use either type.
4	K.C.	M	18	72	160	7 mos.	T 2	None	Poor cosmesis, problem with standing balance.
5	G.D.	F	27	63	130	4 mos.	T 9	None	Poor attitude. Poor cosmesis. Not considered practical by the patient.
6	M.L.	M	29	71	140	8 mos.	T 9	None	Poor cosmesis. Excessive energy. Didn't like the "hassle."
7	J.B.	F	36	67	137	4 mos.	T 5	Craig-Scott KAFO'S 3-4 weeks. Stand only.	Limited transfer function. Suit deflated. Tried only three times and patient lost interest.
8	M.G.	M	24	71	113	23 mos.	T 1	Craig-Scott KAFO'S 8 mos. Functional ambulation	Preferred ankle stability from metal orthoses. Problems donning and doffing.
9	L.J.	M	18	66	119	3 mos.	T 12	Craig-Scott KAFO'S 2 mos. Ambulate with assistance	Poor cosmesis with clothes over it. Needs two assistants.
10	G.R.	F	21	63	144	2 mos.	T 5	None	Knee flexion problems. Suit deflated. Donning, doffing problems.
11	R.M.	M	28	66	105	26 mos.	T 6	KAFO'S 2 yrs. Stand only.	Left hospital ambulatory in orthosis but no longer uses it.
12	K.T.	M	27	70	155	1 mo.	T 4	None	Poor attitude. Lack of acceptance of injury.
13	J.K.	M	50	71	160	28 yrs.	T 12	Metal KAFO'S 26 yrs. Independent.	Restricts hip motion, jacknifing prefers metal.
14	J.W.	M	48	69	161	6 mos.	T 4	None	Excessive energy cost, donning takes 20 minutes.
15	M.H.	F	22	62	98	18 mos.	T 10	None	Excessive energy cost. Patient highly motivated but too much effort.
16	D.R.	F		69		6 yrs.	T 1	Rejected KAFO'S with pelvic band after six months.	Inadequate knee support. Poor cosmesis. Decreased spasticity but caused swelling.
17	E.J.	M	44	65	160		T 10	None	Zippers broke and patient lost interest after repairs made.
18	R.P.	M	32	70	164	4 yrs.		None	Too much trouble.
19	P.P.	M	31	70	170	8 yrs.	T 8	KAFO'S, 2 yrs.	Prefers metal KAFO'S.
20	M.A.	M	22	72	120	16 mos.	T 10	KAFO'S, 2 mos. Independent Ambulation	Difficult to climb stairs, curbs, prefers metal KAFO'S.
21	F.D.	M	39	73	170	4 mos.	T 12	None	Suit too small, poor motivation.
22	P.G.	M	19	70	115	6 mos.	T 12	None	Used in hospital for standing only. Disinterested.
23	R.G.	F	31	66	110	8 mos.	T 10	None	Took suit home and used it, but then rejected it in favor of metal KAFO'S.

Orthotics and Prosthetics, Vol. 31, No. 1, pp. 51–53, March 1977

WELDING THERMOPLASTICS

Neal R. Donaldson[1]
Michael J. Quigley, C.P.O.[2]

The introduction of thermoplastics, i.e., polypropylene and polyethylene into prosthetics and orthotics in recent years has demanded that the orthotist-prosthetist master new skills to take maximum advantage of the properties of these new materials. The art of welding plastics is one such skill. Welding is very useful for repairing plastic orthoses and is essential for fabrication of such things as the ultra-lightweight prosthesis (*3*) and the pelvic girdle of the Boston system for scoliosis control (*2*). Welding is also useful for attaching elastic panels to thermoplastics, and, in some areas, the long flexible welding rods are bunched together and used as twister cables.

The basic plastics welding system, which costs less than $200, consists of a compressed air source, a regulator for it, a tank of water-pumped nitrogen with its regulator, a third regulator to control the air-nitrogen mixture, a welding gun, and a variety of welding tips and welding rods (Fig. 1). The welding unit is designed to direct a flow of compressed gas, either air, water-pumped nitrogen, or a combination of the two, in a fine stream over an electric heating element and onto the plastic. In general, nitrogen is used for welding and air is used to maintain a functional welding temperature between welding operations. The regulators on the compressed air and nitrogen should be set at 20 psi and the combination regulator should be set at 3½ to 4 psi for most orthotics and prosthetics welding. The setting varies according to material thickness, i.e., the thicker the material, the more heat required.

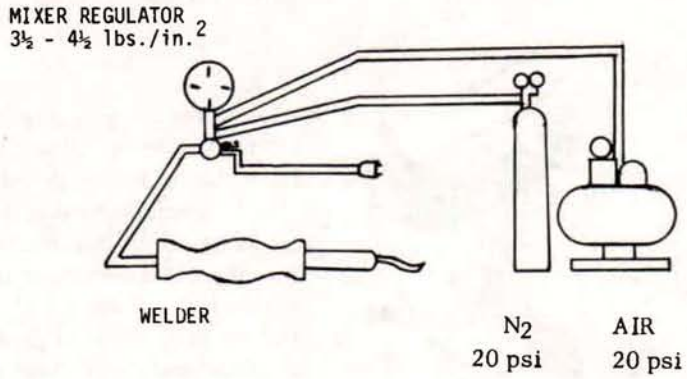

Fig. 1. Schematic of the welding system. A combination of compressed air and nitrogen is recommended, although some practitioners claim satisfactory results with compressed air alone.

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The pieces to be welded and the welding rod must be the same kind of plastic i.e., polypropylene to polypropylene, and they must be of the same type and density. The edges should be clean and level, any stray slivers of plastic should be removed, and the pieces cleaned with a solvent such as acetone. Using the tacking tip, the pieces should be tack welded together. Either the round welding tip or the high speed welding tip can be used for the final weld.

The end of the welding rod should be cut to a 60 deg. angle with a diagonal cutter. When the round welding tip is used the rod should be held at a 90 deg. angle to the joint and the hot air stream directed at the junction of the rod and the material to be welded (Fig. 2). As the weld begins to form, proper heat and pressure will ensure that the rod rolls smoothly into the joint.

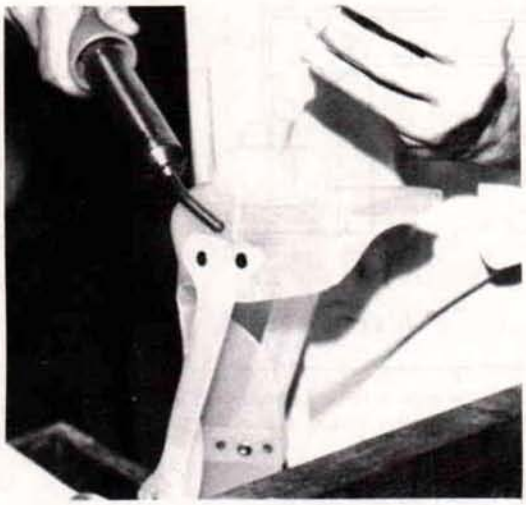

Fig. 2. The welding rod is held at 90 deg. to the seam when the round welding tip is used.

When the high speed tip is to be used, the rod is fed through the tube at the end of the high speed tip. As the weld begins to form, the tip is moved along the joint at a 45 deg. angle while pressure is applied through the welder on to the welding rod (Fig. 3). It is essential that proper rate of feed be maintained because a fast speed will not permit the formation of a secure weld (Fig. 4), while too slow a speed will permit the rod to melt in the tip. Plastic welds differ from metal welds in that with plastics the welded portion is generally weaker than the surrounding material. For this reason, one or more reinforcing welds are placed on each side of the first weld (Figs. 4 & 5).

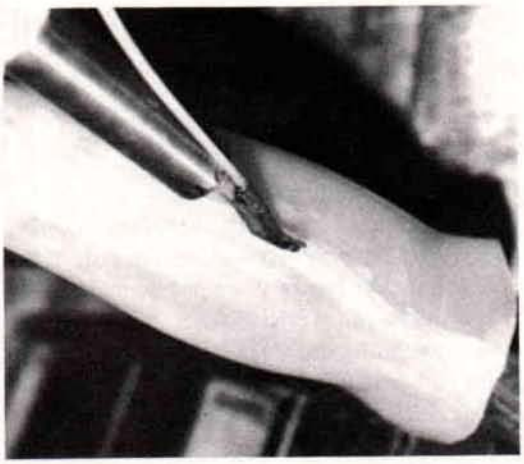

Fig. 3. The rod is fed through the tube in the high speed tip. The proper amount of heat and speed are the critical elements of good plastics welding.

The six basic tenets of good welding are:

1. A small bead should form along each side of the weld where the rod meets the base material (Fig. 4).

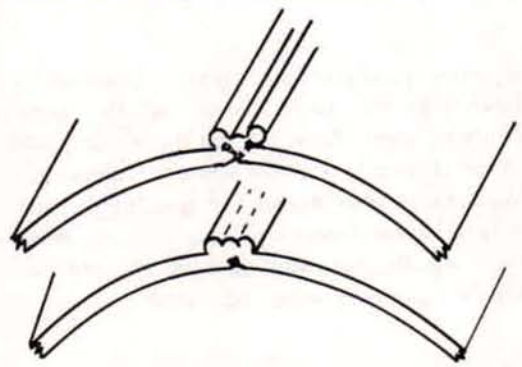

Fig. 4. The butt weld in the top drawing will not hold. This can be caused by insufficient heat or welding too fast. The weld shown at the bottom will hold.

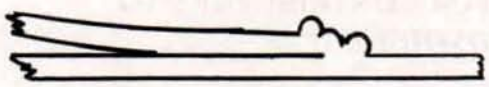

Fig. 5. Lap weld. One central weld and two reinforcing welds generally suffice for most orthotics and prosthetics uses.

2. The rod should hold its basic round shape.
3. Neither the rod nor the base material should char or discolor.
4. The welding rod should not be stretched during the welding process.
5. The heating element is disconnected and allowed to cool before the air flow is turned off. Conversely the airflow is always turned on before the heating element.
6. Oxygen or other flammable gases are never used.

More information about welding plastics is available in the pamphlet "All About Welding Plastics" (*1*).

LITERATURE CITED

1. Seelye Plastics Inc., 9700 Newton Avenue South, Minneapolis, Minnesota, 55431. "All About Welding Plastics."

2. "A Refined Concept in the Orthotic Management of Scoliosis" Hall, J. T., Miller, M. E., Schumann, W. and Stanish, W. *Orth. & Pros.* Vol. 29, No. 4, pp. 7–13. December 1975.

3. "Ultra Light Prostheses for Below-Knee Amputees" Wilson, A. Bennett, and Stills, Melvin, *Orth. & Pros.*, Vol. 30, No. 1, pp. 43–47, March 1976.

PHOTOGRAPHIC GUIDELINES FOR CONTRIBUTORS TO *ORTHOTICS & PROSTHETICS*

Orthotics & Prosthetics, the quarterly journal of the American Orthotic and Prosthetic Association, seeks to present the most recent developments in the field in the clearest and most concise way. Since photographs are an integral part of *O & P*, we'd like to use only the clearest and most concise photographs to illustrate our contributors' articles. Realizing that it is not always possible to hire a professional photographer to provide you with pictures to accompany your writing, we have compiled some recommendations to help you help us to produce the best quarterly possible.

1) Send black-and-white photographs *only*. Color pictures, and especially Polaroid color pictures, do not fare well at all in the black-and-white reproduction process. If at all possible, *avoid* sending color photographs. If a slide or color negative is the only photographic material you have, have a photo lab make a black-and-white copy negative from which the lab can make a black-and-white-print — preferably glossy.

2) Send original or camera-copied photographs, NOT pictures cut out of a magazine, textbook, or newspaper. A picture run in any of those publications has already been subjected to the "half-tone" process, which converts a black-and-white photograph into a pattern of dots that can then be printed to reproduce all the shades of grey that make up the picture. Half-toning a half-tone results in a muddy, murky, seemingly out-of-focus picture, often unsuitable for publication.

3) When photographing inside, use a strobe or flash unit. Available interior light is often not strong enough to produce the contrast necessary for a sharp photograph. Using even the smallest strobe or flash unit will increase your picture's contrast manyfold.

The use of artificial light will also usually take care of the problem of fuzzy pictures due to camera shake, which often occurs when the camera's shutter speed has to be set below 1/125 of a second. If you *must* take a picture using available light and at a low shutter speed, *use a tripod* or follow these steps:

[ ] bend your knees slightly
[ ] keep your elbows close to your side
[ ] draw in a deep breath and hold it
[ ] *squeeze* — don't snap — the shutter release button

4) Send large *glossy* photographs — it's a bit more expensive, but a 5 x 7, or 8 x 10 glossy reduced in size makes a far better reproduction than a smaller one blown up. So-called "Silk-finish" photo paper produces a blurry half-tone.

Suggested sources of inexpensive photographic work:

1) If you are located at or near a college or university, contact the student newspaper. Student photographers often do work equal to or better than that of commercial studios, and usually for far less money.

2) If you are near the National Office in Washington, D.C., contact the Director of Informational Services about having the staff photographer handle the job. Requests for this work must of course come at least 2 months in advance of the actual printing deadline.

Orthotics and Prosthetics, Vol. 31, No. 1, pp. 55–56, March 1977

NEW PUBLICATIONS

REHABILITATION OF UNILATERAL ABOVE-ELBOW AMPUTEES, SELECTED PROBLEMS, Edited by J. Tomaszewska, Polish Medical Publishers, 1976; 97 pp., illus.

This is a report of the results of a research program carried out at the Institute of Orthopaedic Surgery and Rehabilitation of the Medical Academy of Pozhan, Poland during the period 1970–75 under the leadership of Dr. Janina Tomaszewska. The project was supported jointly by the Rehabilitation Services Administration, DHEW, U.S.A. and the Scientific Council of the Minister of Health and Social Welfare of Poland.

Included in the report are results of a study comparing "dual-control" (American) and "triple-control" (German) harness-and-socket systems. The advantages and disadvantages are well defined.

Data on the degree of scoliosis found in 64 above-elbow patients are presented, and suggestions for further work in this field are given.

In the course of the project considerable time was devoted to a study of the phantom limb, including experiments designed to take advantage of this phenomenon.

One chapter is devoted to an excellent presentation of recommended exercises to prepare the above-elbow amputee for training and use of his prostheses.

Also included is a new design for a wrist unit.

Many of the findings of the group at Poznan, while not "breakthroughs", certainly contribute to our knowledge of the problems of the above-elbow amputee, and thus use of these findings will improve present methods of managing the unilateral above-elbow amputee.

This publication should be read and studied by all who are engaged or expect to be engaged in research in upper-limb prosthetics, and by all who are engaged in teaching upper-limb prosthetics. While it suffers from the inevitable problems associated with translation from any language into English it is quite well done, and reflects the high quality of the research program carried out at Poznan.

MINUTES OF A WORKSHOP ON CHILDREN'S PROSTHETICS. May 5–6, 1975, Committee on Prosthetics Research and Development, National Academy of Sciences, 1976; 125 pp., no illus., gratis.

This nicely edited publication contains 36 papers presented at a Workshop held in Seattle in 1975 for the purpose of developing recommendations for further research, development, and education in the area of limb prosthetics for children. Unfortunately the papers are of very little value to anyone because no illustrations are used. Just as unfortunate is that almost no concrete recommendations for further work are set forth. Those recommendations that are included consist mainly of platitudes.

PRINCIPLES OF ORTHOTIC TREATMENT, Wilton H. Bunch and Robert D. Keagy, C.V. Mosby Co., 1976; 144 pp., illus., $17.50.

In the preface to this relatively small book the authors state:

> This book is intened for the resident or student who is expected to prescribe an orthosis and is uncertain what to do; however, it does not provide easy, pat answers for each disease or disability. It presents the basic material necessary to make the decision of orthotic needs. In a summarized fashion,

the book describes the factors that go into choosing the orthosis for a given patient. Thus it trys to avoid being a "cookbook", yet still be a practical aid in real life. For the Milwaukee brace, a checkout protocol is presented.

In this they have succeeded quite admirably. This primer will be just as useful to student orthotists and therapists as it is to residents in orthopaedic surgery and rehabilitation surgery. In fact teachers and practicing orthotists might well benefit by reading this book carefully.

EVALUATION OF THE PRACTICALITY OF USING THE "BOSTON" PREFABRICATED PELVIC GIRDLES FOR THE MILWAUKEE (CTLS) ORTHOSIS, Committee on Prosthetics Research and Development, National Academy of Sciences, 1976, 20 pp. gratis.

At the request of the Children's Hospital, Boston, Mass. the National Academy of Sciences initiated a program for the clinical evaluation of the so-called Boston system for control of scoliosis in 1974. This is the report of the results.

Sixty-four patients were fitted in five clinics between April 1, 1975 and August 15, 1975. For reasons not stated only 28 patients were followed up, and these only at "about six-week and twelve-week intervals." Twenty-six of the 28 patients followed up were fitted at one clinic. Although a great number of problems were encountered by the patients and the treatment teams, the report states "the participants of the evaluation concluded that the use of prefabricated pelvic girdles is practical, and in most cases have continued to use prefabricated girdles in their practices, although not necessarily the same type that was evaluated." Unfortunately, this ambiguous and most inadequate report stops at this point.

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	To	Multiply by
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 $\quad ^\circ C = \dfrac{^\circ F - 32}{1.8}$

°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.

INFORMATION FOR AUTHORS

ORTHOTICS AND PROSTHETICS
INVITES THE SUBMISSION OF ALL ARTICLES AND MANUSCRIPTS
WHICH CONTRIBUTE TO ORTHOTIC AND
PROSTHETIC PRACTICE, RESEARCH, AND
EDUCATION

All submitted manuscripts should include:

1. THE ORIGINAL MANUSCRIPT AND TWO COPIES. If possible, the duplicate manuscripts should be complete with illustrations to facilitate review and approval.
2. BIBLIOGRAPHY. This should be arranged alphabetically and cover only references made in the body of the text.
3. LEGENDS. List all illustration legends in order, and number to agree with illustrations.
4. ILLUSTRATIONS. Provide any or all of the following:
   a. Black and white glossy prints
   b. Original drawings or charts

   Do *not* submit:
   a. Slides (colored or black & white)
   b. Photocopies

PREPARATION OF MANUSCRIPT

1. Manuscripts must be TYPEWRITTEN, DOUBLE-SPACED and have WIDE MARGINS.
2. Indicate FOOTNOTES by means of standard symbols (*).
3. Indicate BIBLIOGRAPHICAL REFERENCES by means of Arabic numerals in parentheses (6).
4. Write out numbers less than ten.
5. Do not number subheadings.
6. Use the word "Figure" abbreviated to indicate references to illustrations in the text (. . . as shown in Fig. 14)

PREPARATION OF ILLUSTRATIONS

1. Number all illustrations.
2. On the back indicate the top of each photo or chart.
3. Write the author's name on the back of each illustration.
4. Do not mount prints except with rubber cement.
5. Use care with paper clips; indentations can create marks.
6. Do not write on prints; indicate number, letters, or captions on an overlay.
7. If the illustration has been published previously, provide a credit line and indicate reprint permission granted.

NOTES:

—Manuscripts are accepted for exclusive publication in ORTHOTICS AND PROSTHETICS.
—Articles and illustrations accepted for publication become the property of ORTHOTICS AND PROSTHETICS.
—Rejected manuscripts will be returned within 60 days.
—Publication of articles does not constitute endorsement of opinions and techniques.

—Permission to reprint is usually granted provided that appropriate credits are given.
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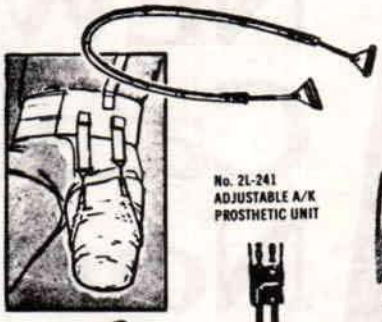
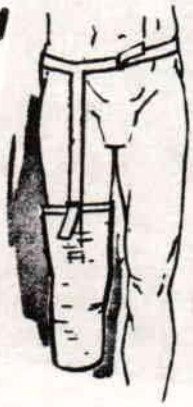
POST-SURGICAL SUPPLIES

ABOVE-KNEE SUSPENSION CORSET

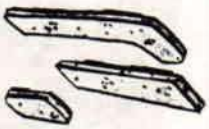
ABOVE-KNEE SUSPENSION CABLES



BELOW-KNEE SUSPENSION BELT (LEFT AND RIGHT)



Felt or Polyurethane B/K Relief Pads



No. 2L-241 ADJUSTABLE A/K PROSTHETIC UNIT

No. 2L-245 ADJUSTABLE B/K PROSTHETIC UNIT

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Order by toe width

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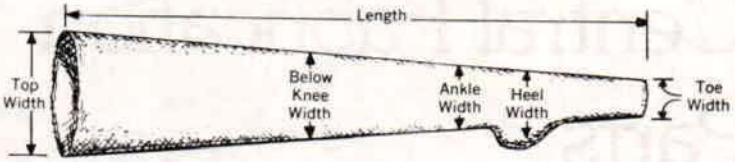
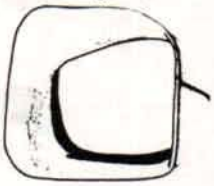
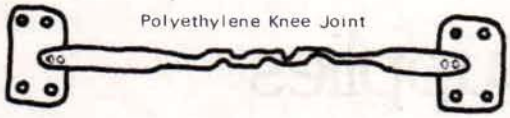


Polyethylene Quadrilateral Casting Brims

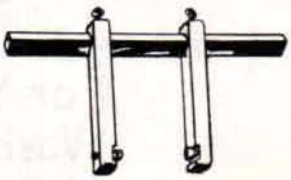


Cast Boot
Small
Medium
Large

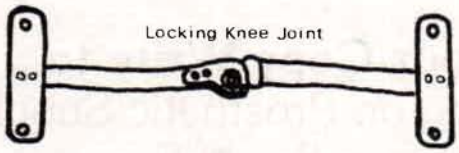
Polyethylene Knee Joint



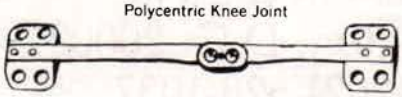
ALIGNMENT JIG



Locking Knee Joint



Polycentric Knee Joint



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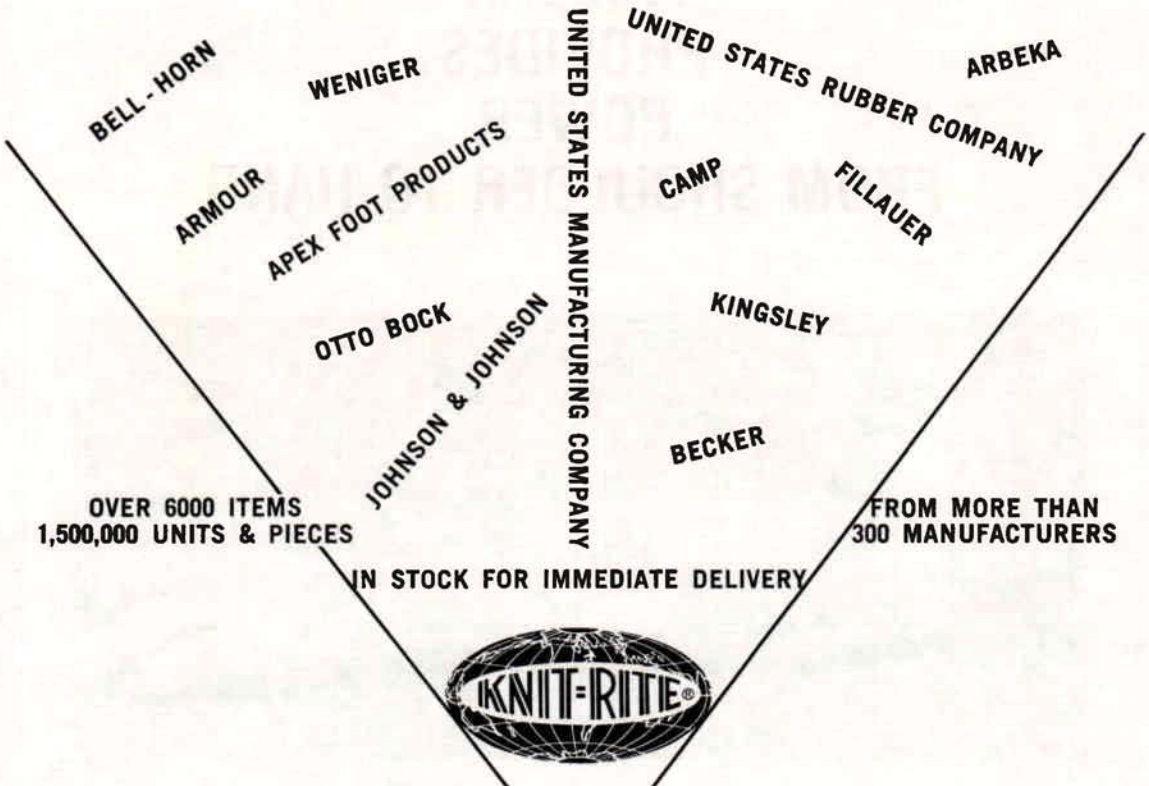

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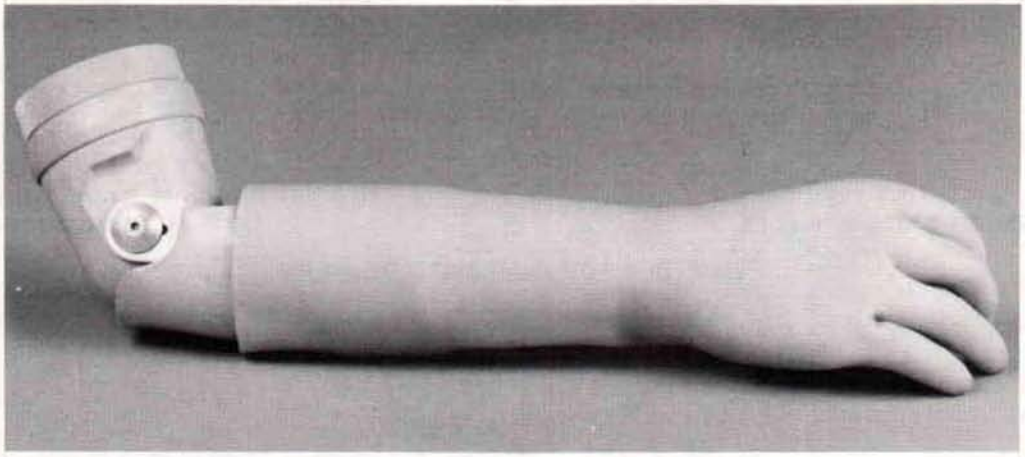

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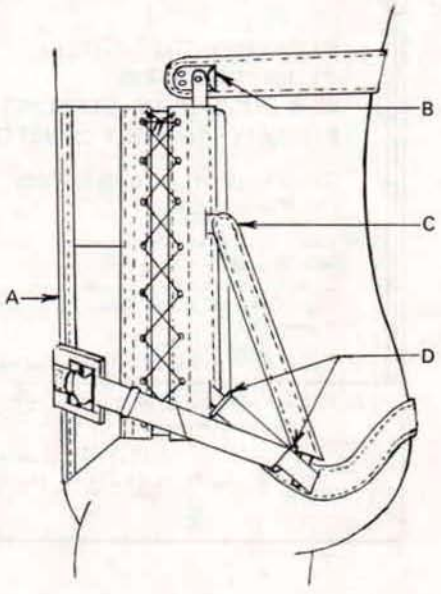

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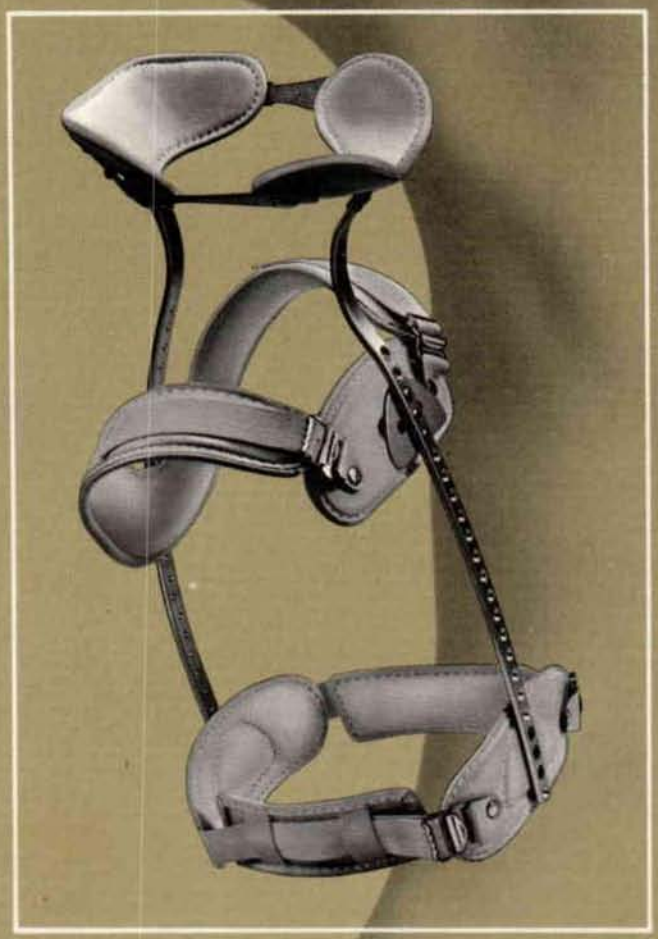

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