September 1979
Volume 33
Number 3

Orthotics and Prosthetics

Journal of the American Orthotic and Prosthetic Association

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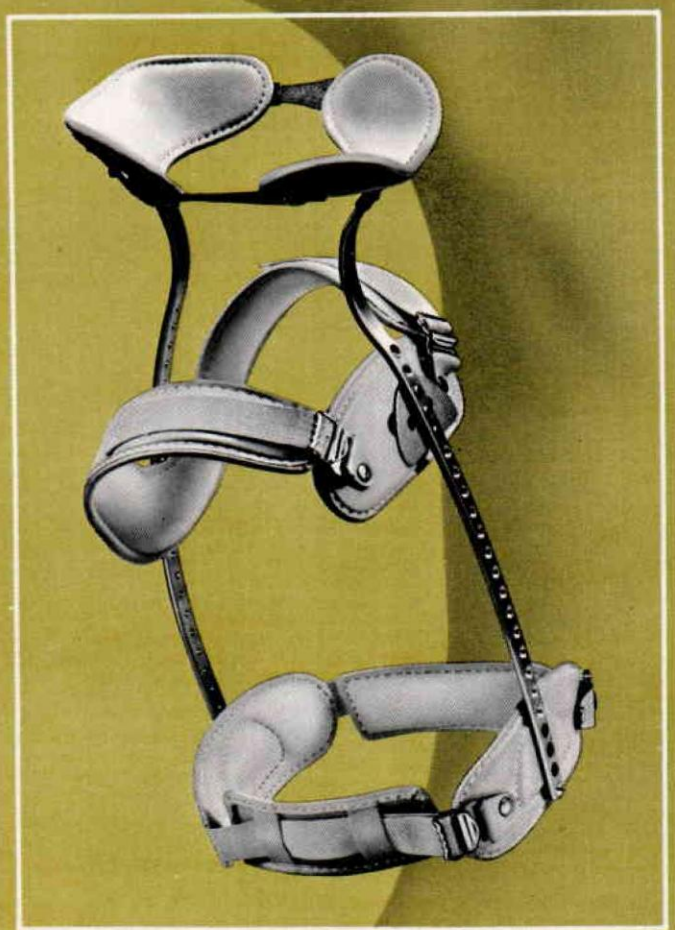

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September 1979 Journal **Volume 33, No. 3**

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Second Class Postage Paid
at Washington, D.C.
US ISSN 0030-5928

Advertiser's Index and Hotline

Advertisers shown in bold-face type are member of The American Orthotic and Prosthetic Association

Orthotics and Prosthetics is issued in March, June, September, and December. Subscription price, payable in advance, is $10.00 a year in the U.S. and Canada. Rate elsewhere is $11.00 a year. Single issues, $3.00 each. Publication does not constitute official endorsement of opinions presented in articles. The Journal is the official organ of the publisher, The American Orthotic and Prosthetic Association in collaboration with the American Academy of Orthotists and Prosthetists, and serves as the U.S. organ for Interbor. All correspondence should be addressed to: Editor: *Orthotics and Prosthetics*, 1444 N St., N.W., Washington, DC. 20005. Telephone, Area Code 202, 234-8400.

Orthotics and Prosthetics is indexed by Current Contents/Clinical Practice.

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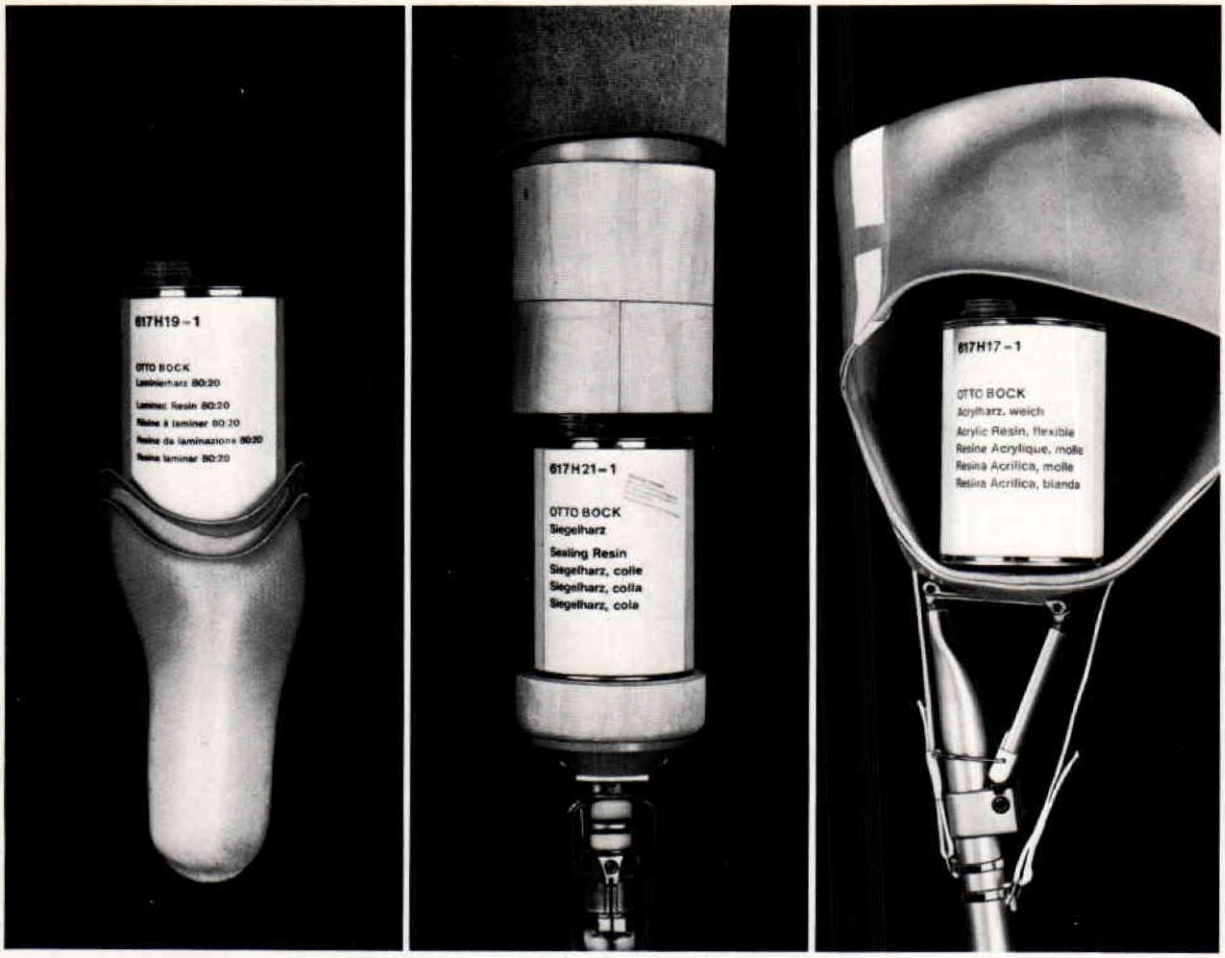

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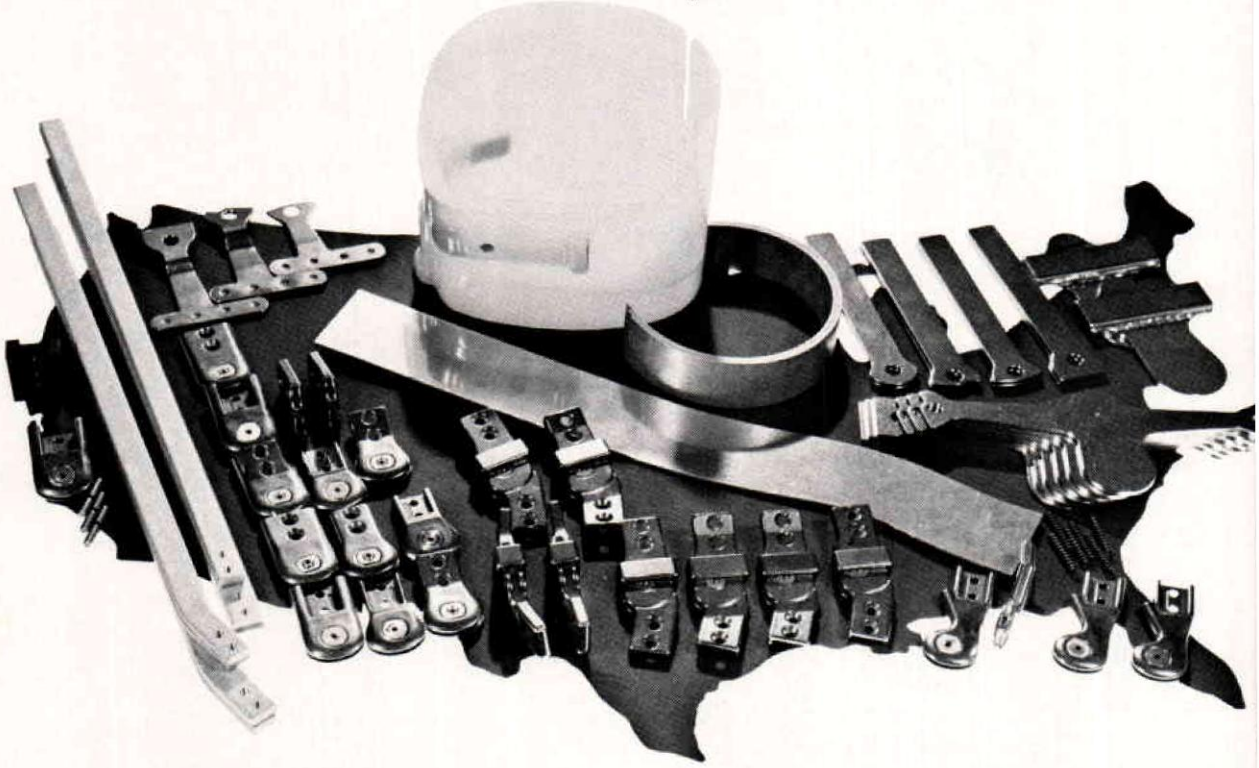

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Commentary

A Year In Review

Dear Member:

This has been an active and productive year for AOPA, and highly successful in many ways. The increase in membership, which at last report was at an all time record, suggests several things to me. First, that the programs and projects have received great emphasis, and therefore have achieved tangible results. Our publications are accurately reporting Association activities and are presenting informative articles such as columns by John Harman, legal counsel, and Drew Upton, medical consultant. Your officers and directors are responsive to your needs and are working to achieve those objectives identified by you, the members. This confirms that efforts made by your Executive Director and his staff to solicit new members has been successful.

The American Orthotic and Prosthetic Associations financial situation is a healthy one. It is returning to its members the maximum amount of effort that its dollars can buy. The deficit budget that we began with this year has disappeared. With income from dues, advertising, and last year's Assembly combined with the support of the membership we are anticipating a modest surplus as we close this fiscal year. Why then is a dues increase necessary for next year? Because, if we intend to continue supporting existing programs, staff, and the funding of new programs, then additional funds are required.

Our National Office staff, which we share with ABC and AAOP, is as competent and capable as we have ever had. A blend of experience and wisdom, with youth and enthusiasm, reinforced where required; aided by able consultants in the legal, accounting, and government relations area.

The committee work for AOPA is comprised largely of volunteers who serve on behalf of the Association and its members. Most of these people receive little recognition for their efforts, but the results benefit all of us.

The Medicare committee is comprised of Herman Hittenberger, Gene Jones, Don Perser, Drew Upton, and Ann Berriman. After efforts which began in 1977 to produce a Medicare Handbook; publication and distribution of the Handbook occurred in the spring of this year. With the assistance of the Bennett Group, a series of Regional seminars were conducted in conjunction with the Handbook.

The growing Government Liaison committee once consisting of Ben Moss and Dan Rowe, now includes Jack Hendrickson, Gene Jones, Don Perser, Troy Owens, and Charles Dankmeyer. Their charge includes the monitoring of government agencies and bureaus, and the laws and regulations that impact AOPA members, and with developing policy and preparing position papers to better inform government officials of our needs and our importance to the physically handicapped. A full time government relations person has, within the past few weeks, been added to the National Office staff. The result of which is sure to be advantageous to AOPA and its members.

Bill Smith, Chairman of the Business Procedures and Data committee, assisted by the members of the committee and subcommittees have produced the Accounting Manual, the Business Survey, and the Directory of O&P Procedures. These publications are products of an effort to keep us informed. A two-day business seminar in the Grand Cayman Islands, was a highlight of the years progress.

It is regretful that we have neither the time nor the space to give a detailed report of the work of every committee and every member that support our Association. However, I want to express my thanks to all who served to make this a great year. We also thank the general membership for their help and support.

Sincerely yours,
William M. Brady

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Orthotics and Prosthetics, Vol. 33, No. 3, pp. 3-9, September 1979

Accomplishments in Modern Orthotic Patient Management—Indications for the Future[1]

THORKILD J. ENGEN, C.O.[2]

In considering the enormous magnitude and the uniqueness of the accomplishments that have been made in the prosthetics and orthotics professions within the past ten years, it seems appropriate that we review together and reflect upon these achievements in an effort to determine our directions and emphases for the future. A positive and exciting revolution has taken place in our field for which several important factors merit recognition.

First—The backbone of our profession—namely, the existing national and international schools of prosthetics and orthotics.

Second—The creation and close collaboration of our international professional organizations.

Third—The gifted foresight, wisdom and strong leadership demonstrated by past and present leaders of each of these organizations.

Fourth—The publication of professional journals, newsletters, and bulletins, disseminating new ideas resulting in improved orthotic and prosthetic clinical processes which, in turn, have had the effect of improving the individual orthotist's and prosthetist's services to his/her patients.

Fifth—The many meetings, in addition to existing international educational programs, taking form as seminars, assemblies, and international congresses such as this one.

Sixth—Numerous physicians, and others within the health care professions, who have taken an active and direct interest in our professional growth.

As a result of these efforts, orthotics and prosthetics have evolved from relatively little known professions (as compared to the older and more classical allied health professions) and have gained respect among all the rehabilitation disciplines. The orthotist and prosthetist are now important—and necessary—members of the clinical team because we have developed professionally to a fuller understanding of the great variety of patients, their disabilities and their needs, as these relate to our services. We can now, better than ever before, participate actively and effectively in the total rehabilitation management of the disabled patient. *Physical restoration of the severely physically handicapped person cannot be achieved without the services of the orthotist and/or prosthetist.*

I wish to review with you *some* of the achievements which are only indicators of

the progress made by many of our colleagues throughout the world. Naturally, some of these innovations and developments may not yet be in general use, but through dissemination of information and transfer of technology, they will be available to all our colleagues in time to come.

My discussion at this point will turn primarily to orthotic patient management as I am an orthotist and better versed in orthotics than prosthetics.

One of the best known accomplishments in our field in recent years is the development and use of new materials, especially thermoplastics—just to name a few, polypropylene, polyurethane and vitrathene, all having excellent physical properties and lending themselves to meeting the individual patient's orthotic requirements much more satisfactorily than conventional orthotic materials. These new materials are lightweight, have great resistance to fatigue, possess excellent moldability, afford improved hygiene and cosmesis, are available at a reasonable cost, and permit relatively simple working methods. A large patient population, with diagnoses of cerebral vascular accident (or stroke), polio, peripheral nerve injuries, and many other disabilities resulting in ambulation disorders, is now able to function with much less difficulty and without sacrificing safety because of the innovations in usage of such materials.

With the introduction of the variety of plastics, we are now able to do our job with great accuracy and proficiency. In addition, some of the devices lend themselves to central fabrication, thus simplifying the manufacturing techniques of systems that are individually adapted to the patient.

A good example is the simple drop-foot orthosis for which the orthotist takes the measurements of the patient's lower limb, identifying the standard module corresponding to those measurements, and individually tailors the orthosis for his patient. Results: elimination of the shoe-brace attachment, improved ambulation, less energy expenditure.

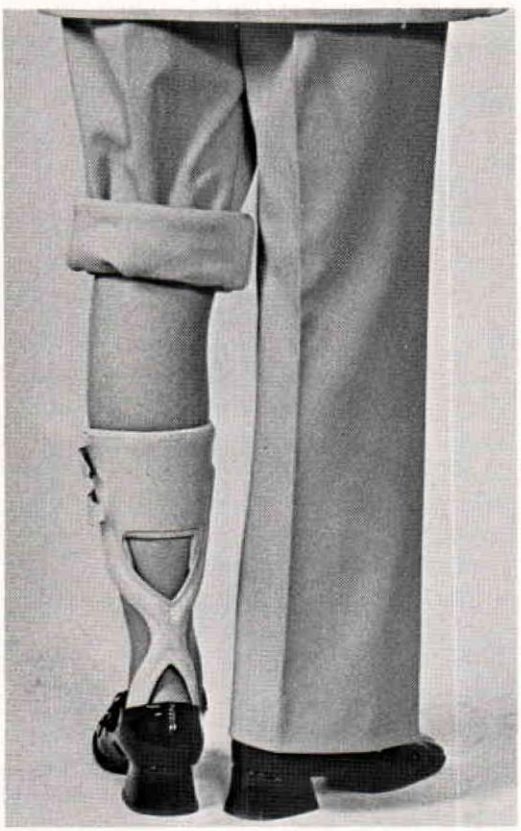

Fig. 1. Example of how new materials led to new design concepts is this ankle-foot orthosis.

In spinal orthotics, plastic material has made a fantastic impact by facilitating the central fabrication of devices such as the Milwaukee Frame. It is used for the entire device itself as a pelvic girdle replacing the steel bands and leather corset.

In traumatic spinal orthotics, a plaster-of Paris cast was formerly used to immobilize the spine for a period of eight to ten months. Now, the cast is routinely re-

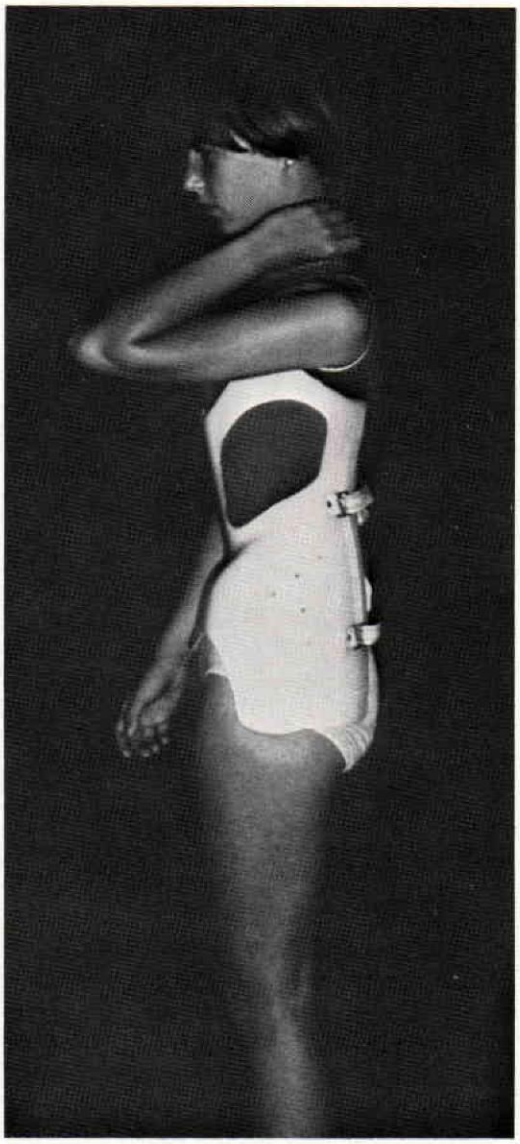

Fig. 2. Centrally fabricated Milwaukee Frame made totally from thermoplastics.

placed by an upholstered plastic jacket that can be applied when the patient is sitting or maybe even ambulating, but can be removed while the patient is resting in bed. In addition to maximal spinal immobility, the jacket allows the patient almost normal hygienic activities that before were very complicated and time consuming. Furthermore, the patient becomes functional in his rehabilitation program at a much earlier stage than previously when the cast was in use.

Orthotists have developed a variety of techniques for handling the new plastics. One widely used technique is drape molding, which is used in conjunction with corrugation where material thickness must be carefully controlled to achieve either the necessary rigidity or flexibility. Another method of handling these materials is the familiar vacuum molding technique. This method produces a very uniform replica of the mold being used. After the fitting and fine tuning are completed on a patient with any of these devices, it is essential that the orthotist carefully instruct him as to wearing time during the initial period necessary to build up tissue tolerance because of the contour fitting technique used.

Obviously, the introduction of these excellent new substances and technologies resulting in new design concepts, has constrained the orthotist to acquire more comprehensive knowledge of patient disabilities as they relate to biomechanics, pathomechanics, and muscular dysfunctions. The acquisition of this knowledge has fostered a closer working relationship between the orthotist and the physician, as well as with others on the rehabilitation team including the patient himself.

Great strides have been made in restoring function to the upper limb for patients with spinal cord injuries, brachial plexus injuries, peripheral nerve injuries, and other impairments affecting the upper limb.

Prevention and/or correction of such deformities are predominantly accomplished by applying a three-point corrective pressure system to the flexion contracture, whether it be the fingers, wrist, elbow, shoulder or knees.

Electronics is now affording us new and

practical means of restoring hand function. The new systems are electronically powered and operated. Additionally, they have reached a high degree of reliability. One device, weighing only seven ounces, can provide a C5-6 quadriplegic with a controllable, but powerful, five-pound finger prehension. This is more than adequate to manipulate any objects used in daily living activities—even the telephone—from a wheelchair (sitting) position.

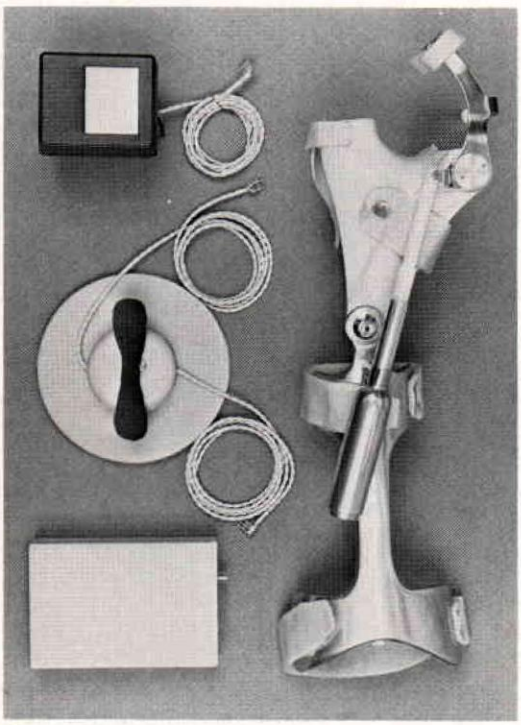

Fig. 3. Advancement made by combined technologies is in the form of microelectronics as used in orthotic patient management.

For the even higher C4-5 quadriplegic patient, where more sophisticated orthotic assistance is needed, pneumatically or electronically powered systems can help him attain some useful upper extremity function.

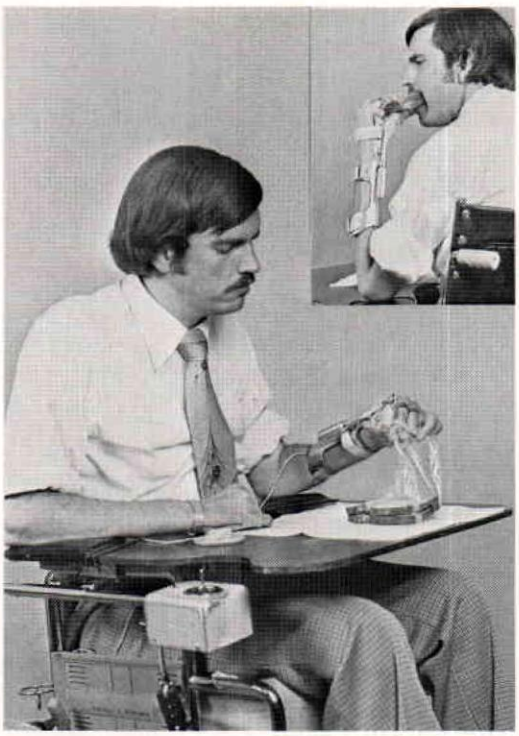

Fig. 3A. Quadriplegic patient using the more efficient and simplified electronically powered finger prehension orthosis replacing the pneumatic system he previously used.

Along with these notable orthotic innovations, there are additional services emerging—namely, through biomedical engineering and the rehabilitation engineering groups.

There was an initial period when the rehabilitation engineer as well as the rehabilitation community were not sure how to interpret the engineer's role in the overall patient management. The introduction of this new element into the system had a particular impact on the orthotist and prosthetist. After some eight years, it is evident that the biomedical engineer, and more specifically the rehabilitation engineer, does not supplant the orthotist and prosthetist, but instead each functions in a supportive role with the

other to enhance the quality of life for the severely handicapped.

Thus far, biomedical engineering has made its greatest impact in the area of *environmental controls,* which have proven immensely important and useful for people who need assistance beyond what an orthotist can provide. Through the use of a variety of electronic systems, the patient is able to control his environment very effectively, providing some degree of independence.

In rehabilitation engineering, *mobility aids* are valuable engineering contributions toward helping the handicapped return to an independent lifestyle. These devices are becoming very popular in the United States. A prime example of mobility aids is the highly sophisticated van that even the severely handicapped person can drive independently and which has a built-in wheelchair lift that he can control independently.

Fig. 4. A major contribution through rehabilitation engineering is the development of a multitude of vehicles that can be operated independently by severely handicapped persons.

The foregoing has been a review of what we have accomplished and what we have to build on. But we are facing grave problems in the *sheer numbers* of people throughout the world needing orthotic and prosthetic services as contrasted with the number of persons available to meet those needs.

The few statistics that are available to us on an international basis are surely incorrect—or at best, incomplete.

As professionals and members of our various professional orthotic and prosthetic organizations, we have a clear obligation to set about providing the additional manpower to serve those in need. Our obligations and responsibilities now extend beyond merely assuring that we ourselves are professionally are technically competent. We must become advocates for the changes which are vital to diminish the horrendous and unacceptable chasm between the people we have taken care of and those yet to receive our help.

It is not for us to say, "Can we afford to do it?" Rather, we must answer the question, "Can we afford *not* to do it?"

Specifically, and on a practical level, we must first speak to the matter of education. I propose that we initiate an international student exchange program to provide dissemination of knowledge across national boundaries on both an undergraduate and graduate (continuing education) level. The program could be structured and conducted by a committee or group composed of members from our national and international organizations. It could best be funded by the federal governments of the participating members. Curriculum committees would be established so there would be as little duplication of effort as possible among the institutions; so that students would be

channeled to the institutions whose programs best meet their needs, the needs of their patient populations, and degree of technical sophistication extant in their areas. Other groups chosen from our membership would monitor quality of teaching and effectiveness of the exchange programs.

Indeed scattered efforts have been made by individuals and institutions or organizations in various nations to conduct exchange programs from time to time, but what we seek here is a concerted and centrally coordinated effort under the sponsorship of one entity.

Continuing with educational needs, we must increase our sharing of orthotic and prosthetic developments and expand the knowledge base—in the news media, where appropriate, to the general populace, and in our professional and technical publications to health professionals. We must increase our efforts to work with other medical professional organizations—the orthopedic surgeons, for one example—to educate those disciplines to the need and proper use of orthotic and prosthetic services for their patients.

Lastly, in our discussion of educational needs, we must work through our national organizations and our national governments for the establishment of additional schools for undergraduate training. This might include both an increase in the number of technical schools as well as establishment of orthotic and prosthetic programs within our colleges and universities.

We also face the task of capturing the young person, at the time of career choice, for the prosthetic and/or orthotic sciences. Ours is a solid, scientifically-based health service, and we must convey that fact to the students we are seeking to attract. However, the teaching curricula must continuously be updated to follow the rapid changes in technology and services. In addition, the quality of instructors must be re-evaluated at various times, to insure that the student receives training that provides him with the proper base from which to exercise his responsibility as a professional.

Second, in concert with our educational endeavors, is the need for more and better organized petitioning of our national governments for increased research and development funds. It is not inconceivable that we will reach a stagnation point as more and more funds are diverted to other purposes, or to other disciplines within the medical area.

As to the actual practice of our professions, I re-emphasize the need for more collaboration among all of us. If we are to standardize, if we are to achieve central production of modular units, if we are to attain a high level of quality not only in production of actual appliances but also in provision of professional consultative services, we must work one with another so that we do not become isolated and in-grown. Through these efforts, we would also have the mechanisms for evaluation of systems developed throughout the world. This is imperative if we are to increase the physicians' confidence and interest in us and in the merit of our services; if we are to convince the politicians of the need for governmental support; and most importantly, if we are to provide the genuinely useful services that our patients have every right to expect from us.

We have much to be proud of, but we also have weaknesses and areas where improvement is desirable. We still have much to learn in the area of professional relationships both among ourselves and with other health practitioners. A fair degree of the unsatisfactory working relationships in the past has stemmed from the fact that some of our activities were viewed as being strictly commercial while others were recognized as being academic or professional.

We must take a look at ourselves and scrutinize our own participation in the health care delivery system. We are no longer simply providers of a physical product. That is an outmoded concept. We provide professional services of which the actual physical product is only a part. We are full-fledged members of the clinical patient management team. And being so, we must make available to the patient the highest quality services resulting from our experience, training, and education in a highly specialized field. As the initial manifestation of our changing role, the prosthetist and orthotist must become more active in the prescribing process of orthotic and prosthetic devices. It is folly to expect all physicians to be knowledgeable and current, not only in their own milieu, but also in our profession, considering the myriad of refinements and alterations that have been made in traditional devices as well as the many entirely new and sophisticated systems that have been developed.

Consequently, it is up to us to accept this responsibility without delay in order that the patient will receive the very best orthotic and prosthetic services and systems tailored specifically for him.

From the foregoing discussion, I have thus extracted the following points which are put to you for consideration as GOALS of our professional society, as well as for us individually:

1) To enhance *educational opportunities* in the prosthetic and orthotic sciences, especially to promote *student exchange.*

2) To update *teaching curricula* and re-evaluate instructor training methods.

3) To *petition for government funding* for prosthetics and orthotics research and development.

4) To develop and increase *collaboration* among ourselves.

5) To *conduct an international survey* to include: number of disabled; nature of their disabilities; number of physically handicapped being served; number of those only partially served or not served at all; number and distribution of orthotists and prosthetists, those in private practice and those in academic programs.

6) To *enlarge the role* of the qualified prosthetist and orthotist in *prescribing* prosthetic and orthotic services.

7) To enhance the professional image of the orthotist and prosthetist by *formal recognition* of colleagues making outstanding contributions in our profession.

I sincerely believe it is a proper and vital task for our association to address itself to these goals through the creation of study groups, operating committees, and secretariats. We are now strong enough to become even stronger. Although we are old as far as our unique work is concerned, we are young in organization and few in number.

But, if we stand united behind our goals, we will surely grow. There must be universality of purpose among us; we must all strive for the same high level of excellence.

I challenge you to see your individual role in an enlarged sense; you will then have taken the first step toward fostering recognition and acceptance of the professional orthotist and prosthetist throughout the medical and allied health professions.

Footnotes

[1]Keynote address presented at the Eighth Congress of the International Association of Orthotists and Prosthetists; October, 1978; Madrid, Spain.

[2]Associate Professor, Departments of Rehabilitation and Physical Medicine, Baylor College of Medicine; Houston, Texas; and Director, Department of Orthotics, The Institute for Rehabilitation and Research; Houston, Texas.

Orthotics and Prosthetics, Vol. 33, No. 3, pp. 10-19, September 1979

Orthotic Management of Thoraco-Lumbar Spine Fractures with a "Total-Contact" TLSO

EDWARD P. VAN HANSWYK, C.O.[1]
HANSEN A. YUAN, M.D.[2]
WAYNE A. ECKHARDT, M.D.[3]

This paper reports the experiences with a "total-contact" plastic TLSO (thoracic-lumbar spinal orthosis) for management of unstable thoraco-lumbar spine fractures at the Upstate Medical Center in Syracuse, New York. The custom fabricated bivalve design, although not original in itself, incorporates a number of orthotic management techniques that, when viewed collectively, develop an original orthotics management concept.

Spinal Orthotics

Over the years, spinal orthotics has consisted mainly of the various designs handed down from the late 19th century. The names Knight, Taylor, and McCausland are all associated with various spinal orthoses describing a specific design advocated by these famous physicians. The advantages of these designs are dependent upon the particular area, or the degree of area encompassed by the device.

The particular design, no matter what material it was made of, still provides the same two force system: 1) a three-point pressure system reducing or limiting motion in a direction, and 2) the increase in intra-abdominal hydraulic pressures to limit weight forces on the vertebrae.

These designs were in general use and acceptance until the extensive Norton-Brown study of 1957 documented the limited effect these orthoses have on certain areas of the spine. In fact, Norton and Brown showed that the longer devices actually increased motion in some areas of the spine, including the lumbar area (1).

THORACO-LUMBAR SPINE INJURIES

The thoraco-lumbar junction marks an area of transition of characteristics of the spine from the stiff thoracic region to the more mobile lumbar region. Injury to this region is quite common. When a force is applied to the upper body, the flexible lumbar spine is in a susceptible region between two relatively more stable segments.

The injury can range from a stable soft tissue injury, to complete spinal column disruption with fracture, dislocation, and instability. The T_{12} to L_2 region accounts for approximately 50 percent of all vertebral body fractures, and 40 percent of all spinal cord injuries occur in this region.

In the case of spinal fracture, including both the stable and unstable types, the orthotic force systems available, as pointed out by the Norton-Brown study, do

not provide the degree of stabilization required in all cases.

The critical point here is the stable/unstable nature of the injury.

STABLE SPINE FRACTURE

In most stable spine fractures, the purpose of the orthotic management effort is to relieve pain and discomfort, and at the same time allow healing.

The stable types of thoraco-lumbar spine fractures include: 1) vertebral body compression fractures; 2) isolated pars defect and spinous process fracture; and 3) transverse process fractures.

The stable category of thoraco-lumbar spine fractures from an orthotic point of view require limitation of gross motion in one plane only.

The anterior body compression fracture (Fig. 1) is usually caused by sudden vertical stress of hyperflexion, accompanied by lateral motion resulting in the compression of the vertebral body. Extreme violence is not necessary for this type of injury. It can occur when jump-landing on feet or buttocks.

A vertebral body compression fracture of up to 50 percent is basically stable with no immediate threat to the spinal cord, and a Jewett hyperextension orthosis is generally used to limit flexion and to prevent further vertebral stress, to allow healing, and to reduce pain accompanied by flexion.

The spinous process fracture and the isolated pars defect are usually caused by sudden hyper-extension motion or a striking blow.

The transverse process fracture (Fig. 2) often results from a sudden wrenching motion or a blow.

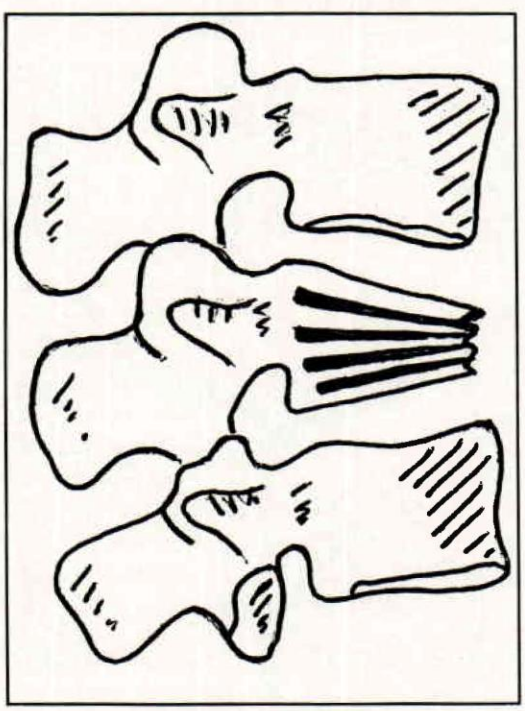

Fig. 1. Diagram of a compression fracture.

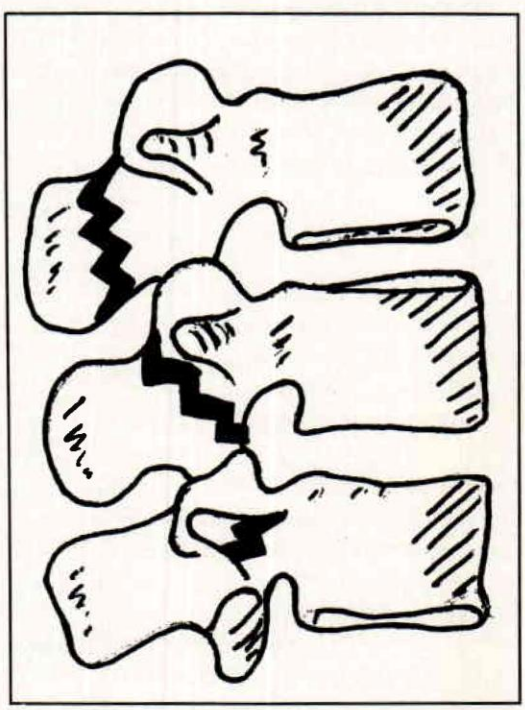

Fig. 2. Diagrams spinous process, pars defect, and transverse process fractures.

Orthotic management with a McCausland chairback or Taylor orthosis, limiting hyperextension, is usually required for the spinous process fracture. Only symptomatic support for the transverse process fracture is necessary, either by a corset or simply bed rest for a few days until comfort is regained.

Overall, there is a general willingness to use the conventional orthosis for these relatively safe injuries.

UNSTABLE SPINE FRACTURES

It is the unstable spine fracture (re: the involvement of the posterior elements and the danger of involvement or compromise to the spinal cord), that causes a major concern. The orthotic management of the unstable spine requires a surety of support. However, it is in the unstable category that conventional orthoses are most inadequate.

The unstable type of thoraco-lumbar spine fractures include the fracture dislocation, severe ligamentous disruption with dislocation, and the "Chance" type fracture.

The fracture dislocation (Fig. 3), with or without neurological involvement, is caused by violent hyperflexion or hyperextension accompanied by rotation, and is almost always treated surgically with open reduction and internal fixation by a Harrington rod, Muerrig-Williams plate or other instrumentation.

This type of fracture is extremely unstable and care must be taken to eliminate motion in all planes. The danger to the spinal cord is obvious and if neurological involvement is not apparent initially, special care must be taken to avoid cord damage.

The "Chance" type, or seat belt fracture, is characterized by the fracture line completely through the vertebra (Fig. 4). Although no gross dislocation is present, the anterior body and posterior elements are involved. The "Chance" fracture,

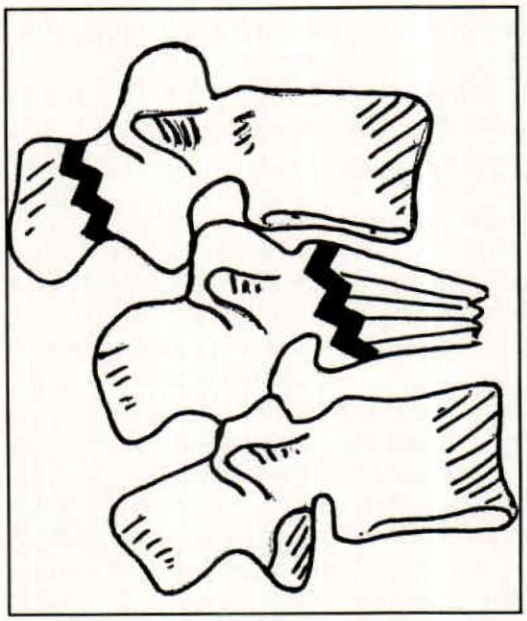

Fig. 3. Diagram of a fracture dislocation.

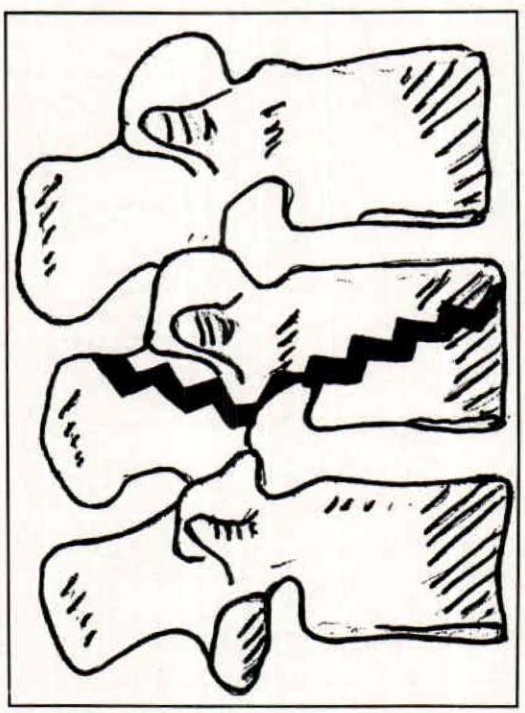

Fig. 4. Diagram of a "Chance" fracture.

usually in the thoraco-lumbar region, is caused by a violent hyperflexion from a vertical force accompanied by a horizontal force. The "Chance" fracture is also unstable. It presents a danger to the spinal cord, and therefore care must be taken to limit motion in all planes.

With no neurological involvement present, internal fixation is not necessary and the "Chance" fracture can be managed conservatively with limitation of motion and unweighting.

At University Medical Center, interest in the orthotic management of the unstable thoraco-lumbar spine fracture, including both the postoperative, internally fixed, fracture dislocation type, and the "Chance" type, led to the development and use of the "total-contact" plastic TLSO.

Orthotic Principles of "Total-Contact" Plastic TLSO

The availability of the thermoplastic material, polypropylene, led to its use in the fabrication of the "total-contact" plastic TLSO incorporating a number of concepts. Added to an expanded use and understanding of the common three-point force concept, and the increases in intra-abdominal pressures were the repositioning of spinal segments; the inductive force, or response of the body's righting reflex as an adjunct to the three-point force system; and distraction, especially costal distraction to aid in the intracavity pressure stabilizing effect.

Repositioning Spinal Segments

The repositioning or flexion of the lumbar segments of the spine is a case in point. Norton and Brown showed that a spinal orthosis of general design with pelvic band and paraspinal uprights, well fitted around the pelvis and to the general contours of the lumbar lordosis when standing, became poorly fitted and offered no support or restriction when bending or sitting (Fig. 5). The natural tilt of the pelvis was altered with the release of the hip flexors, changing the angle of the lumbar posture, and causing poor alignment of the orthosis.

To overcome this orthotic shortcoming, a reduction of the lumbar lordosis is necessary. By repositioning the lumbar spine and reducing the lumbar lordosis in neutral, or when standing, the change in pelvic tilt to the bending and sitting position is negated, and, therefore, does not affect the fit or stabilizing effect of the orthosis.

The total-contact concept of using plastic molded to a repositioned plaster form allows maintenance of the reduced lordotic posture in the orthosis more so than with the conventional orthotic design.

The reduction of the lumbar lordosis also offsets the center of gravity in the sagittal plane, resulting in a natural righting reflex in extension. This reflex is used to augment the three-point force system of orthotic support (2).

Distraction

A usable distractive force on the spine has been demonstrated by Blount with the Milwaukee CTLSO (3). With the total-contact concept of TLSO, the plastic shape molded over a plaster model reflecting an elevated rib cage combined with the reduced or extended lumbar spine, results in a distraction between the lower thoracic and lumbar spine as an adjunct to intracavity pressure and unweighting. With this understanding, a casting procedure was devised.

Plaster Cast Procedure

A plaster cast model, reflecting the pelvis tilted posteriorly, reduced lumbar lordosis, and elevation of the rib cage, is used to mold the plastic total-contact orthosis. The body repositioning required to obtain the plaster cast necessary to

form the plastic orthosis must be tempered by the limitation of movement suggested by the injury.

The unstable fracture, either "Chance" type or postoperative (internally fixed) fracture dislocations, must be treated with special care. The patient confined to bed or Foster frame must be maintained in the horizontal, unweighted position when a cast is taken or an orthosis is fitted.

The cast must be taken with the patient in either a supine position on a Risser table, or in a two-stage supine/prone position on a Foster frame or in bed. The conditions and restrictions placed on patient motion and equipment availability, may dictate the method chosen.

When the Risser table method is used, the cast is taken in a regular circular-wrap manner and bivalved for removal.

The supine/prone casting method, when necessary, is done in two stages. The positioning of the patient in the reduced lordotic posture with hips and knees in flexion is necessary where casting on the frame or bed (Fig. 6).

The patient is rolled or flipped, care being taken to maintain the flexion at hips and the position of the knees, and the opposite side of the cast is applied (Fig. 7).

Plastic Molding

After conventional cast preparation, the plastic is molded in a two-stage procedure, creating a "clam shell" or bivalved opening with overlapping sides for

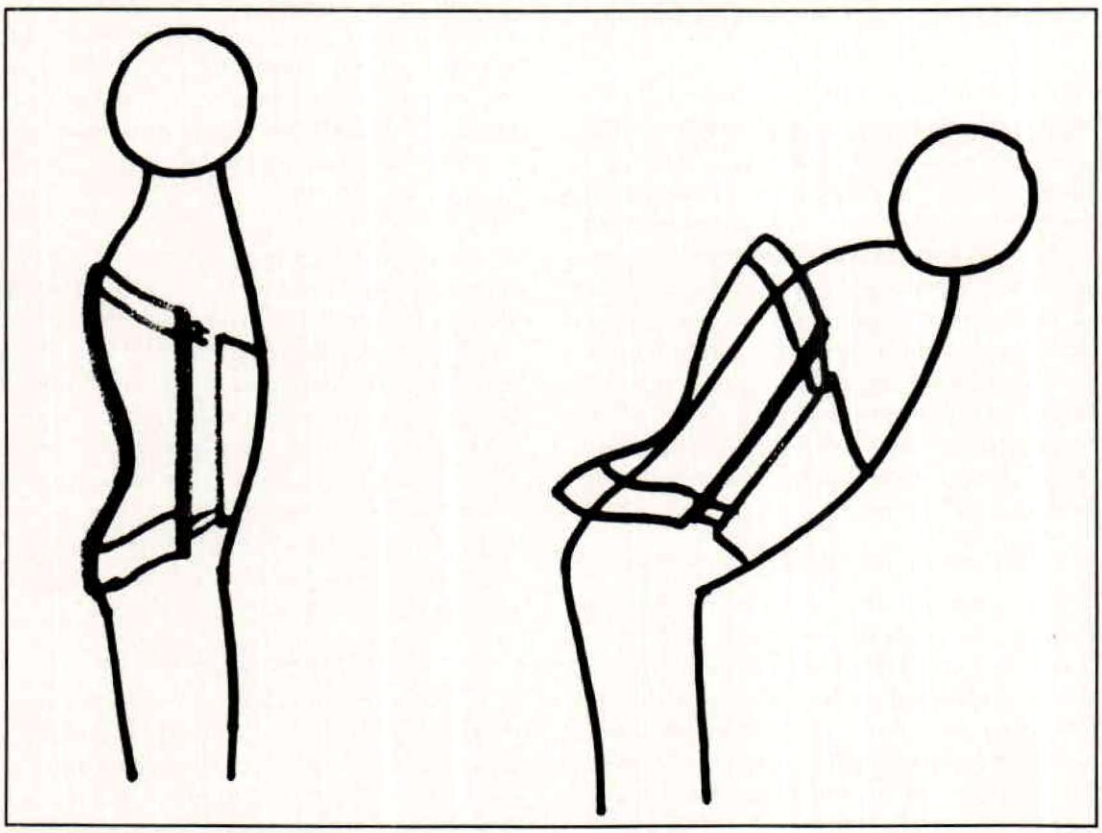

Fig. 5. Diagram showing deficiencies of conventional spinal orthosis as described by Norton and Brown (1).

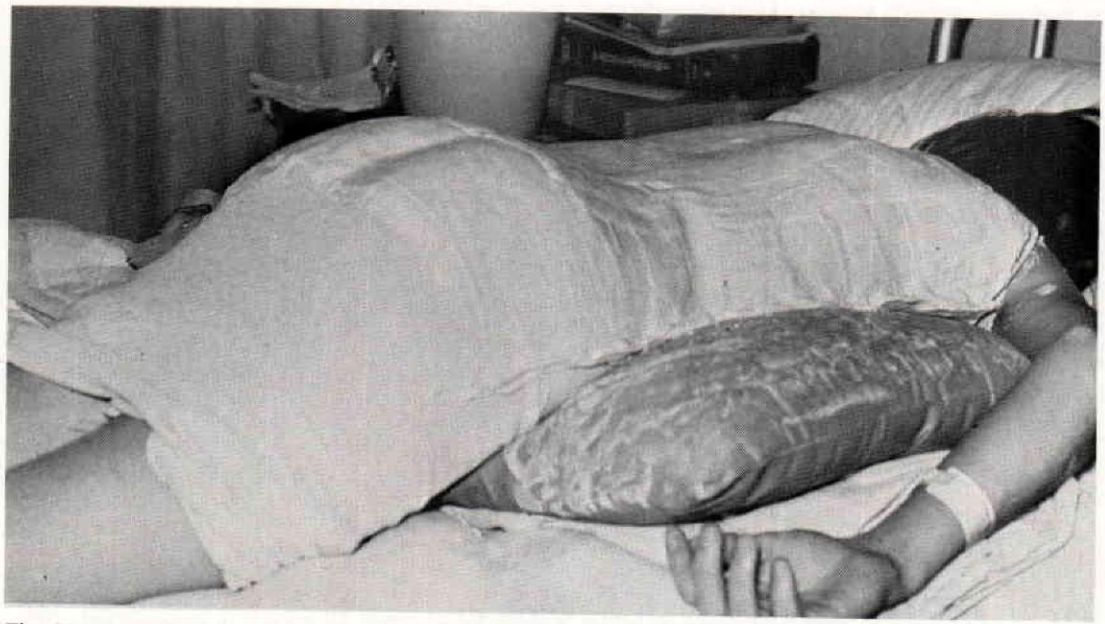

Fig. 6. For casting the patient is placed in a reduced lordotic posture with hips and knees flexed.

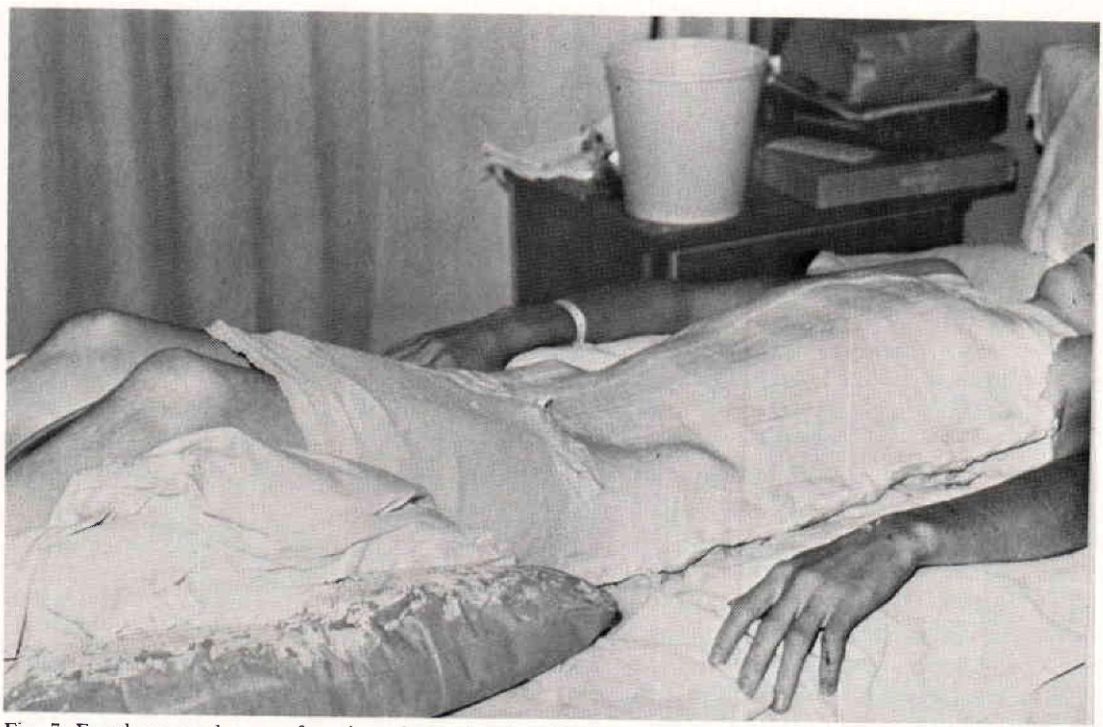

Fig. 7. For the second stage of casting, the patient is rolled into a supine position. The flexion of the hips and knees is maintained.

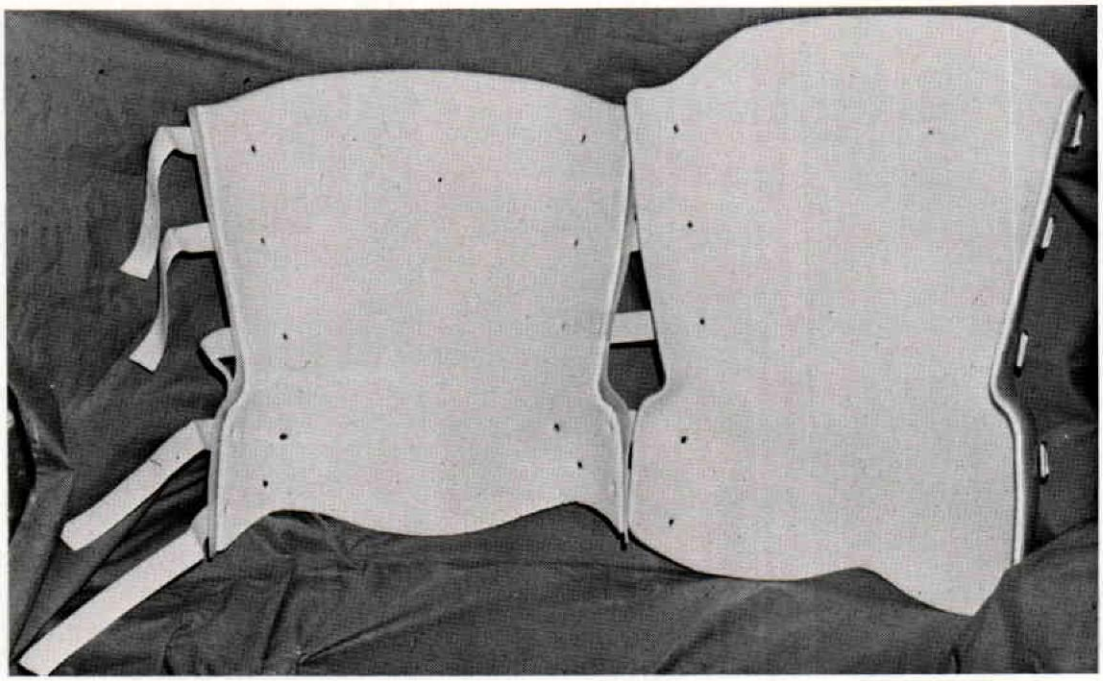

Fig. 8. The total-contact TLSO in the open position.

adjustability.

Pelite foam padding is used inside the jacket with reinforced areas posteriorly at the PSIS and anteriorly at the ASIS and iliac crests. Both halves are connected with Velcro and hook closures for adjustability and secure positioning (Fig. 8).

Plastic Trim

The total-contact plastic TLSO extends from the axilla level of the thorax, superiorly, to the pelvis, inferiorly, allowing flexion of the hips (Fig. 9). The superior trimlines determined by the level of involvement can be reinforced also with shoulder straps to provide stability up to the T_8 level. The molded pelvic section, with reduced lordosis and added support and stability, influences reduced motion to L_3 (see Case 1, presented below).

This total-contact concept also proved advantageous for use with neurologically involved patients. The use of the Jewett hyperextension orthosis to prevent flexion in a patient with reduced sensation in the lower torso presented problems. When sitting, the lack of sensation and proprioception caused flexion to occur over the entire lumbo-sacral-hip joint area and resulted in an unacceptable degree of pressure on the lower abdomen.

The limited area covered by the Jewett pad contributed to this excessive pressure.

With the total-contact device, the stabilizing force is distributed over the entire lower pelvic area, and the flexion can occur at the hip only (Fig. 10).

Rehabilitation and Nursing Advantages

The total-contact TLSO has the following advantages when used to manage the unstable spine fracture.

1. The orthosis is applied by a supine/prone roll and does not necessitate exces-

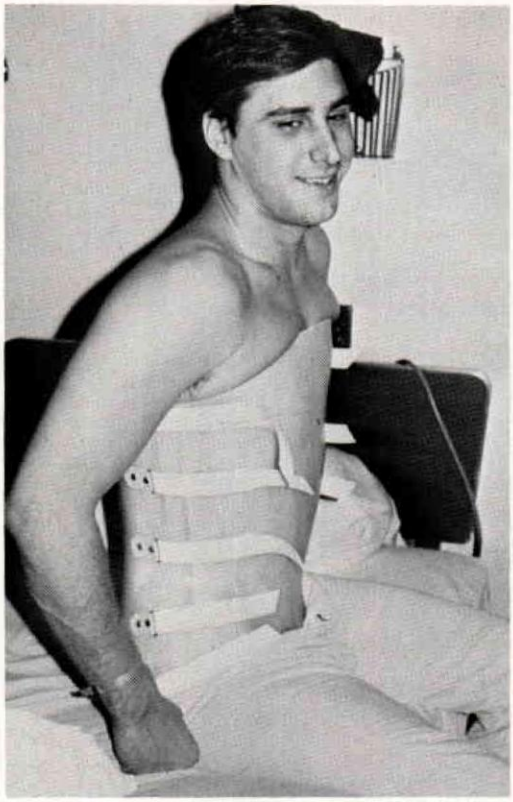

Fig. 9. The total-contact TLSO in position on patient.

sive movement by the patient or motion of the spine. Since the total-contact orthosis follows the body contours so closely, the "guess" in positioning on the patient is lessened.

2. The orthosis can be worn while in bed. Since the posterior section is contoured smoothly to the patient's body and padded with foam to relieve pressure areas, it can be worn while lying supine without the creation of excessive pressure points.

3. Early postoperative or posttrauma rehabilitation and resumption of activities of daily living is an advantage. For the period during which the natural stabilization is occurring, the limitation of motion by the orthosis allows early activity and discharge.

Results

Case Study Number 1

An example of the stability offered by the total contact TLSO is presented with this case study.

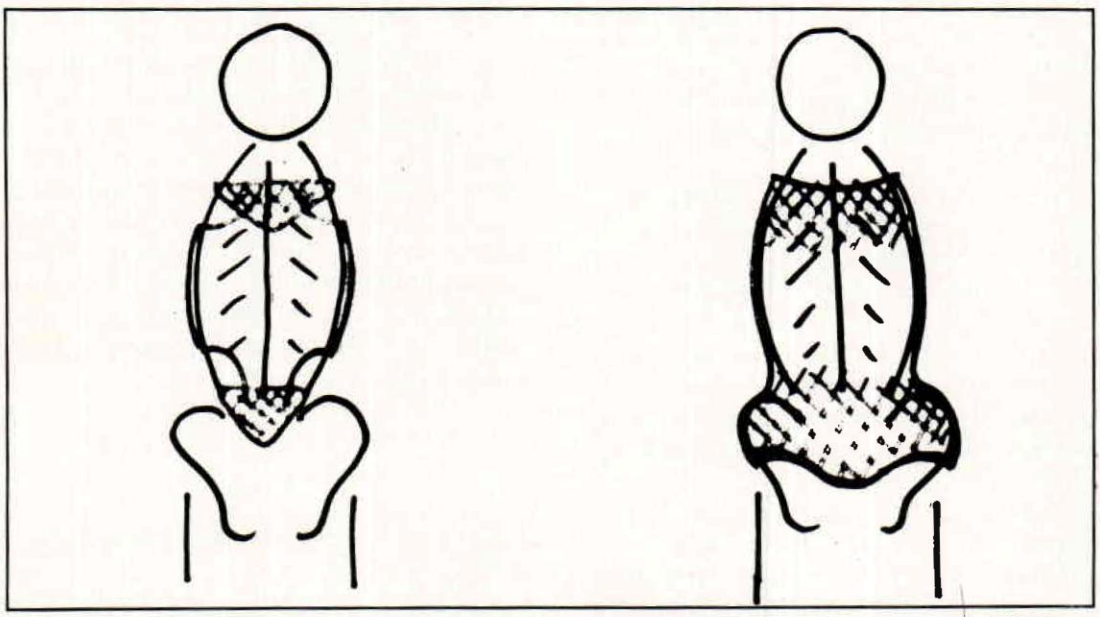

Fig. 10. Diagram showing differences between the Jewett spinal orthosis and the total-contact TLSO orthosis.

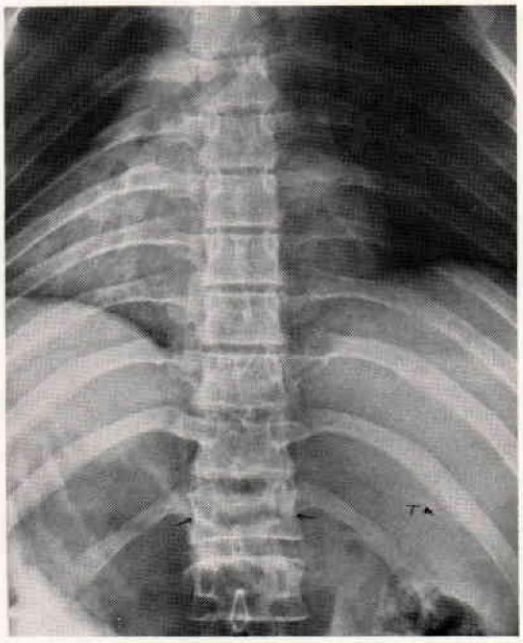

Fig. 11. Initial A-P X-Ray view of Case No. 1.

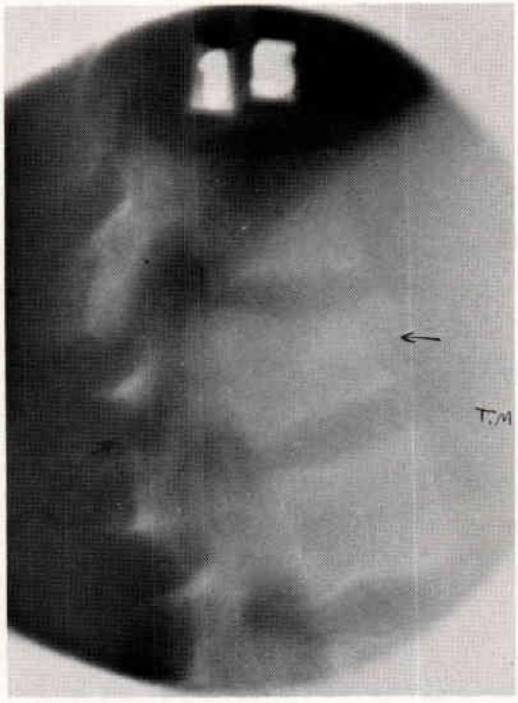

Fig. 12. The lateral tomogram of Case No. 1.

This patient presented with a neurologically intact "Chance" fracture of T_{12}.

The initial A-P X-ray view (Fig. 11) shows the fracture line through T_{12}.

The lateral tomogram (Fig. 12) shows the anterior body and posterior element involvement.

In order to demonstrate the effectiveness of the support and limitation provided by the total-contact TLSO, a series of flexion and extension films were obtained.

Figure 13 is a standing lateral view in neutral in the total-contact TLSO.

Figure 14 is a standing lateral view in forward flexion in the total-contact TLSO.

Figure 15 is a standing lateral view in extension in the total-contact TLSO.

These views were measured. No appreciable motion between T_8 and L_2 was demonstrated.

Conclusion

The "total contact" concepts of:

1. repositioning of the lumbar spine.
2. thoraco-lumbar distraction
3. distribution of force pressures

have been demonstrated relative to support of certain unstable spine fractures.

The "total-contact" TLSO can be applied and worn while maintaining respect for patient immobilization and unweighting. Overall, it has proven to be a worthwhile tool in the management of thoracolumbar spine fractures.

Footnotes

[1]Director of Orthotics, SUNY, Upstate Medical Center, Syracuse, New York.

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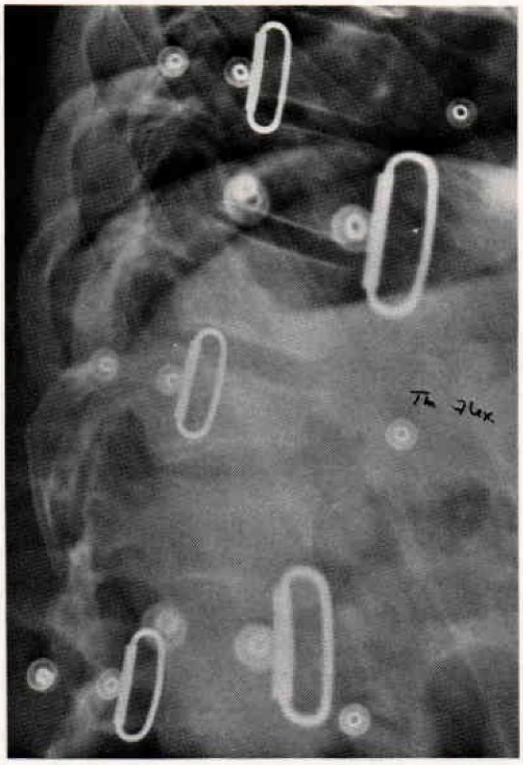

Fig. 13. Standing lateral X-Ray view of Case No. 1 in neutral total-contact TLSO.

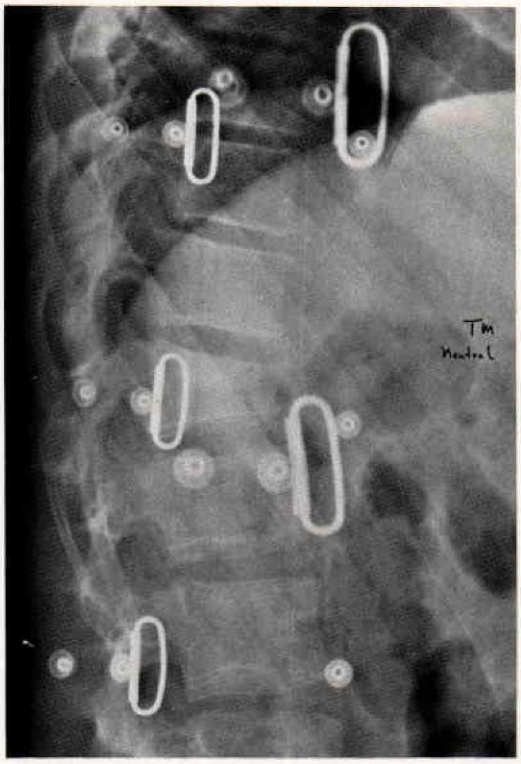

Fig. 14. Standing lateral X-Ray view of Case No. 1 in forward flexion in TLSO.

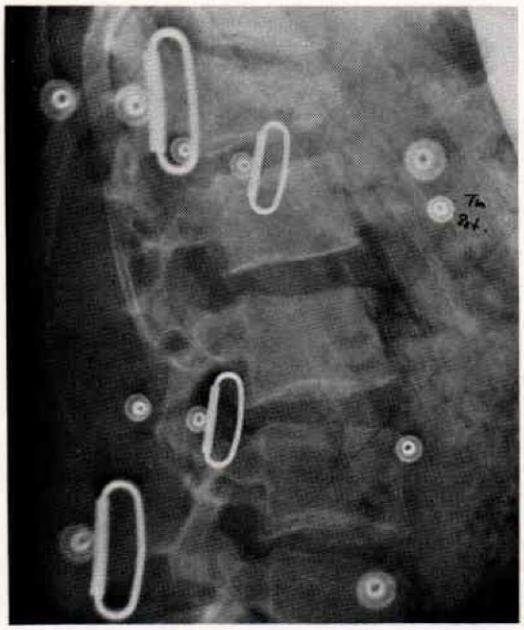

Fig. 15. Standing lateral X-Ray view of Case No. 1 in extension in total-contact TLSO.

[3]Orthopedic Resident, Department of Orthopedic Surgery, SUNY, Upstate Medical Center, Syracuse, New York.

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(3) Blount, W.P., *"Non operative treatment of scoliosis with the Milwaukee brace,"* Manitoba Medical Review, 45: pp 478-480, October 1965.

Orthotics and Prosthetics, Vol. 33, No. 3, pp. 20-24, September 1979

Thermoplastic Body Jackets for Control of Spine after Fusion in Patients with Scoliosis

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KARL FILLAUER, C.P.O.[2]

With the introduction of thermoplastics new applications and techniques are being sought for their utilization in spinal orthotics. One of the most recent applications is replacement of the plaster-of-Paris Risser body cast with a lightweight plastic jacket that has been developed and introduced by Dewey Friddle, C.P.O., Greenville, South Carolina.

The need for such a design which would provide stability, comfort, lightness, cosmesis, allow the wearer hygienic care, and still fit properly during the course of treatment, seemed to be apparent. Our experience in the various designs used for scoliosis, kyphosis, and lordosis orthoses led us to our initial fittings of postfusion body jackets. Several designs and materials have been employed since our initial fittings.

The Design

Our present design consists of a two-piece jacket molded from two to three millimeter-thick thermoplastic material, polypropylene or Subortholen, unlined (Fig. 1). Anteriorly it extends from the symphysis pubic to the sternal notch, with an opening for the breasts and posteriorly from the apex of the buttocks to the spine of the scapulae. The jacket is fabricated over a custom plaster cast of the patient and formed in two lateral shells overlapping anteriorly and posteriorly. The overlapping feature permits adjustment for growth during the average wearing period of nine months. The shells are

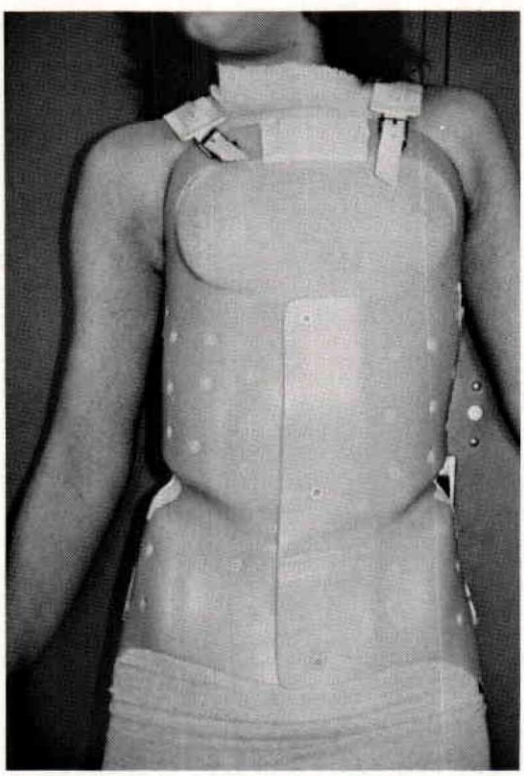

Fig. 1. Two-piece thermoplastic body jacket for control of spine after fusion.

held together with Nyloplex rivets. Shoulder straps connect the posterior and anterior section of the jacket.

Because the jacket is designed to maintain the postsurgical position, not necessarily to correct it further, cast modifications are less drastic or severe than for a TLSO design.

Plaster Wrap

Both presurgical and postsurgical plaster molds have been employed. The presurgical impression is easier to take. When the cast is made postsurgically it is essential to compare the patient's cast to the achieved curve reduction and resultant increase in thoracic length. We have found that presurgical and postsurgical contours vary greatly and, hence, we now prefer the following technique.

Our method for postfusion casting is simple and is performed in the patient's bed three to four days after surgery. While the patient is in a supine position, a cotton stockinet is applied carefully over the torso. The waist, ASIS, symphysis pubis, sternal notch, prominent ribs, and breasts are identified and marked with an indelible pencil (Fig. 2).

Plaster splints, 8 to 15 layers in thickness, are applied extending from symphysis pubis to sternal notch and laterally to midline (Fig. 3). After the plaster has set the patient is "log-rolled" to a prone position. The thick anterior section minimizes distortion that might take place as the patient is rolled over. Vaseline is applied to the edges of the plaster shell. The posterior section is applied to extend from the C-7 level to the gluteal fold and to overlap the anterior shell laterally by at least one inch. Five to eight layers of plaster are needed for this section. After the plaster has set, key marks are scribed onto the two halves, the posterior section is pried loose, and the stockinet cut for re-

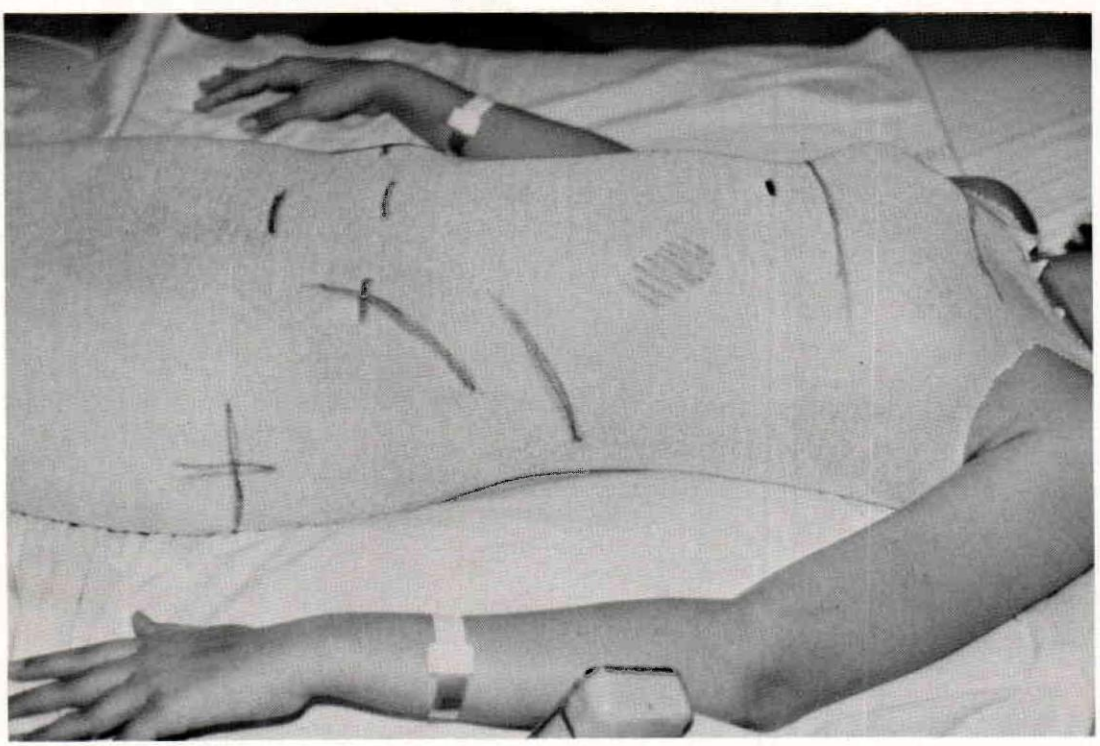

Fig. 2. Prior to casting the waist, ASIS, symphysis pubis, sternal notch, prominent ribs, and breasts are identified and marked on the cotton stockinet that covers the torso.

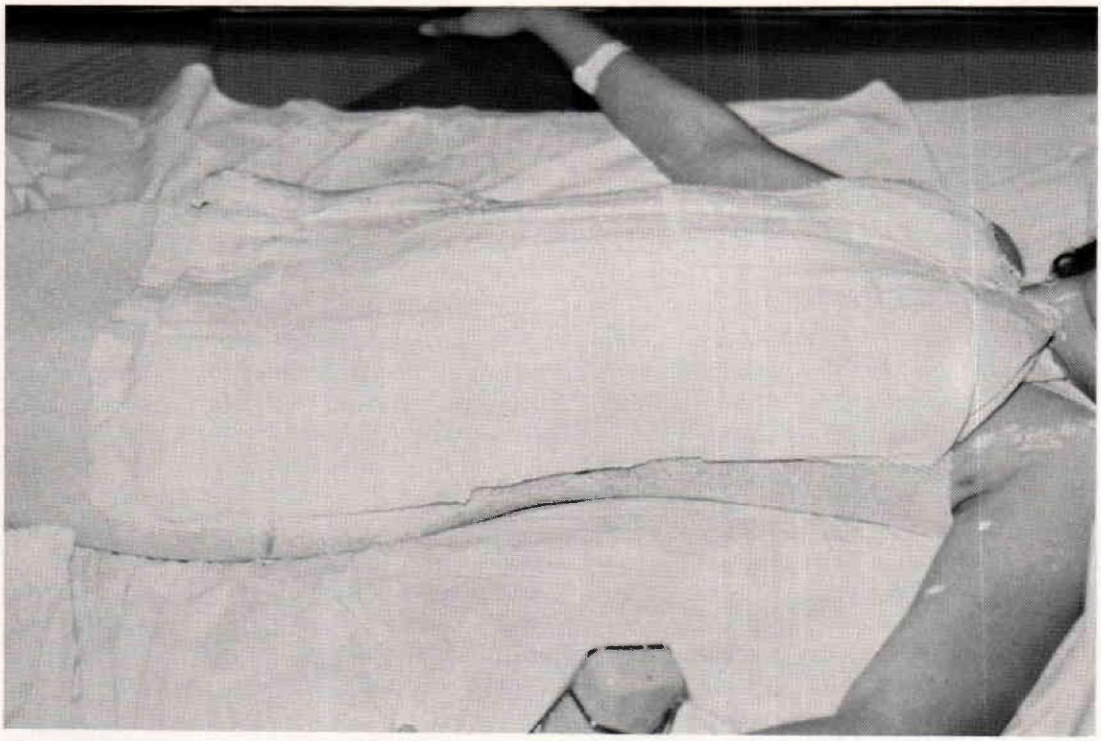

Fig. 3. Plaster splints, 8 - 15 layers in thickness, are applied to the anterior portion of the torso.

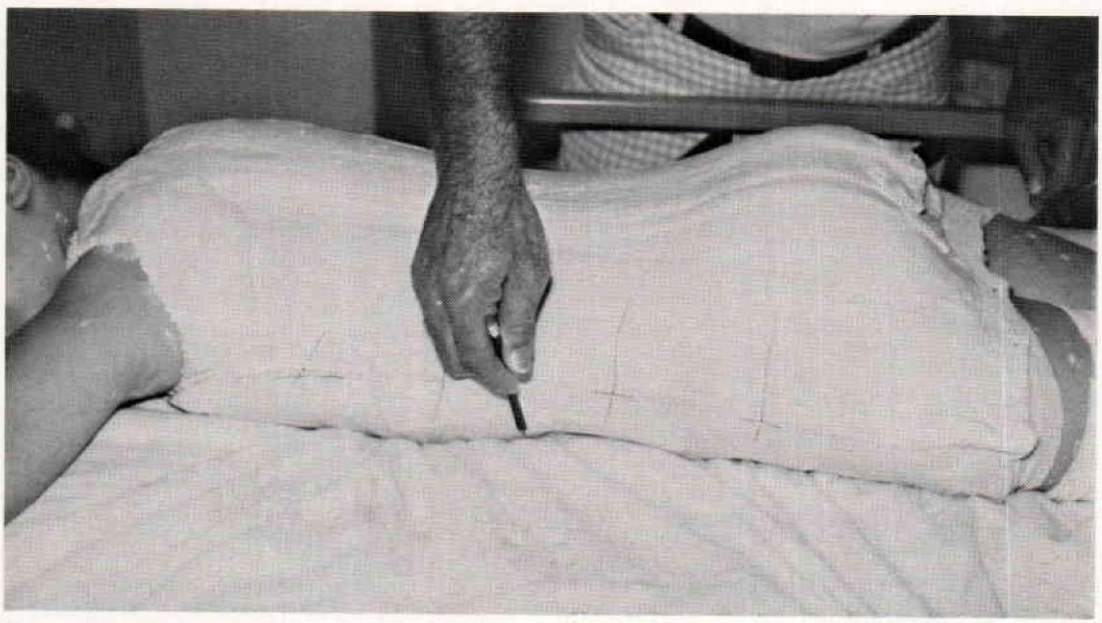

Fig. 4. Key marks are inscribed on the edges of the two halves of the plaster after it has set so that proper alignment can be maintained when the cast is poured.

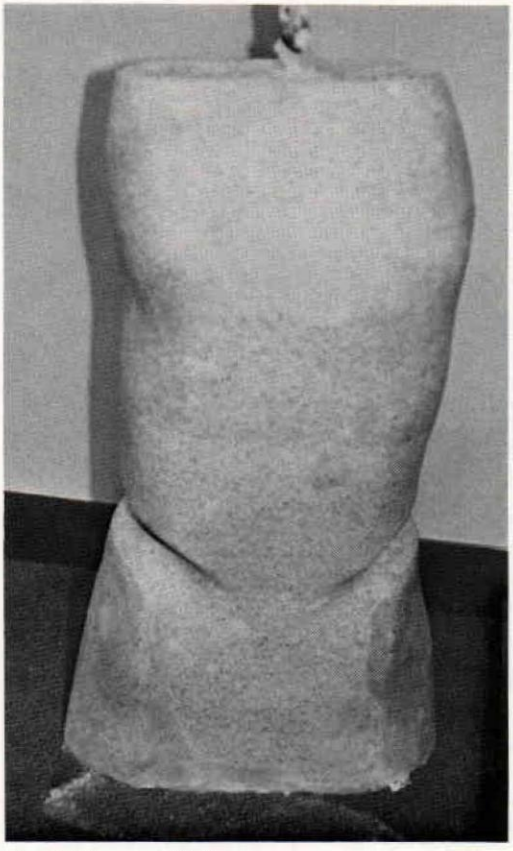

Fig. 5. The modified cast.

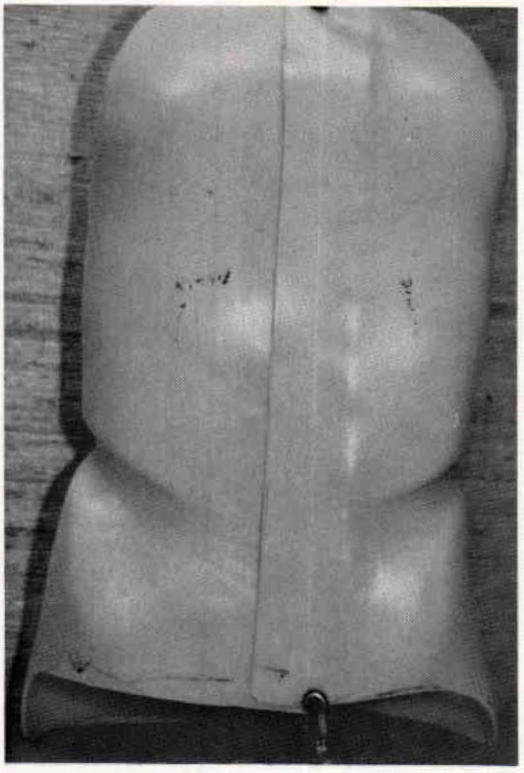

Fig. 6. Initial trimming of the orthosis is conservative.

moval of the posterior shell (Fig. 4). The patient is "log-rolled" into the supine position and the anterior half is removed.

The sections are now realigned and secured together with plaster bandage. Cast modifications similar to those used in fabrication of a TLSO or a Milwaukee pelvic section are carried out (Fig. 5).

Fabrication

Depending on the material selected either drape forming or vacuum forming techniques may be used. Initial trimming is conservative leaving the module long and untrimmed for the breast area (Fig. 6). We have found that for best results the module is applied to the patient and the desired trim lines are marked on the jacket. Donning the jacket is accomplished by having the patient roll to one side and applying one section and then roll to the opposite side and applying the other section. The two halves are temporarily held with tape (Figs. 7 and 8).

Fitting

The jacket is applied six to eight days after surgery over a cotton stockinet which can be removed for bathing. The jacket is taped together and worn for at least 24 hours, in order to allow for removal under a nurse's supervision if the initial fit requires alteration. The patient is allowed to sit and walk immediately with nurse supervision. Discharge is permitted one to two days after the delivery of the jacket and the tape closure is replaced with Nyloplex rivets (Fig. 1).

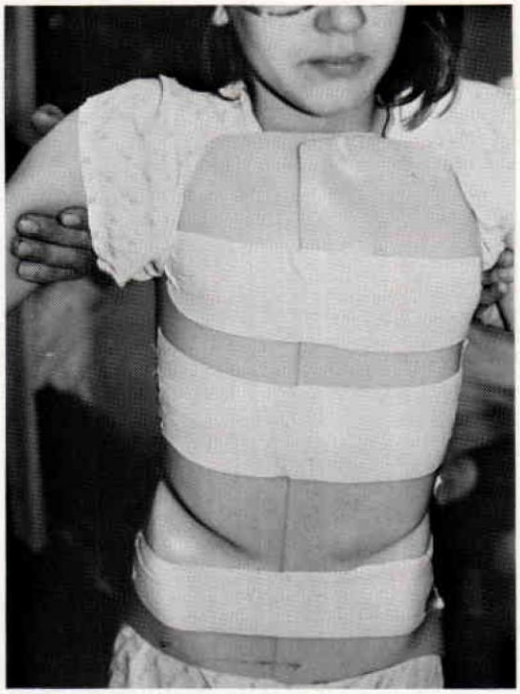

Fig. 7. Anterior view of orthosis being held in place with tape during fitting process.

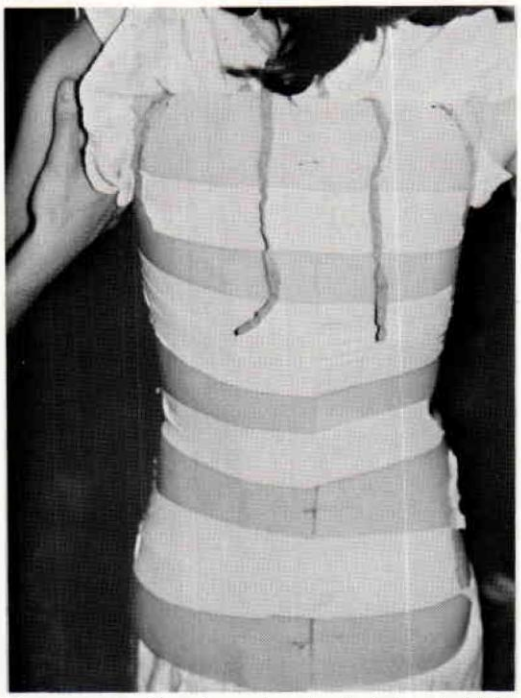

Fig. 8. Posterior view of orthosis being held in place with tape during the fitting process.

Results

To date we have fitted more than 30 postfusion jackets. We have employed various materials, with various thicknesses and trim lines, and have found certain advantages in Subortholen. This material lends itself well for this application due to its strength, malleability, and durability. Early jackets were of two-millimeter thick polypropylene that required vacuum-forming equipment. We feel that polypropylene's strength is satisfactory, but its workability does not compare to that of Subortholen for this use.

Because a liner is not used, the patient may remove the stockinet without removing the jacket and bathe.

Clinically, our results are promising, and radiographically comparable to conventional plaster Risser casts. The weight difference between the Risser cast, about 20 pounds versus a 2-pound plastic jacket, need not be elaborated upon. We currently feel that the advantages of this system far outweigh the few difficulties we have had. There are two primary problems that we still have to contend with: 1) the jacket tends to migrate superiorly, and 2) several cases of heat rash have occurred, which we feel are the result of inadequate ventilation.

We intend to follow this report later by recording one-year postfusion results. To date we have been recording age, sex, casting technique (preoperative or postoperative), material used, thickness of the material, initial postoperative degree of curvature, and one year postoperative curvature for each patient.

Footnotes

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Orthotics and Prosthetics, Vol. 33, No. 3, pp. 25-31, September 1979

Electrical Power-Assisted Seat Lift: Is It Helpful? An Appraisal of Its Function

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This study was carried out to determine the desirability of power-assisted chairs for medical purposes. There seems to be wide public interest in such devices, especially among the geriatric population. Because these chairs are expensive, they could be a significant economic consideration in the provision of health care.

A survey of medical literature reveals that power-assisted chairs to aid individuals with various disabilities in rising from seated positions have been manufactured since 1939. Early models were experimental and designed for individuals with specific disabilities who had difficulty in rising from a standard chair. Young, in 1949, described an early model of a power-assisted chair that was activated by springs (1). Another model had been used by a patient with muscular dystrophy ten years prior to Young's 1949 report. At that time, there was no commercial manufacturer of power-assisted chairs. However, in recent years, there has been an increasing number of manufacturers of motor driven, power-assisted chairs. At least three companies have advertised in the United States medical and lay literature: Burke, Inc., American Stair-Glide, and Ortho-Kinetics, Inc. Whether the system is named power-assisted chair, elevating system, electrically-activated seat, and whether the specific lifting mechanism is a pneumatic bladder or a linkage system, the goal is the same: to assist the disabled individual to rise by use of mechanically elevating seats.

Automatic chairs are becoming increasingly popular among the public. Manufacturers and physicians claim that certain patients, such as those afflicted with arthritis, Parkinsonism, stroke, and other paralytic conditions, are benefited by the power-assisted chair seat. Our study was undertaken to verify, by experimental techniques, the claims of the manufacturer and reasons for acceptance by the public.

Description of Chairs

The chair, originally described by Young (1), resembled a dining room chair with a spring mechanism concealed in the arm rests. The seat tilted forward through a hinge located several inches in front of the chair at the seat level. In the lowered position, the seat gave an initial upward boost of about forty pounds, sufficient to allow the patient to arise with ease and the number of springs and tension were varied to suit requirements of

the individual patient. The present day electric models of elevating chairs vary in their lifting mechanisms and degree of angulation of lift in the elevated position, and have the same assisting lift concept as the mechanical chair described by Young. Some chairs simply tilt the seat cushion forward as the hinge is located at the lower front edge of the seat (Burke). Others, by means of a linkage system, raise the seat vertically a few inches before significant tilting begins (Ortho-Kinetics and American Stair-Glide). The Burke chair seat is elevated by a pneumatic cushion. When activated, an electric motor compressor combination fills an air bladder which gently lifts the cushion upward and forward. Control is provided by a constant-pressure switch which, when released, stops the chair seat at any angle between horizontal and about 60 deg of angulation. A valve is used to control escape of the air from the bladder allowing the seat to return slowly to a lowered position.

Ortho-Kinetic and American Stair-Glide chairs have an electric motor and linkage system to elevate the seat. The linkage system can be adjusted to provide several degrees of angulation of the elevating seat to permit the user to select the most useful angle. A constant-pressure switch can stop the raising or lowering of the seat in any position and the angle of the seat back can be adjusted by a crank screw. These chairs rise slightly more rapidly than the Burke chair and do not have the slow cushion descent of the Burke seat. All three of the chairs are made of various materials and different colors. They can be adjusted to fit persons with long or short legs by changing height.

Methods

Four methods of evaluation were used.

1) *Electromyography.* Electromyography of selected thigh muscles was used to determine activity during rising and sitting. The electromyograph used was the TECA 4 with high speed paper recording. Muscles studies were made of the rectus femoris and vastus medialis, using surface electrodes. The rationale for this study was that reduction in muscle contraction during the lifting phase of the chair should reduce stresses on the knee joint.

2) *Angular Displacement of the Knee During Power-Assist.* A goniometer similar to the one described by McLeod and Kettlekamp (2) was used at the knee. It consisted of an elastic knee support with medial and lateral hinged metal staves. A potentiometer measured movements of the knee joint in the sagittal plane, which were recorded on electrocardiographic paper. The rationale for this was that angular displacement of the knee should be increased by the seat lift without muscle assistance.

3) *Percentage Body Weight Shift Using an Electronic Scale.* With a subject in the seated position, a recording of weight upon the feet is obtained as the subject is power-lifted and assumes the standing position. The weight upon the feet of a properly seated subject is approximately 12 percent of body weight. As the subject rises, the weight on the scale increases to 100 percent of body weight. The rationale for this study was that the greater the percentage of body weight shift by the chair, the less energy was needed by the patient to rise. The electronic scale to measure weight shift consisted of four force transducers and associated electronic circuitry to convert electrical energy into weight. Body weight shift upon the feet was calibrated in terms of percentage weight transfer of the subject during rising. Recordings were made on electrocardiographic paper.

4) *Survey of Patients Using the Chairs.* This was a questionnaire and telephone survey of patients who had owned the

chairs for at least two years, asking questions regarding effectiveness in helping the disorder, mechanical problems encountered, subjective opinion regarding appearance, controls, etc. Five hundred questionnaires were sent to randomly selected owners who bought the chair in 1975, and thirty telephone calls were made on a random basis to purchasers living near Kansas City.

Test subjects for the measurement methods were seven healthy adult male and female volunteers weighing between 140 and 175 pounds. Electromyographic recordings from the front of the thigh, knee action and weight shift were all recorded, having the test subject rise and lower himself in the chairs with and without the external power. Upper limbs were not used during the act of standing. Figure 1 illustrates the recording system with the subject rising from the chair.

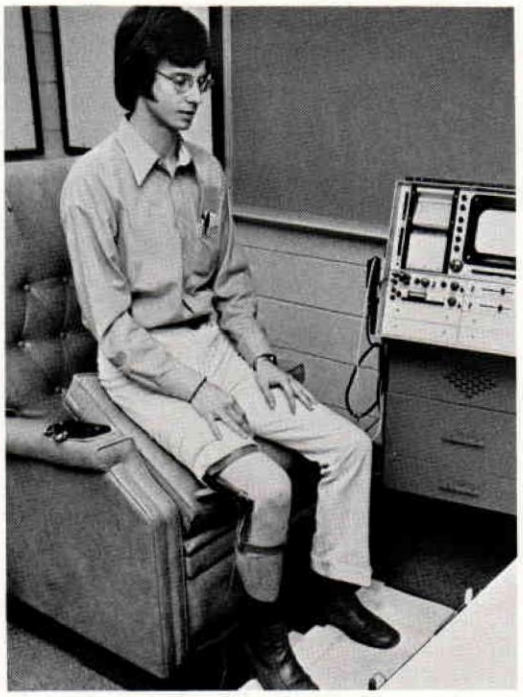

Fig. 1. Subject and recording system.

Results

1) *Electromyography.* Electrical activity from anterior thigh during standing was recorded for all subjects. The voltages from the electromyographic recordings were consistently 50 percent greater when the subject was rising under his own power than when assisted by the chairs. However, duration of the electromyographic activity was several times longer when using motor-assist than when rising to stand unassisted. Significant electromyographic recording still occurred after the motor stopped, indicating quadriceps muscles were required during the final phase of standing from all chairs. Electromyographic results were similar in all chairs except for total duration of electromyographic activity. Duration ranged from ten seconds for the seats with linkages to thirty seconds for the pneumatic seat.

2) *Knee Goniometry.* In the sitting position, the knee angle was such that the standing required exactly 90 deg of motion to assume upright posture. The main result with power-assist was to help subjects extend through 15-40 deg of the 90 deg required. This assistance occurred during the initial phase of the act. The remaining motion as noted by the electromyographic recordings had to be achieved by the subject's own muscles. In regard to knee extension, the Ortho-Kinetic chair performed better than the other two models as shown in Figure 2.

3) *Body Weight Shift on an Electronic Scale.* Although the three chairs use different mechanisms to shift body weight to the feet, the overall ability to actually accomplish this was quite limited (Figure 3). The chairs were capable of shifting the subject in such a manner that 15-30 percent of his total weight was transferred to the feet when the motor completed its

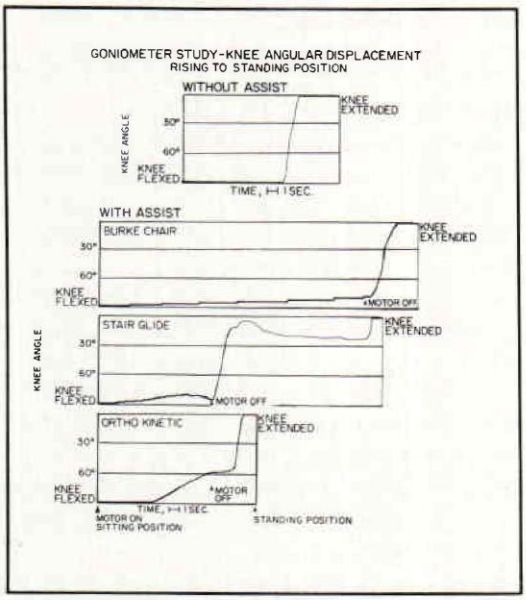

Fig. 2. Goniometer study

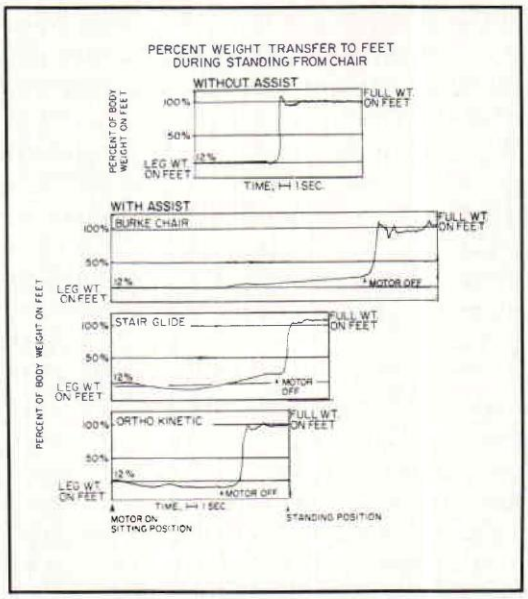

Fig. 3. Weight-shift study

cycle. Therefore, subjects had to perform the remaining of the 70-85 percent weight shift using their own muscles. Without assistance, the act of standing requires shifting somewhat less than 90 percent of body weight. It takes one second for a subject to rise to a standing position unassisted. Motor-assisted chairs shifted weight over a period of fifteen to thirty seconds, as observed in this study.

4) *Survey of Users.* Questionnaires and survey which was started late in the study had a very satisfactory response of 216 (43.2 percent) out of 500. It was conducted on patients who had purchased the Burke Chair in 1975. Those using the chair ranged from 21 to 99 years of age with a majority of 64.5 percent over the age of 60. Mean age was 72 years of age. The slightly higher ratio of females to males, 124:92, probably reflected the increased number of females in this age group. Most patients had used the chair for at least 24 months and some for up to 33 months. We found the commonest reason for purchase of the chair was arthritis, 131 out of 215, or 60.7 percent. This was closely followed by patients with Parkinsonism, stroke and fractures as shown in table 1. It is notable that four major disease categories, arthritis, Parkinsonism, stroke and fractures of the lower limb accounted for almost all of the users. Although 42, or 20 percent, reported multiple medical problems, presumably these four major disorders accounted for the primary reason for purchase in almost all cases. 166, or 76.8 percent of the respondents were still using the chair. The usefulness of the chair was reflected in how frequently the patients were using it, as also shown in Table 1. Those not using the chair were mostly patients who had died or had improved in their medical condition. Very few were not using it because of dissatisfaction and this was reflected in some very favorable comments. Actually, only four out of the entire survey said that the chair was undesirable.

A telephone survey produced a very similar result. 14 out of 30 randomly se-

lected patients were reached by telephone and diagnoses were similar as shown in Table 1. Ten of these patients were using the chair frequently and were very favorably impressed.

Other comments from the survey were of interest. Mechanical or service problems were only mentioned by three patients on both surveys. Many commented favorably on the benefit to family as it assisted the aged relative in keeping him more mobile and less assistance was needed in his care by the family.

Discussion

This study was carried out to determine the value of these chairs as a medical piece of equipment rather than a specialized piece of furniture or special gadget. In determining the effects of the chairs, it was important to make a comparison between mechanical chairs and normal chairs when standing without assistance. Goniometry tracings (top of Figure 2) suggest a smooth, rapid, unlabored knee motion during normal standing. The efficient way of rising unassisted requires a center of gravity to move forward with feet placed slightly under the chair, one slightly ahead of the other. The individual then bends forward from the hips, placing the center of gravity over the feet and then rising by contracting extensor muscles. Sitting is the reverse of this, but in addition requires the hip and knee extensor muscles to exert undue stress on the knee joints. Smidt (3) points out that shear forces on the knees are probably maximal when the flexed knee is loaded as during rising or sitting down. Thus, it might be particularly important to unload the painful knee of the arthritic patient during the first phase of standing. This would be one purpose in using the power-assisted chair as it could encourage the arthritic to stand up more often.

There are other acts of motion, when standing and sitting, which can modify to some degree lower limb joint motion and muscle action and duration of transfer. These motions include head positioning, upper limb assistance, arm positioning, back extensor muscle contraction, and ankle motion. Any abnormal movements, as in spasticity or ataxia or lack of certain movements as in joint ankylosis will change the act of sitting and rising, hampering these maneuvers. A power-assisted chair might assist or substitute for these trunk and arm motions.

In normal sitting, these chairs provide assistance of less than 30 percent of the actual standing and only one-third of the decrease in the knee movement required for rising. Three quantitative studies concur with our personal observations on motions that normal subjects undertake to complete the action of standing. Electromyographic studies, when the power-assisted chair is used, indicated the maximum level of quadriceps contraction is lower than when standing unassisted. Since it is stress across the knee joints which produces pain in arthritis, this suggests that slow speed of sitting allowed by this chair may also be important in the arthritic. The results of the knee goniometry study shows that the knee motion is possibly helped more than percentage of weight shift. This would also suggest that patients with arthritis of the knee would benefit from these chairs.

The Body Weight Shift Transfer Study indicated that weight is not significantly shifted by the mechanical action. Therefore, patients with significant paralysis might not complete the final weight shift necessary to stand when using these chairs. That is, such patients still need muscle contraction to complete the motion. One might conclude that arthritic patients would gain more from using these chairs than paralyzed patients. Although our clinical experience with paralyzed patients and these chairs has been

limited, we have a definite impression that patients with serious leg paralysis did not feel the chairs were particularly helpful.

The survey of users did not confirm or seem to respond with our attempt to quantitate the assistive functions of the chair. In general, those responding were very enthusiastic about the chair. As might be expected, the largest users of the chair are patients with arthritis. It seems, in some instances, the chair may serve as a stimulus to further exercise to the patient. Some patients with fractured hips, for example, stopped using the chair's assisting feature as strength returned in their thigh muscles following the fracture.

Although the survey could be criticized for its incompletion, in our opinion 216 replies out of 500 is an acceptable response from this type of mailed questionnaire. Further studies may be indicated to find out the appeal of these chairs such as the importance of initiating motion or psychological factors. Subjective reaction by the patients and staff in the Rehabilitation Medicine Department were that the Burke Chair seemed to take longer to elevate but had the desirable feature of lowering the patient slowly. The American Stair-Glide Chair was perhaps a little more versatile and quieter than the other two. Of the three chairs, the Ortho-Kinetic Chair was the best as far as the actual assistance with knee angle correction, but it was considered the least desirable as it was quite noisy and did not have as attractive an appearance as the other two chairs.

Conclusions and Summary

Measurements made in this study did not support the claims of the manufacturers that their chairs have a very significant effect in assisting certain categories of patients rising from the sitting position. Probably, the most significant help is in two categories of patients—those with arthritis and Parkinson's disease and, according to the survey, those with lower limb fractures and strokes also find them useful. The power-assisted chairs relieve stresses on the knee during early standing for the arthritic. They presumably initiate motion for the Parkinson's disease patient who has great difficulty adjusting the center of gravity over his base of support. We would stress that the chairs are most effective when they are individually fitted. Because persons vary in height and weight, suppliers should make proper measurements to insure optimal sitting on the seat for the users. As there are such differences between the observed mechanical effects and the acceptance by the users of these chairs, further studies of psychological effects or simply the initiation of motion provided by the lift in these chairs needs to be further investigated.

The authors would like to express their thanks to Burke, Inc., P.O. Box 1064, Mission, Kansas, for their helpful cooperation and financial assistance in this project and to American Stair-Glide and Ortho-Kinetics Companies for letting us borrow their chairs for this study. We would also like to express gratitude to Mr. Steve Goldman, osteopathic student, for his help with electromyography and assessments.

Footnotes

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TABLE I

Response to Mail Survey of Chair Users—216 of 500 Questionnaires.

Age Group	No.	Diagnosis	No.	Utilization	No.	Comments	No.
Age Unknown	10	Arthritis	131	Often or as needed	134	Very favorable	116
Under 39	3	Parkinsonism	30	Under 4-5 times daily	28	"Helpful" or	
40 - 49	6	Stroke	30	Only 1-2 times daily	13	"No comment"	96
50 - 59	27	Fracture	24	Never or rarely	24	Unfavorable	4
60 - 69	37	Cardiac Disease	16	Response not clear	17		
70 - 79	71	Muscular Dystrophy	8		216		
80 - 89	54	Multiple Sclerosis	6				
Over 90	8	Other	14				
			258				
	216	Multiple problems including those above	42				

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Orthotics and Prosthetics, Vol. 33, No. 3, pp. 32-39, September 1979

The Diabetic Patient: Orthotic Considerations

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The orthotist plays an important role in the care of the diabetic patient, especially in the treatment of the major complications presented by the insufficient vascularity and neural function associated with diabetic neuropathy. These diabetic complications, including muscle weakness of the extremities and decreased protective sensation of the skin and joints of the foot, require expert orthotic management.

History of Diabetes

That diabetes is caused by the inability of the pancreas to produce the natural insulin needed for proper body metabolism is perhaps the one fact agreed upon by most authorities in the literature.

Controversy remains on most all other areas, including etiology and treatment, and, although diabetes has been recognized for centuries, these controversies still exist.

The name "diabetes" was first introduced by a Roman physician, and accounts of the disease were recorded as early as 1500 B.C. While references to diabetes mellitus in early medical writing are few, it is not surprising, in view of the late-in-life onset of the disease and the short life expectancy in early times.

Clinical interest in the complications of diabetes began in the late 19th century, with the increasing age of the population and the development of clinical biochemistry.

The discovery of insulin in 1921 allowed the successful treatment of acute manifestation of the disease, and although this development offered hope to those affected, it also presented a greater survival rate of the diabetic population and a greater preponderance of diabetic complications.

Prior to 1921, the average duration of life after onset of diabetes, was 1.3 years for those with onset under age 10; 2.7 years for those with onset between ages 10 and 19; and 4.3 years for those with onset between ages 20-29. In contrast, comparison figures in 1968 were 29.8, 26.7, and 27.2 years, respectively (1).

However, almost 60 years after the development of insulin, the exact cause of the disease is still unknown, even though, in the last two or three decades, interest in diabetes and recognition of related physical and social problems have been greatly intensified.

It is estimated that in the U.S. at least 2 percent of the population, or 4,000,000 people, have diabetes. It is estimated further that in the U.S. probably 50,000,000 persons now living, either have diabetes, will develop diabetes, or have a diabetic relative.

The impact of the disease as a public health problem becomes more apparent

when one considers the medical and social complications of long term diabetes. These complications lead to marked disability due to involvements in the brain, eyes, heart, kidneys, and the limbs.

Classifications of Diabetes

Diabetes can be classified into two distinct types, I, Hereditary and II, Non-Hereditary, with the hereditary classification the most predominant. The non-hereditary type can be broken down further into juvenile and adult types.

Juvenile Onset

The growth or juvenile onset type is unstable from the beginning. The onset is often abrupt, usually with diabetic coma as the first indication of the disease. This type of diabetes is prone to ketoacidosis (the inability of the body to overcome the disruption in metabolism), and is dependent on insulin for control.

Adult Onset

The maturity or adult onset type is by contrast stable and more difficult to diagnose immediately, or even to establish a date of onset, which usually occurs after age 40. Coma and keto-acidosis is usually achieved by dietary restriction, with or without insulin.

The slow onset of the disease must be recognized and treated, and satisfactory control is dependent upon patient understanding and cooperation. The relative mildness of onset is at times the forewarning to development of other major characteristic complications.

Diabetic Complications

There are three major characteristic complications, a) diabetic retinopathy, b) nephropathy, and c) neuropathy.

Diabetic retinopathy, or vascular disease of the retina, is one of the more serious complications of diabetes. It is estimated that 2 percent of the diabetic population suffers blindness due to retinopathy. There is no known cure, and the pathogenises of the condition remains obscure.

Diabetic nephropathy, or renal vascular disease, is also a serious complication, and the resultant kidney dysfunction is a cause of death in diabetics.

Diabetic neuropathy, or vascular insufficiency and derangement of metabolism in the peripheral nerves, can lead to catastrophic complications of diabetes. These are the complications which especially lend themselves to Orthotic/Prosthetic management.

Diabetic neuropathy is a common name for several disorders of the peripheral nervous system. The conditions involving the lower limbs include: 1) polyneuropathy, 2) mononeuropathy, 3) arthropathy, 4) amyotrophy, and 6) diabetic cold feet.

1. Polyneuropathy, the most common variant of diabetic neuropathy, begins with sensory impairment, in a stocking effect (beginning at the feet and moving upward), followed by numbness and stiffness of the limb. Motor symptoms, weakness, poor proprioception, and trophic changes including Charcot joints, also occur.

2. In mononeuropathy, the nerve most frequently involved is the common peroneal.

3. In arthropathy, both sensory and autonomic nerves of the joint are involved. A variety of changes occur in the joint, initially painful but later with painless destructive lesions.

4. Anhidrosis, a specific syndrome involving the autonomic nerves, causes excessive sweating over the upper body, but a total absence of sweating below the waist resulting in dry, cracking feet and legs.

5. Amyotrophy, with the occurrence of proximal muscle weakness of the lower

limbs associated with extensor-plantar response. Pain, weakness, and weight loss, but without objective sensory loss occurs in the iliopsoas and quadriceps group.

6. Diabetic cold feet, an early manifestation of an alteration of symphatic control of the blood vessels, marked by bluish lower limbs.

In general, the outlook for recovery from the various forms of diabetic neuropathy varies. Although mild motor weakness and slight insensitivity persists, complete recovery from polyneuropathy is expected. On the whole, recovery from mononeuropathy is also expected, although when severe, collateral circulation may not be adequate. The outlook is less than satisfactory for amyotrophy. While recovery of clinical function may take a few years, the neuropathic foot remains insensitive and the Charcot joint suffers recurrent trauma, and the outlook is poor.

Treatment

Treatment of diabetic neuropathy is based mainly on relief of symptoms, with measures taken to prevent increased complications. Continued control of the diabetes by diet and appropriate doses of insulin are necessary, and during the acute and painful phases of mononeuropathy and amyotrophy, bed rest and passive exercises are helpful.

It is in the postacute stages that orthotic management is necessary. Insensitive feet, Charcot joints, and muscle weakness, are all complications of diabetic neuropathy requiring orthotic management and treatment.

Insensitive Feet

The major complication, and perhaps the most significant orthotic consideration in diabetic neuropathy is decreased protective sensation of the foot.

Hemodynamically poorly placed and requiring an accurate monitoring of blood flow by the sympathetic and parasympathetic nervous systems, the foot also requires the assistance of a normally functioning muscular system to insure return of the blood to the body. The foot is exposed repeatedly to trauma by frequently being brought into contact with the ground, and therefore requires an adequate sensory system for protection. Finally, it is farthest away from the central nervous system and, therefore, has to maintain the longest supply lines for these functions. These motor, sensory and autonomic systems are all at a disadvantage in the foot, and nerve fibre damage can easily combine with circulatory disturbances to produce complicated lesions.

A clinical classification of foot lesions has been described by Dr. F. William Wagner, Jr., Co-Chief of the Diabetic Surgical Services at Rancho Los Amigos Hospital (2). The classification from potential breakdown to total foot destruction is defined in six grades (Fig. 1). Starting at grade 0, a condition of bony prominence and pressure points, but without open skin lesion, through grade 5, a condition of whole foot gangrene.

Considerable success in treating grades 0, 1, and 2 conservatively, without amputation, is described by Dr. Wagner. Partial success in treating grades 3 and 4 was achieved by healing the lesion and thereby preserving the foot for orthotic management. Of a total 151 patients evenly distributed through grades 0-5, 107 were healed short of Symes amputation.

Healing Cast

The use of protective plaster casts is one conservative method of treatment (Fig. 2).

In the diabetic foot, tissue breakdown is caused by unappreciated trauma. Excessive pressure or intolerable shear forces traumatize insensitive skin and

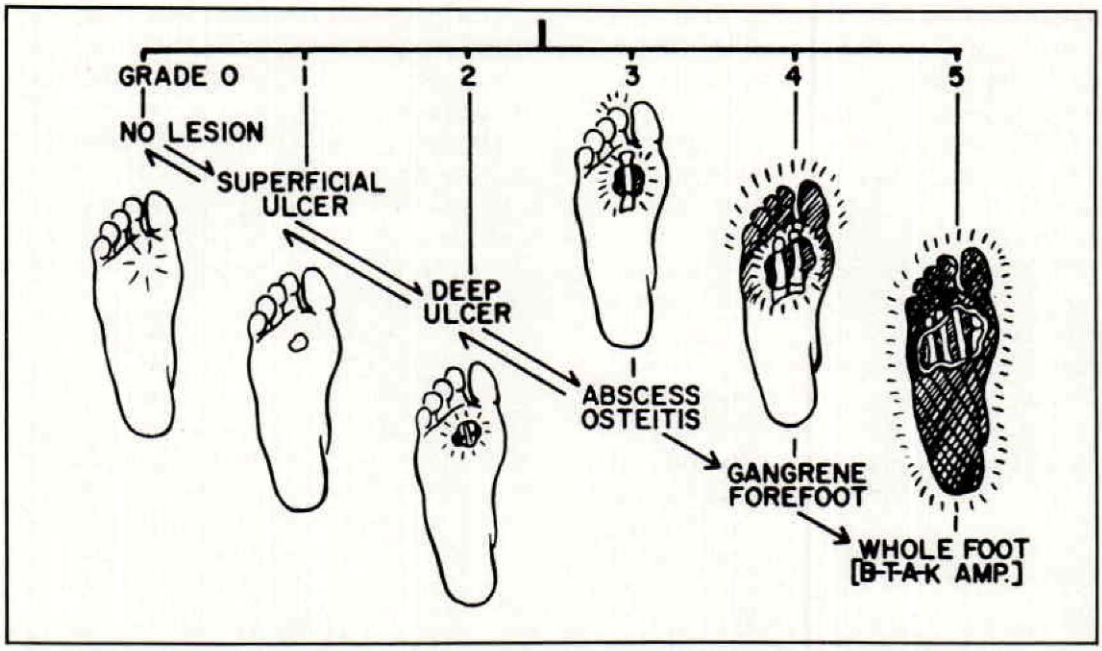

Fig. 1. The natural history of the breakdown of the diabetic foot (1).

cause tissue breakdown. Inflammation and edema prevent the body's own vascular healing process from taking place.

When arteriosclerosis or other contraindications such as undrained abscesses can be ruled out, or can be drained by surgery or treated with antibiotics, cast treatment can be started.

The function of the cast is to allow walking or other physical activities without added trauma. The encapsulation by the plaster cast results in a reduction of edema. The constant stress over a broad area not only controls the edema, but also helps to mature the affected tissue, and encourages faster wound healing.

Diabetic Foot Wear

When healing takes place, the Plastazote "forgiving" shoe is prescribed.

The Plastazote shoe (Fig. 3) constructed of the "forgiving" Plastazote insole and moulded Plastazote upper is combined with various heel and sole modifications to allow walking contact with the ground, without excessive trauma to the newly healed lesion.

The Plastazote insole, moulded to the foot or to a plaster cast, protects the insensitive, thin-skinned bony prominences of the plantar surface, while the molded Plastazote upper reduces pressure to the uneven dorsal surface of the toes and foot. Modifications consistences of the "SACH" heel, and metatarsal or rocker bars reduce trauma and excessive pressures when the patient walks.

A ready-made type of Plastazote shoe is available from Apex,[2] and the custom fabricated type as described by Guilford[3] can be used.

The depth inlay[4] or extra depth shoe[5], one which can accommodate a contoured Plastazote insole without compromising the dorsal surface of the toes and foot, is also used after healing of the lesion.

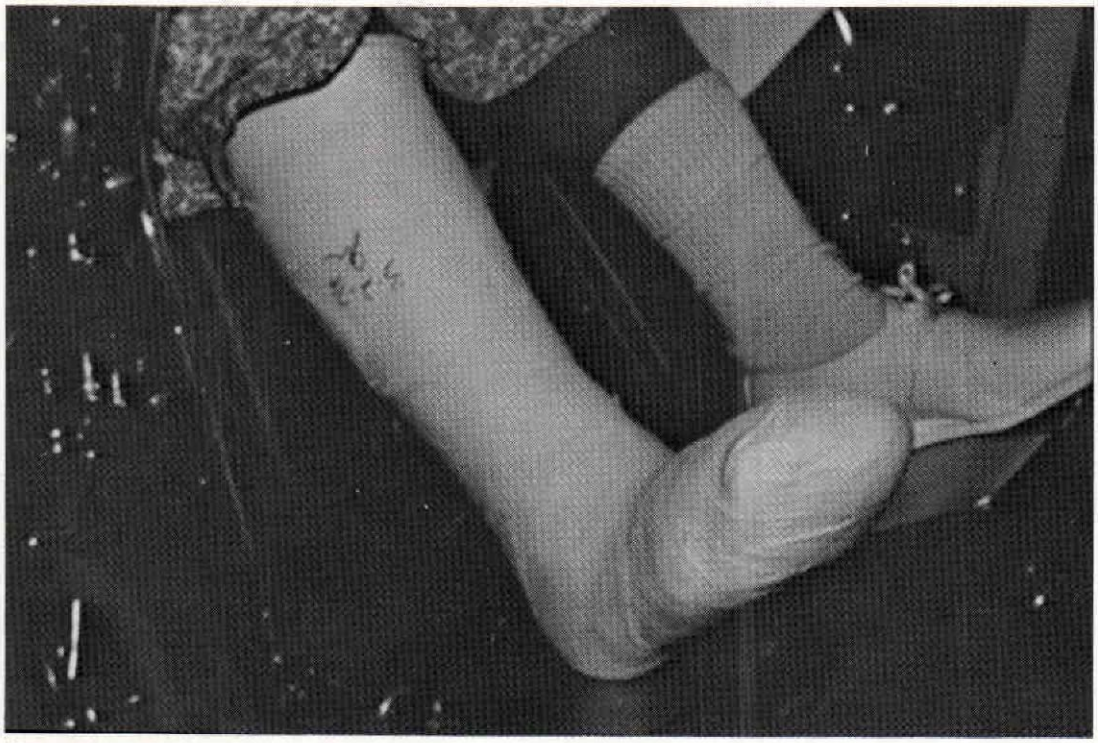

Fig. 2. Plaster casts to protect the foot is one conservative method of treating the diabetic foot.

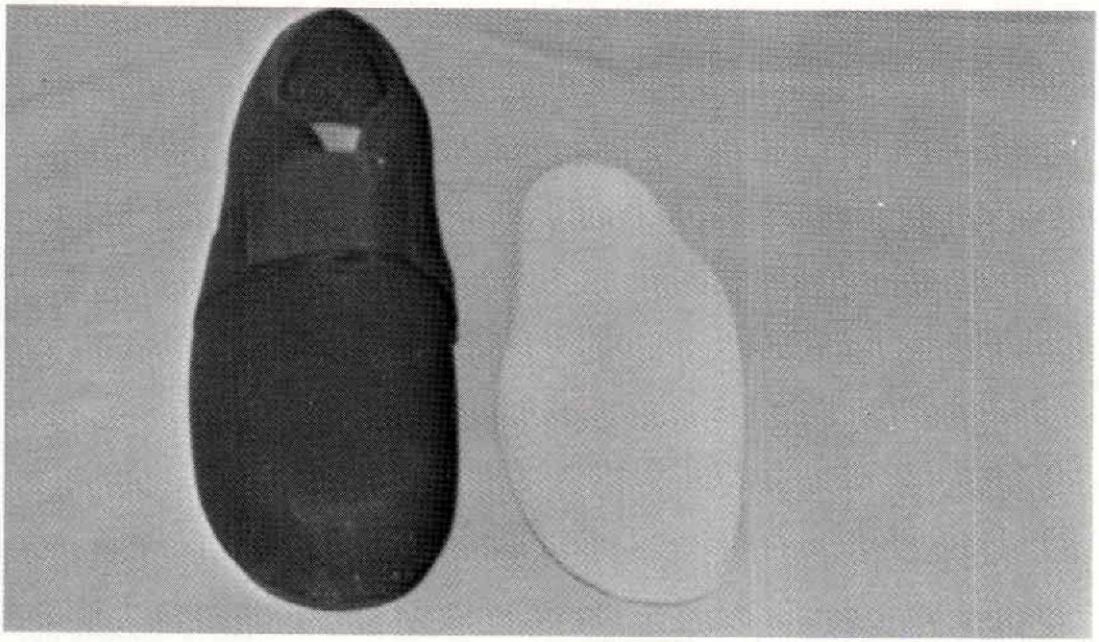

Fig. 3. The Plastazote shoe.

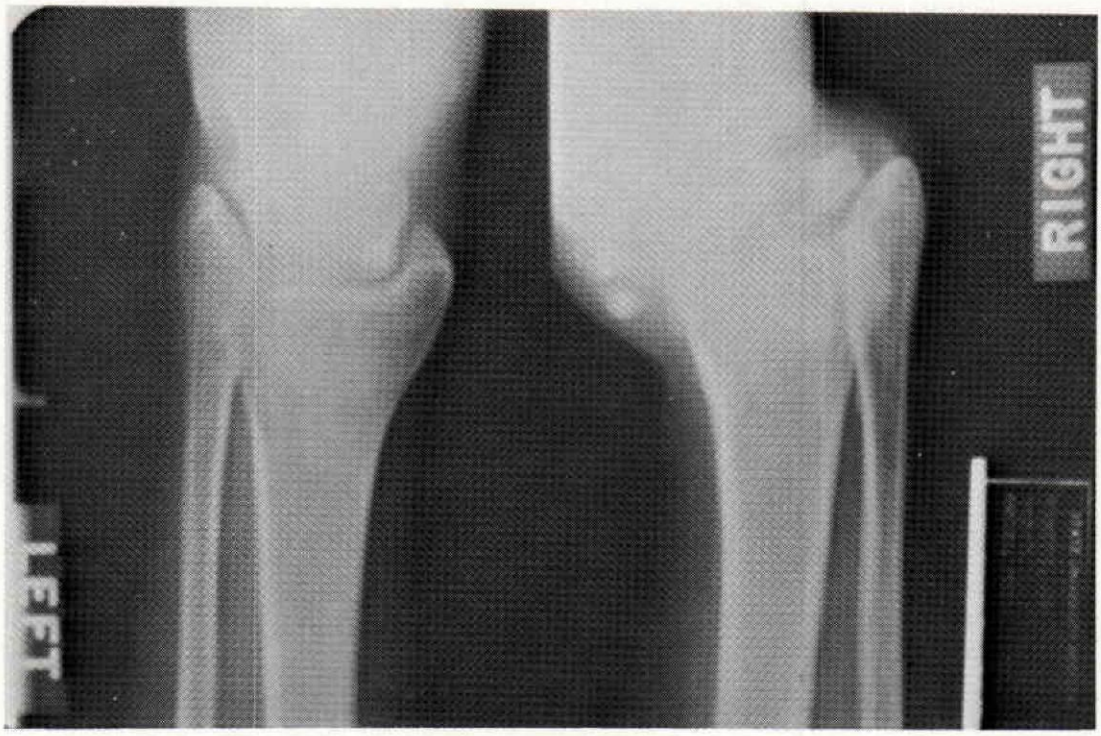

Fig. 4. X-Ray views of Charcot joints.

Extreme care is taken in the fitting and modification of footwear for diabetics with potential for, or healed, foot lesions. It is important that the patient be included in this effort, and made aware of his specific foot and footwear problems.

Diabetic Foot Care

Daily foot hygiene is mandatory and must be encouraged. Mild soap and warm water are used. Complete drying of the skin, especially between the toes, and square toenail trimming are mandatory, as well as close inspection of skin for blisters and pressure areas.

Periodic re-evaluation of the foot, shoe, and shoe modification will insure proper continued orthotic management.

Charcot Joints

A second complication responding to orthotic management is Charcot joint disease, usually in the ankle and foot, and is the result of recurrent trauma unappreciated because of diminished proprioception. The actual change in the joint is an exaggerated form of degenerative arthritis, instability, and swelling (Fig. 4).

Treatment is by support, unweighting, and protection from stress and further in-

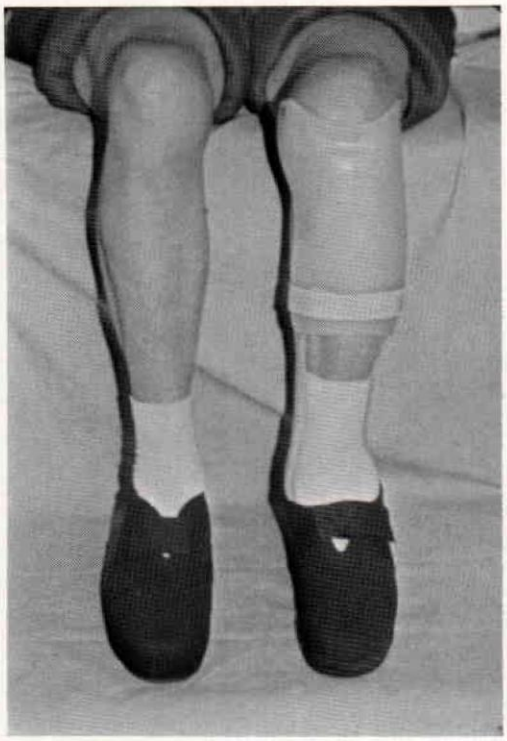

Fig. 5. An AFO with the patellar-tendon-bearing feature for treatment of Charcot joint.

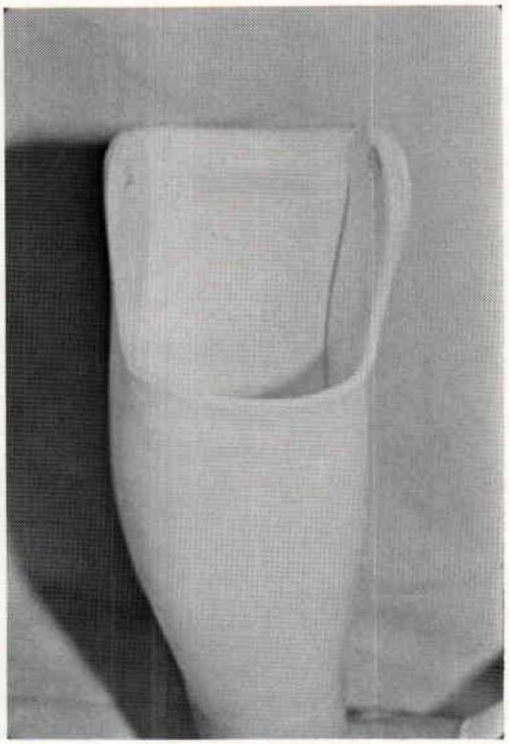

Fig. 6. Plastic foam is molded carefully over the patellar-tendon bridge and the proximal contours of the AFO to provide protection over the tibial crest.

jury. Orthotic protection of the distal joints of the foot requires the shoe modification, rigid sole and/or rocker bar. A Plastazote insole may also be used.

Orthotic management for protection of the ankle joint and proximal joints of the foot requires an AFO with a patella-tendon bearing area (Fig. 5).

Special care in design and fabrication is necessary because of the neuropathic complications presented by the diabetic patient.

1. Foam rubber is molded carefully over the patella tendon bridge and proximal contours to provide protection over the tibial crest (Fig. 6).

2. The trimlines at either malleolus must be sufficient to maintain rigidity in the flexion-extension plane, and to cover totally each side to maintain medial-lateral stability. Plastazote padding is used to prevent pressure to insensitive skin, and added or removed to accommodate changing contours and edema (Fig. 7).

3. A Plastazote insole is also incorporated in the moulding of the plastic to protect the insensitive and bony prominences of the foot.

4. A depth shoe or Plastazote shoe is used to accommodate the added inner soles without causing pressure to the dorsum of the foot and toes.

Muscle Weakness

A third complication in diabetic neuropathy is muscle weakness of the lower limb. Involved are the iliopsoas muscle and quadriceps group proximally, and the anterior peroneals below the knee. The involvement is usually isolated, prox-

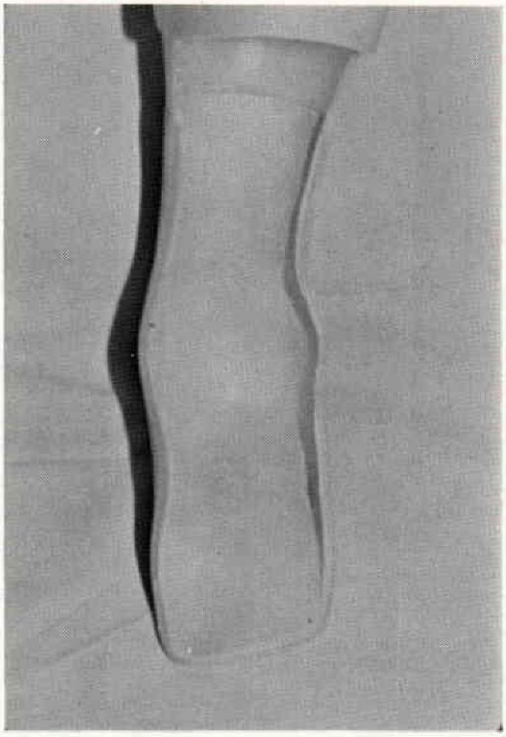

Fig. 7. Plastazote is used to prevent excessive pressure over insensitive skin in the AFO.

imal or distal, and is unilateral.

With a proximal muscle weakness, the orthosis of choice is dependent on many variables, but sufficient involvement of the quadriceps to cause knee instability requires a knee-ankle-foot orthosis (KAFO).

When the involvement is isolated to the peroneals resulting in a "drop foot", an AFO is sufficient.

The sensory involvement in the diabetic must be kept in mind during fabrication. Insensitive areas around the ankle and especially the plantar surfaces of the foot must be recognized and protected with adequate contours and/or Plastazote padding and insoles.

Conclusion

An overview of diabetes and the orthotic considerations of the diabetic have been presented.

We would re-emphasize that diabetes is an enormously complicated disease and carelessness or mistreatment can have catastrophic end results. The possible devastating problems of the diabetic patient demand knowledgeable orthotic management.

Footnotes

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[2]Apex Foot Products, Corp., 200 Forest Avenue, Englewood, N.J. 07631

[3]Guilford, Arthur, C.O., Suite E, 19437 Mount Langley St., Fountain Valley, California 92708

[4]Alden Shoe Company, Taunton St., Middleborough, Mass.

[5]Miller Shoe Company, 4015 Cherry St., Cincinatti, Ohio

References

(1) Joslin, Elliott P., *"Joslin's diabetes mellitus"*, Eleventh Edition, 1971

(2) Wagner, F.W., Jr.: *"Classification and treatment outline for diabetic foot lesions"*; Instructional Course, American Academy of Orthopedic Surgeons, New Orleans, Louisiana, Feb. 1976.

Orthotics and Prosthetics, Vol. 33, No. 3, pp. 40-42

NEW PUBLICATIONS

The Psychological Rehabilitation of the Amputee, Lawrence W. Freidmann, M.D., F.A.C.A., F.I.C.A., Charles C. Thomas, Springfield, Ill. 1978-157 pages with Bibliography and Index

Dr. Friedmann, a psychiatrist, has spent many years in clinical practice in and around New York City. This book is a result of his experience, a survey of the literature, and interviews with patients. While it undoubtedly would have benefitted from tighter editing, it is quite readable and largely free of the murkiness and illegibility that, in this reviewer's opinion, mars many psychological and sociological works. Based on a fount of practical experience and written in language free of jargon, it should be of interest to many who participate in the treatment of amputees.

The book opens with a brief chapter that sketches out the attitudes of various societies and ages towards amputation and amputees which we are heir to. It concludes with two chapters of the phantom limb sensation and the treatment of phantom pain. The book is perhaps most successful in detailing the reactions of individuals to pre- and postamputation events and the subsequent rehabilitation period. There is a wealth of practical information that describes methods of dealing with the patient during this oftentimes difficult period of adjustment. All experienced clinicians will almost certainly identify aspects of himself and of his patients in this section. It should serve as a useful and interesting medium of personal reappraisal towards the rehabilitation process. Particularly welcome is the stress on viewing amputation in a positive light and the need for instilling this belief. Shorter chapters discuss rejection of prostheses by amputees and the question of the child amputee and his family.

More difficult and perhaps controversial is the chapter covering the question of the amputee's role in society and society's acceptance of the amputee. The tone is pessimistic and rather troubling. While the situation may indeed be dark, it should perhaps be seen in another proportion. Much that is negative seems to be written of upper-limb amputees who represent a minority of amputees. Moreover, upper-limb amputees are more readily identified as such than lower-limb amputees. If the price of such stigmatization is indeed so heavy, then maybe there needs to be a reconsideration of the current prescription philosophy that stresses function over cosmesis and hooks over hands.

CHARLES H. PRITHAM, C.P.O.

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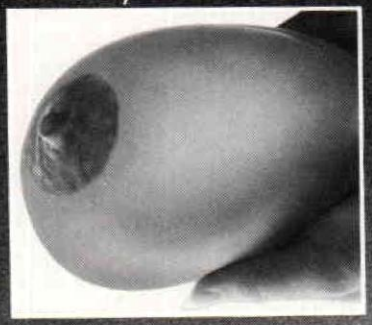

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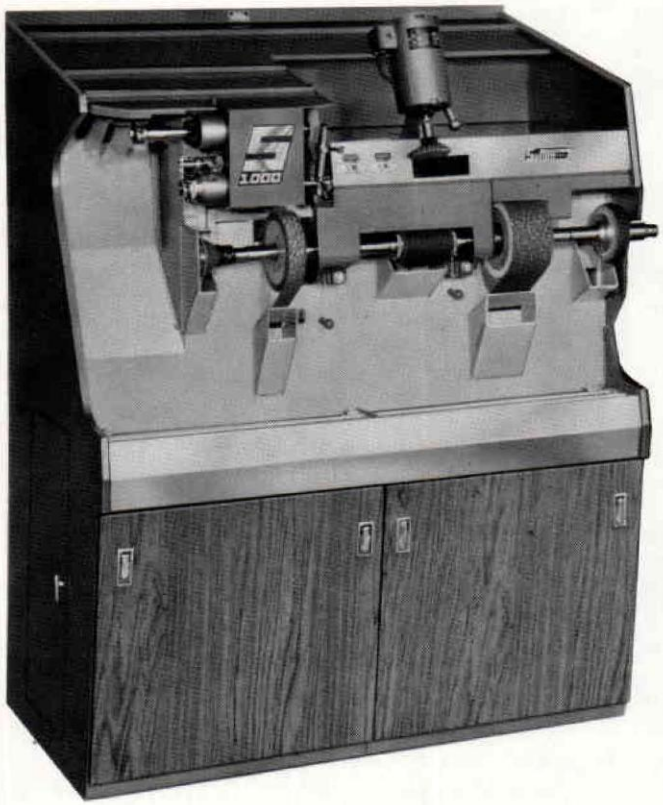

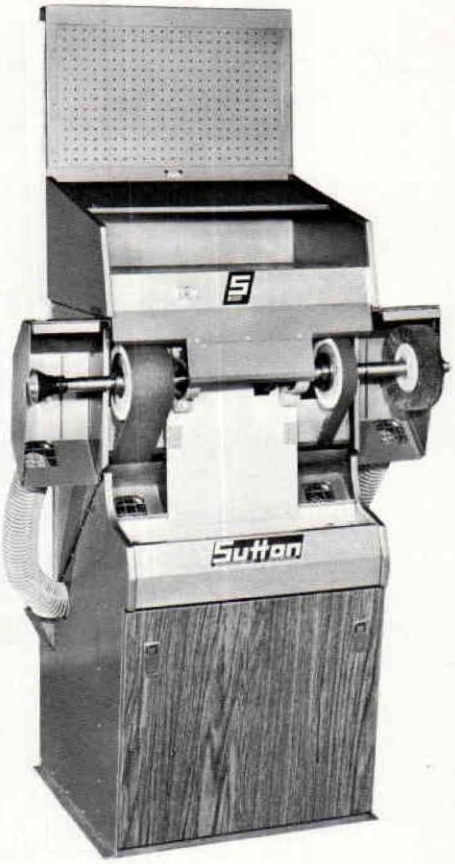

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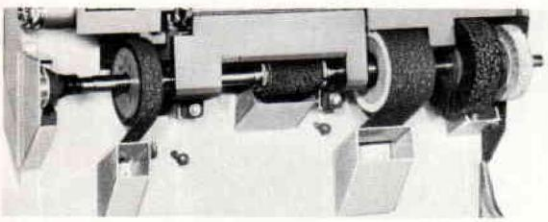

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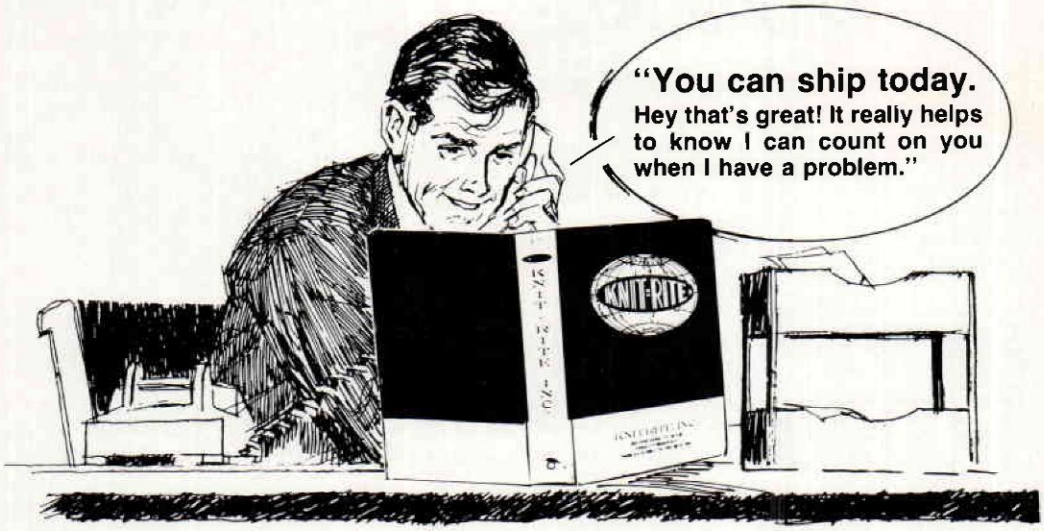

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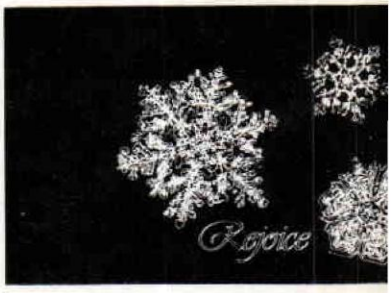

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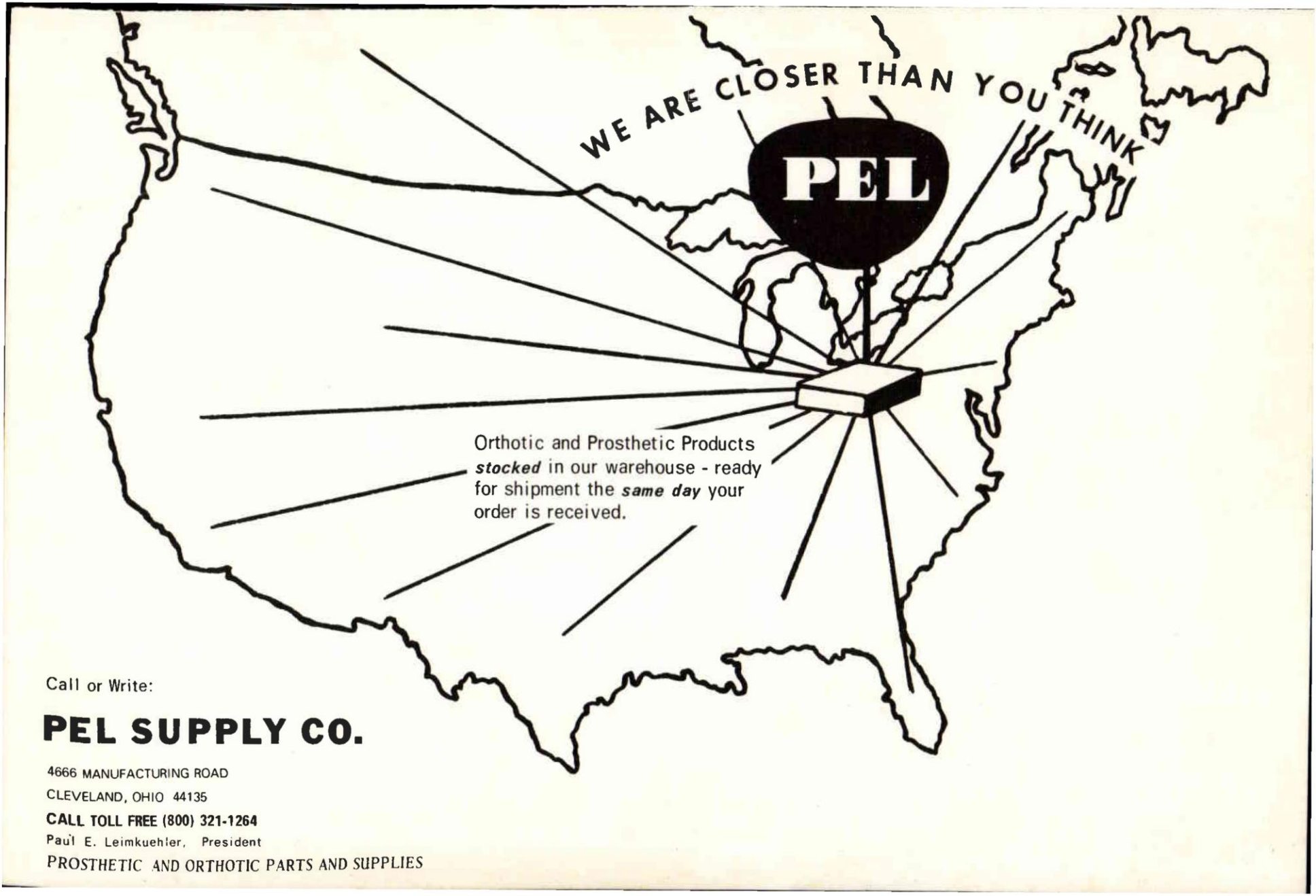

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