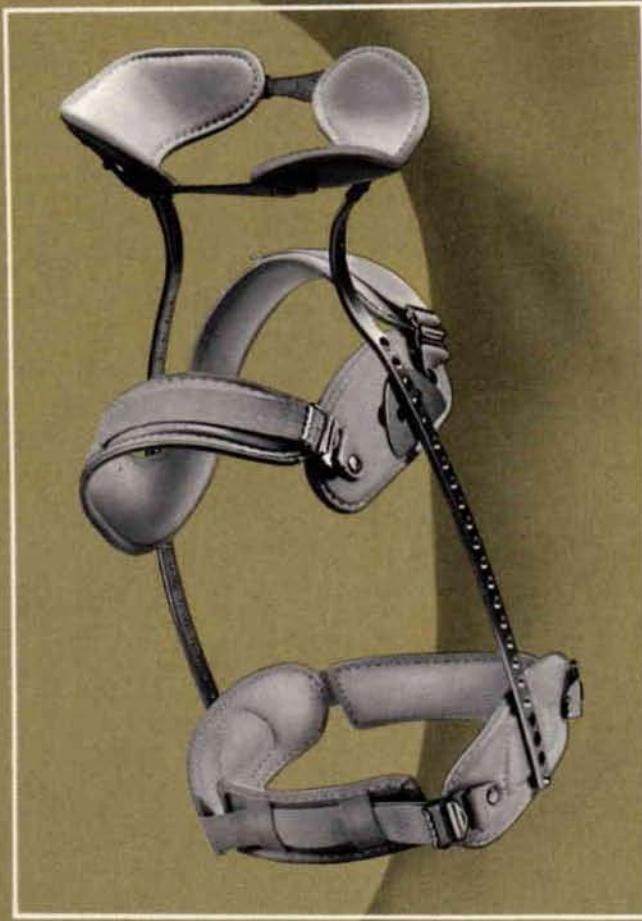


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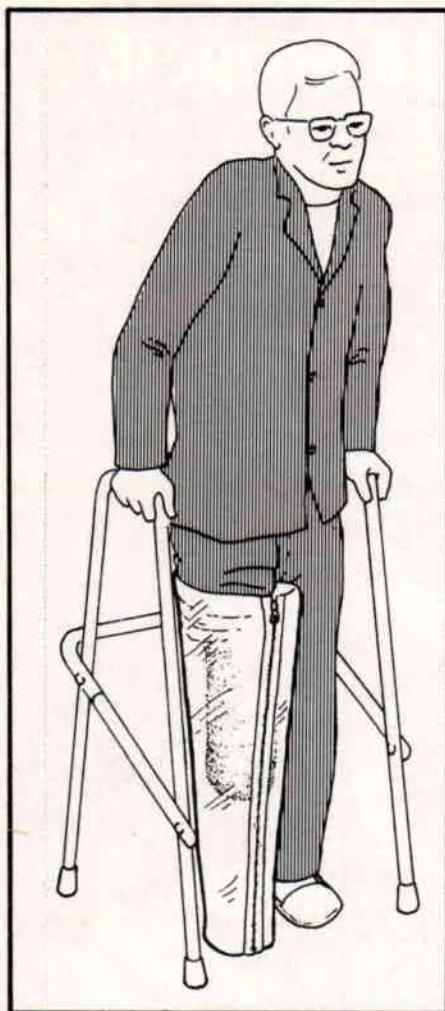


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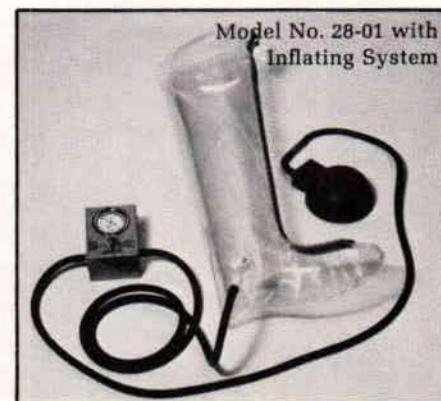
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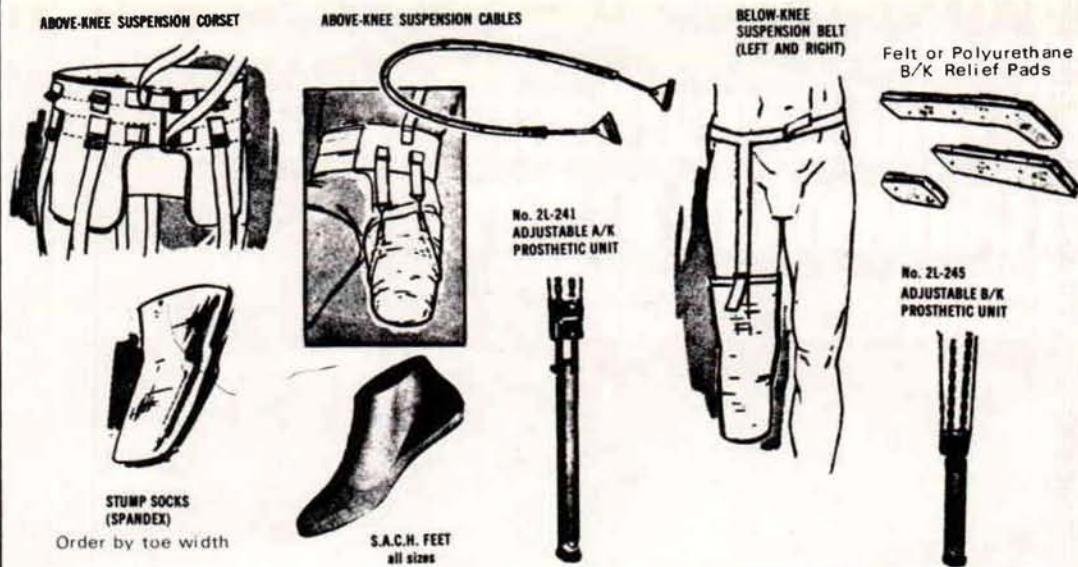
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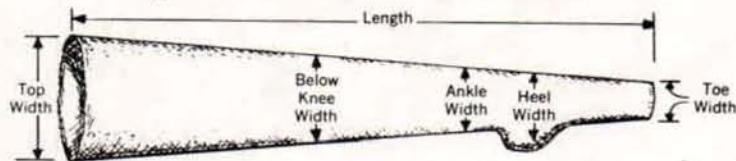


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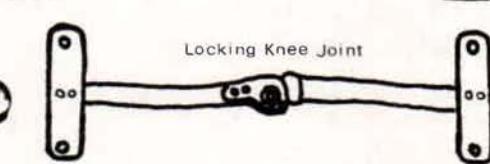
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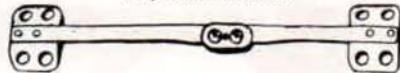


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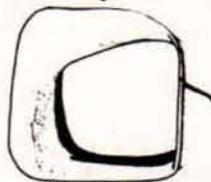


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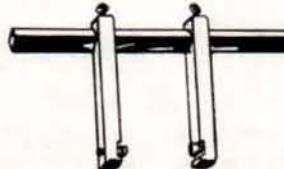


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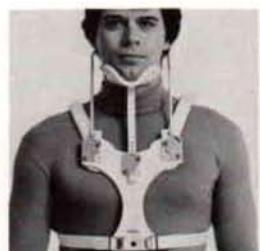
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TOMORROW

Orthotics and Prosthetics of tomorrow will hold only faint resemblance to that of yesterday and today. The days of the "fitter" performing clinical tasks part-time and fabricating devices the other part of the time is fading into a bygone era.

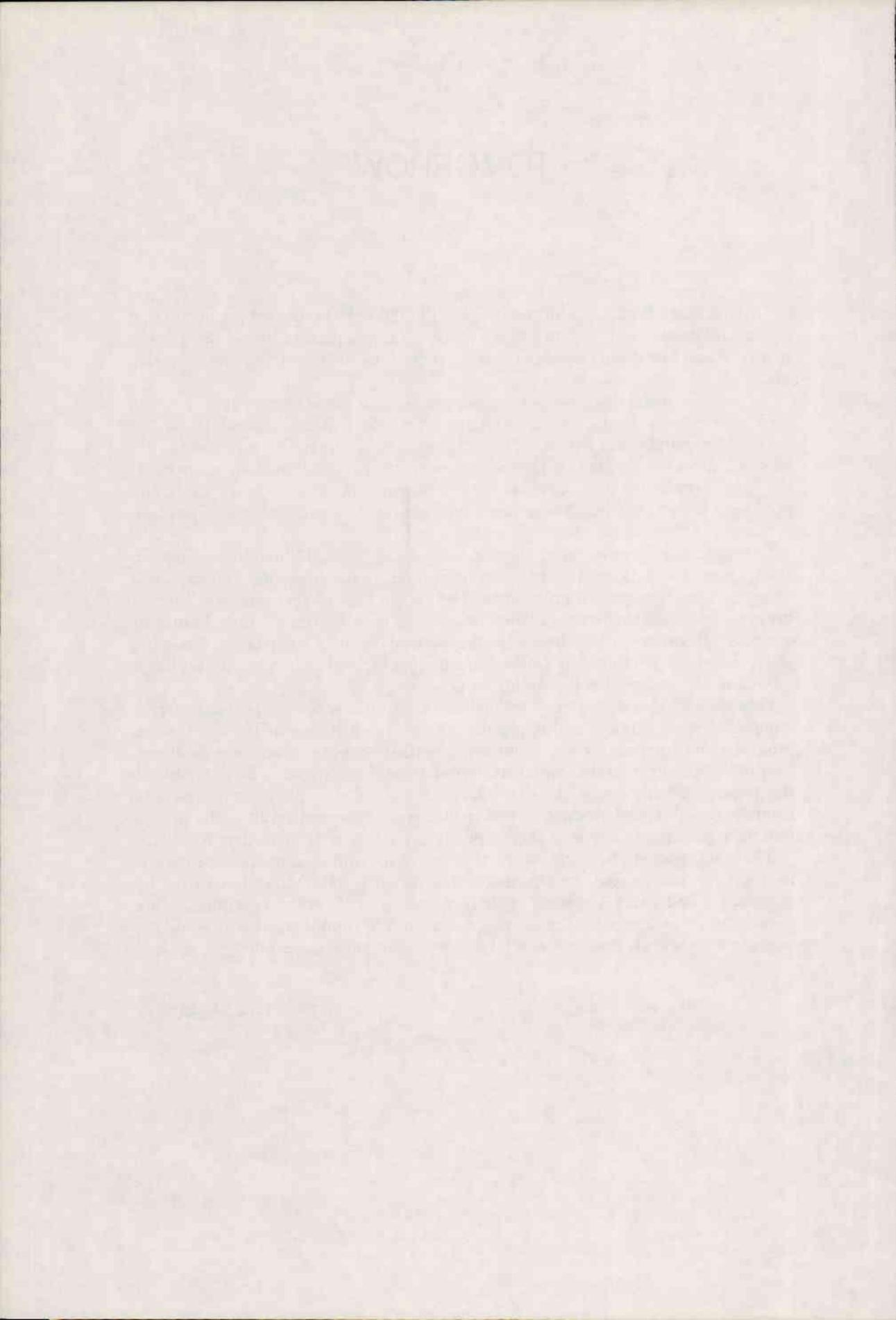
As medical technology becomes more effective in maintaining life in patients with severely involved medical problems, our field will be responsible for not only greater numbers of patients, but for more complex treatment procedures. We cannot expect the number of practicing prosthetists and orthotists to increase at the same rate as the need, and therefore, we must become more efficient and proficient in patient care. At the same time we must become more efficient and proficient in fabrication of devices.

Our field must provide specialists in patient care and additional specialists in fabrication. The patient care specialist must broaden his education to encompass all aspects of orthotics and prosthetics. The patient care professional will support his practice with a smaller population base, since he will offer the fullest range of services. His offices will be located in the medical complex, will have a minimum staff, will have a minimum amount of equipment, and will rely entirely on a fabrication laboratory for the supply of devices.

Fabrication laboratories may specialize in specific services, or may offer a complete line of services and appliances. These production experts will have to provide rapid, quality service to remain competitive and sustain their business. Through specialization the craftsmanship of yesterday will again be available to the patients of tomorrow through specialization. The application of modern technology will speed production and reduce costs. The end result to the patient will be superior care and a quality appliance at a cost no greater than today's.

There are, and will be, too few practitioners of the orthotics and prosthetics arts to properly handle the treatment of the patients today and tomorrow by yesterday's and today's system of delivery of services. Some practitioners are moving in the proper direction; everyone must. We cannot stand still while the world moves ahead. Progress is a train; we cannot stop it; we must get aboard.

TED THRANHARDT



EDUCATION AND TRAINING DIRECTIONS¹

Anthony Staros²

The techniques and formats of prosthetics-orthotics education should be discussed mostly by the specialists — they with their better knowledge of the pathways to more efficient and productive learning. But there is also need for those concerned with broad ranging programs of patient care, development, and evaluation to be heard and read, because of the need for patients to be served safely and properly by new technology as soon as practical. It is for this reason that I now speak out.

A BRIEF HISTORY

The practitioners of prosthetics and orthotics have come a long way with the base established by research and development groups mainly in the form of an array of new devices and techniques founded on sound principles and disseminated by the education establishment. A short twenty-five year period has been the span for the conversion of "limb and brace makers" to prosthetists and orthotists. The present-day "sons" of the craftsmen have been fortunate, experiencing as well as helping to promote the growth of a new calling — a professional one, now based on preparation at the level of a college degree. The patients of today are the chief beneficiaries of this. They are now surely better served.

Where do we go in the next twenty-five years — for the next generation — and how do we get there?

The history of prosthetics-orthotics education is reflected in the rapid growth in the university-based programs, a grossly different format from the loosely organized apprentice-

ship system formerly used in the United States. When it became apparent that prosthetics and orthotics was no longer a trade but a profession based on biomechanical and social principles of practice, the preparatory process took a form which had professional service as a product. Originally this was by means of short-term courses offered by the universities to up-date certain practices on the basis of products of research and development. With these came the teaching of basic principles underlying prosthetic fitting, nearly all derived from the VA-sponsored work of the University of California in both upper- and lower-limb prosthetics.

Later, certificate programs were established to offer the necessary prosthetics-orthotics supplement to a person prepared in a regular college program in a related field such as biology or rehabilitation therapy. Baccalaureate programs in prosthetics-orthotics, now at several universities, are intended to begin the preparatory process even earlier.

A landmark conference supported by the United Nations was held in Holte, Denmark in 1968 (2). At this conference standards for training in prosthetics and orthotics and associated curricula were recommended for use throughout the world. It was here also that the first precisely specified job descriptions for the prosthetist and orthotist and for the supporting technicians were written. All other conferences which followed, all other deliberations and discussions which came after did not alter significantly the base established in Holte.

As an example, the second U.S. educational conference held at Ponte Vedra, in 1976, restored the two-level concept of practice established in Holte after a temporary period during which U.S. practitioners felt a need for a third, intermediate level of "Associate."

Ponte Vedra II also gave deserved recognition to the certificate programs and appropriate cog-

¹From a talk delivered before the Seventh International Congress in Orthotics and Prosthetics, Diplomat Hotel, Hollywood Beach, Fla. October 23, 1976.

²Director, Veterans Administration Prosthetics Center, 252 Seventh Avenue, New York, N.Y. 10001

nizance of the involvement of the prosthetics-orthotics profession in "rehabilitation engineering." The relationship of the prosthodontist and orthotist to this broader field, rehabilitation engineering, must indeed be considered as we contemplate and then offer future directions.

DIRECTIONS

PREPARATORY PROGRAMS

An education based on a baccalaureate degree in prosthetics and orthotics and those training efforts employing certificate programs after bachelor degrees from other, related fields will if properly supported meet the demand for professionally trained prosthodontists and orthotists. Directions for the future should offer that such preparatory programs be sustained with perhaps more emphasis on the early degree preparation in prosthetics and orthotics and less dependency on certificate programs. But a properly constituted data base to predict both future needs and future supply should be used to guide the educators.

UPGRADING

From my own point of view an important arena for education and training in the future should be that associated with up-grading, or continuing, education. We see no shortage of innovation, either products of individual initiative or Government-funded programs. There will be constant change in techniques and devices. So that patients can benefit as soon as possible, there is a need for efficient dissemination of information to the practicing professionals.

We need first to identify the relationships between the research, development, and evaluation efforts and the education and training programs. Secondly, we need to have the practitioner in prosthetics and orthotics involved closely with all phases of the overall program.

It would be very useful if the prosthodontist and orthotist, as part of his commitment to his profession, became involved in those evaluation programs which require structured protocols and are funded by his and other professional societies and the Government. Thereby he would participate in activities which determine the route of change.

Here is a major role for the American Academy of Orthotists and Prosthetists to play as a participant in evaluation, as a part of a management team which needs to be structured to play the role which for many years was filled by the U.S. National Academy of Sciences through its Committee on Prosthetics Research and Development.

By such involvement in evaluation, the prosthodontist and orthotist will become directly aware early of some of the innovations. He will be thus well equipped to teach the application of them, perhaps even better than the original innovators, but he must learn how to teach, and he should, for teaching, use a forum in which teaching is most efficient, something which depends on that which must be taught. Some of this has been done in the past, in a manner wherein the evaluator served also as the teacher, but only as part of a University or National Academy of Sciences program but even then, it was not the practitioner who was the real teacher. Now is the time for the prosthodontist's and orthotist's own professional society to do much of the teaching in prosthetics and orthotics (3).

We all know there is need for continuing education in prosthetics and orthotics but there has been difficulty in getting support for such training. However, are laboratory courses (Fig. 1) needed for all such education? There are other mechanisms that we should encourage use of, such as the AAOP seminar programs. In these, better direction, with over-all long range planning of a course series seems needed. Large consumers such as the government's health care agencies should participate, not only helping with course plans, but most importantly, with financial support and with recognition of these courses as qualification channels for fee

schedules with special requirements for new product or process.

A possible additional training mechanism is that of a preceptorship, properly organized and administered. This method commonly used by

other professionals, is based on a system wherein a "student" works with a recognized teacher, or preceptor, for a certain period of time in the preceptor's laboratory or clinic (Fig. 2). For certain needs, for example, powered



Fig. 1. Laboratory instructional course in prosthetics.

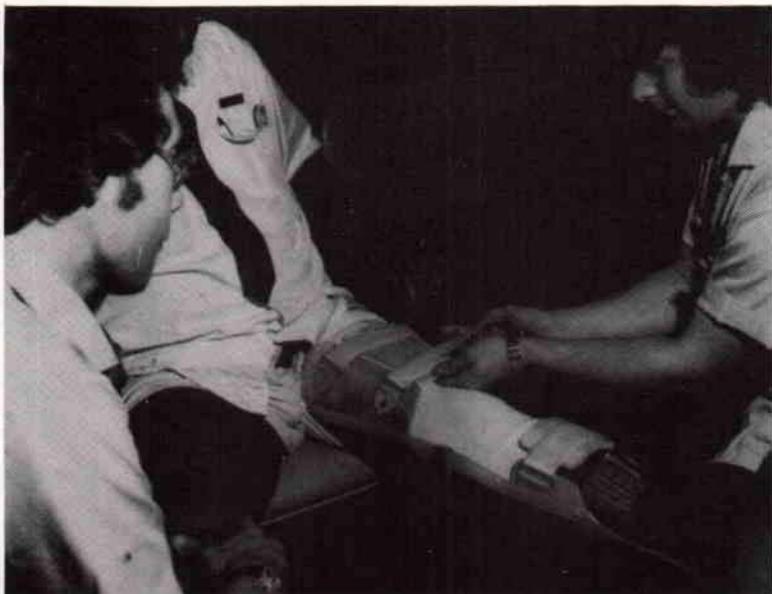


Fig. 2. Preceptorship — Learning by serving the patient with a "new" system under the watchful eye of an orthotist experienced with the item.

limb orthoses or prostheses, the preceptor method may be the most efficient way of transferring information and certifying qualification. Indeed one could have practitioners, after participation in a structured evaluation program, become "certified" preceptors on a certain item, teaching others assigned on a scheduled basis and establishing some of the students as preceptors themselves.

Also not to be overlooked is the use of "canned" home instruction systems using video and audio facilities (Fig. 3). Increased government support of this approach is needed.

MORE ON GOVERNMENT SUPPORT

Unquestionably, the government, through its health care agencies, should support upgrading education and training efforts as it supports the research and development which forces the change requiring the dissemination of information. The government now supports evaluation; as a consequence, it must participate in planning the scope of any education and training efforts to be organized by the practitioners. Together, the practitioners and the Government should structure an enduring system with bal-

ance among laboratory courses (but only after carefully scrutinizing the real need for these), seminars, and preceptorships, the balance being determined as a function of the requirements of individual innovations.

The government can also recognize the *professionalism* of prosthetics and orthotics by establishing fee schedules to replace the "artificial limb contract." But equally important is a recognition the practitioner himself must provide — a recognition of his own identity as a professional. That the prosthodontist and orthotist act like professionals is necessary, so that the attempts being made by the government to establish professional methods for reimbursement will be acceptable to those who still consider the prosthodontist and orthotist as "limb and brace makers."

REHABILITATION ENGINEERING

The term "rehabilitation engineering" has bothered some people in prosthetics and orthotics because it is a field which embraces prosthetics and orthotics as well as all other technologies associated with patients during the rehabilitation process. Distorted are the current

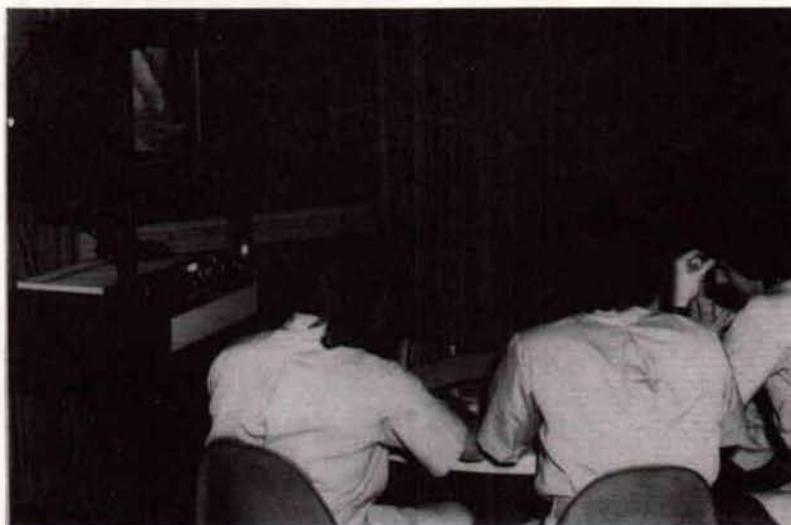


Fig. 3. Team instruction by the use of video and audio tapes.

visions of Ph.D. engineers dominating or usurping prosthetists and orthotists in their milieu, the fitting laboratory, telling them what, when, where, and how to perform.

Because of its expanding interest in all aspects of rehabilitation technology, the Government's several health care agencies have encouraged the identification of rehabilitation engineering, particularly through HEW's Rehabilitation Engineering Centers. This constitutes no threat to prosthetists and orthotists.

In writing about the clinical engineer some years ago (1), we foresaw that many of the duties of the rehabilitation engineer would put him in the clinic as a colleague and collaborator of the prosthetist and orthotist.

Since that time and true to our early estimates we have had great success in the Veterans Administration with our own clinical engineers. Specializing on the problems of the severely handicapped, they contribute on all aspects of rehabilitation engineering including the selection of beds, patient transfer and lift systems, environmental controls, wheelchairs, licensed vehicles, and even occasionally prosthetics and orthotics.

They participate in the hospital clinic teams in which surgery and rehabilitation are involved. They go on daily rounds, working closely with the physicians and surgeons, prosthetists, orthotists, nurses, therapists, and other professional personnel.

They are active in discussions of the prescription, and with their wide knowledge of the many kinds of equipment available, they serve a major role in the specification of the devices and processes needed for a particular patient. In fact they go into many patients' homes, serving needs there by recommending new devices and in some cases, installing those devices, later seeing to their repair and maintenance (Figs. 4 and 5).

The VA clinical engineers have been particularly valuable in evaluations of new hardware, for their proximity to the care of severely handicapped patients gives them an excellent orientation for analysis of the quality and effectiveness of new systems. In this way they are close to the development process as it occurs elsewhere, and in some cases project themselves and their ideas into the process. But their forte is the clinical role; their service to pa-

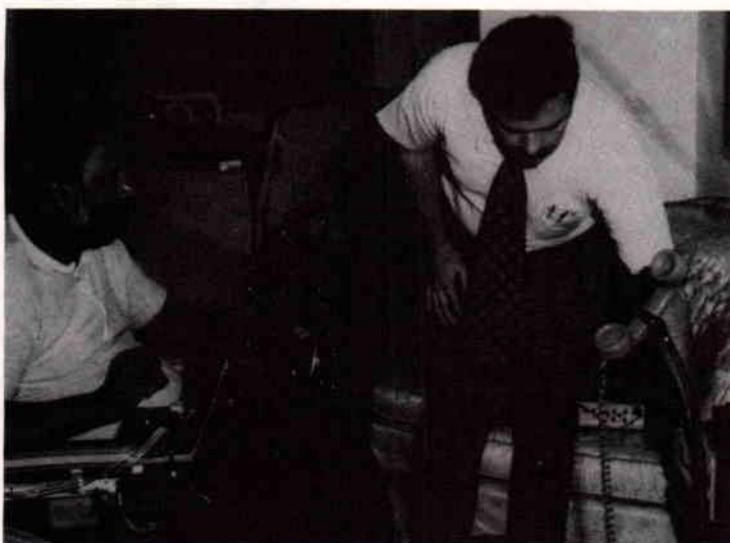


Fig. 4. Hospital-based home care in rehabilitation engineering: Installation of communication devices and other appliances for patient use throughout the home.



Fig. 5. Hospital-based home care in rehabilitation engineering: Introduction of remote control of appliances from the wheelchair.

tients. Evaluation is an essential part of this, as it is with any other professional, particularly the prosthetist and orthotist.

Our prosthetists and orthotists have now learned to use their services especially in fitting the more sophisticated electronic systems such as powered upper-limb prostheses and orthoses (Fig. 6). They have also been used quite regularly in our functional electrical stimulation projects.

Our handicapped drivers have benefitted by the availability of our clinical rehabilitation engineers; for these people we are able to provide help in selecting adaptive equipment and, in some cases, having the engineers install the devices (Fig. 7).

They have in fact learned to be bedside-oriented engineers, developing with patients a rapport that meets the highest standards of professional practice.

In originally writing of the clinical engineer and proposing his employment in the VA health care system, we did not ever believe that such a job would present a threat to prosthetists and orthotists. It has not become one. The clinical



Fig. 6. The engineer and prosthetist team serving the patient.



Fig. 7. A lift system for wheelchair access to a vehicle. This kind of item requires professional engineering inspections at installation and periodically thereafter.

ehabilitation engineer is a generalist with his attention directed to those broader areas of technology which are especially responsive to the needs of the severely handicapped; prosthetics and orthotics fittings will not be his forte, but he will be involved. Although he will necessarily have an interest and will indeed be of assistance to the prosthettist and orthotist responsible for fittings of such devices as those associated with bioelectric systems (FES and the like), the prosthettist/orthotist role will not be jeopardized.

If the clinical rehabilitation engineer does his job well, he will be nearly fully concerned with the severely handicapped, in the hospital and in the home; he will worry about transport systems (Figs. 8 and 9), environmental controls, and the like; he will concern himself with the architecture in and around the disabled person's environments and, most importantly, he will try to design job modules for restoration of vocational potential — a form of industrial engineering.

A part of all this is, of course, prosthetics and orthotics design; in this he, the clinical engineer, and the prosthettist and orthotist will develop those special systems needed to interface a severely handicapped patient with a transport system; with a vehicle, with his job, and with needs in his home. The technology



Fig. 9. Another form of joy-stick control: — an adaptation of the lunar rover module control developed by NASA for the Apollo project.

introduced for the rehabilitation of patients can not be considered independently of the total system, a part of which is the prosthetic-orthotic restoration whenever possible.

Our concept of the clinical rehabilitation engineer (not Ph.D.'s but baccalaureate and master's degree recipients) is a person *on the same level* as the prosthettist and orthotist, with each enhancing the knowledge and capability of the other. The prosthettist and orthotist, especially with the upgrading programs which have evolved, has become as well-prepared as the clinical rehabilitation engineer. We can structure further change by developing new courses for some prosthettists-orthotists, who may wish to expand their scope beyond prosthetics and orthotics into rehabilitation engineering. We now see a need for new bachelor degree programs to be developed to prepare rehabilitation engineers, but before that we may need to have graduate degree programs for those who have already graduated from regular engineering programs. We can visualize other programs, structured either through an organized upgrading process or through a full-year, full-time program, to provide a graduate degree in rehabilitation engineering for prosthettists and orthotists.



Fig. 8. A "joy-stick" control for braking and acceleration: — uses servomechanisms in engine compartment.

SUMMARY

These, then, should be the directions: properly, structured, efficient upgrading of prosthetists and orthotists prepared at the bachelor's level, to include the involvement of prosthetists and orthotists in evaluation and the use of new formats such as preceptorships and "canned" training programs, and less dependency on expensive laboratory courses; more generalized recognition of prosthetics and orthotics practice as professional; the clarification of lines of demarcation between the prosthetist and orthotist and the clinical rehabilitation engineer, but with cognizance that such lines will gradually become less clear as better designed upgrading programs have more impact; and the structuring of special undergraduate and

graduate curricula in clinical rehabilitation engineering.

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SEATING AND POSITIONING FOR THE PHYSICALLY IMPAIRED

Wallace M. Motloch, C.O. (C)¹

The Rehabilitation Engineering Program of the Children's Hospital at Stanford has devoted considerable effort toward the solution of seating and positioning devices for the severely physically impaired because little in the way of habilitation can be realized unless the child can maintain an effective sitting position. The subject of seating and positioning for pilots, astronauts, truck drivers and other equipment operators has been studied extensively by N.A.S.A. (4), automobile manufacturers (1), and others, but because these studies involve only subjects with normal skin sensations, good protective musculature and skin, and the ability to shift around automatically, the results have been of very little use to us.

The physically impaired must "reeducate" their weight-bearing areas to function in a way that they were not designed to work. The normal function of the skin layer in the seat area has to change from basically a temperature control device and bacteria barrier to a weightbearing surface through which the body weight has to be supported. This function may cause impairment of the circulation and an increase in humidity because of the poor ventilation. These unfavorable conditions may occur 10 to 15 hours per day, day after day, for years. Because of the many complexities and limitations that occur in fitting and fabrication of special seats for the physically disabled, it may be helpful to classify these needs and problems and discuss the features of each.

CLASSIFICATION SYSTEM

Table 1 is a matrix of type-of-patient versus

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the time the patient is expected to use his chair daily. The type of patient is either "cerebral palsy" or "other than cerebral palsy". The times are "short" (up to 3 hours), "medium" (3-6 hours), and "long" (6-10 hours). Some design criteria are listed also in Table 1.

The primary reason that we believe the cerebral palsy seating systems are different from all others is that people with cerebral palsy do not perceive reclining postures as positions of relaxation. They also need special positioning for reflex pattern inhibition and maximum functioning of the upper limbs. In the near future we hope to show through the use of oxygen consumption measurements that unless the cerebral palsy person is positioned in space as described here he will consume more energy while sitting.

The position of relaxation and comfort for cerebral palsy-type disorders can be defined as follows: (Refer to Figure 1)

1. The head and shoulders should be vertical.
2. The lumbar spine should be rounded.
3. The hips should be flexed 10-30 deg. from the horizontal.
4. The knees and ankle joints should be flexed to 90 deg.
5. The thighs should be abducted.
6. The shoulders should be rounded in the transverse plane.
7. There should be no stimulation over the occipital area.
8. There should be minimal stimulation over the ischial tuberosities and plantar surface of the feet.
9. There should be a general feeling of firmness and security.
10. There should be a general feeling of comfort and relaxation.

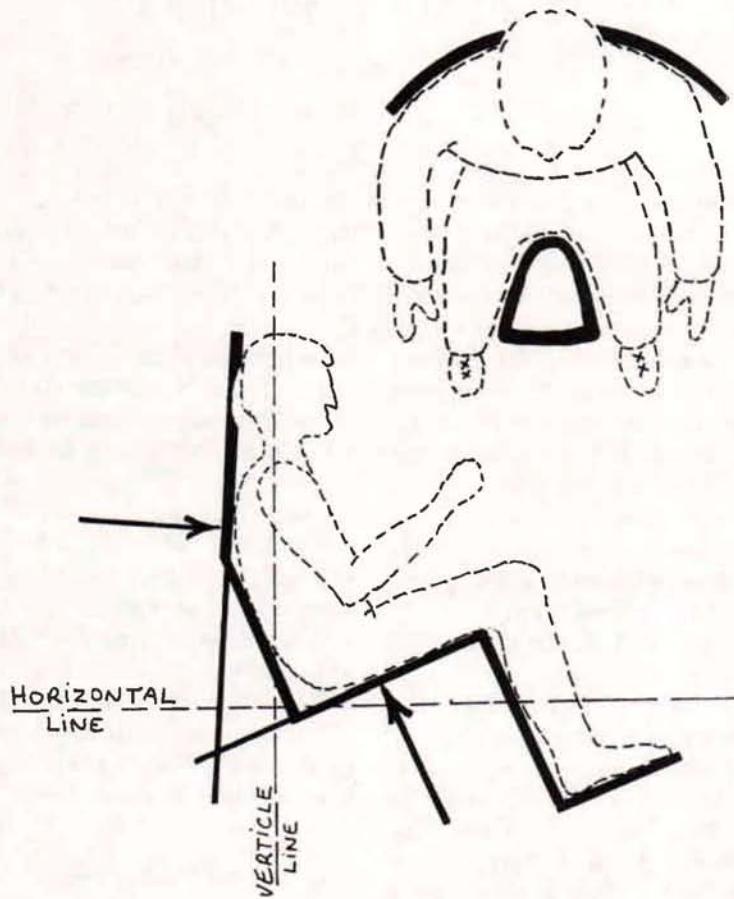


Fig. 1. The basic cerebral palsy sitting posture for a driver's seat.

1. The head and shoulders are on a vertical line.
2. The lumbar spine is rounded.
3. The hips are flexed 10-30 deg. from horizontal line.
4. The knees and ankle joints are flexed to 90 deg.
5. The thighs are abducted.
6. The shoulders are rounded.
7. There is no stimulation over the occipital area.
8. There is minimal stimulation over the ischial tuberosities and plantar surfaces of the feet.
9. There is a general feeling of firmness and security.
10. There is a general feeling of comfort and relaxation.

DESIGN CONSIDERATIONS FOR BASIC CP SEATS

In CP seating the position of the head and shoulders in space plays an important part. The exact location of these two segments in a particular patient can be found by rotating the patient in space and photographically recording the relaxing posture (Figs. 2 and 3). This



Fig. 2. The positioning of the patient in space to locate the most relaxed spacial alignment of body segments. Note the use of a plumb bob for vertical reference line.



Fig. 3. A finished orthopedic seat insert with a clear plastic tray. Note the direct transfer of spacial alignment as seen in Fig. 2 to the finished product.

posture is the sum of the following functions: visual perception of the horizon; the relationship of the head and shoulders in space to provide the balance and resolution that influence reflex patterns like the neck righting reflexes, protective parachute reflex, and proprioceptive sensors; and information from the inner ear that senses the position and movement as well as a great number of positions and reflexes. The most influential of the reflexes seem to be the tonic labyrinthian and the tonic neck and trunk reflexes. Dr. Peiper (5) states "... the leading reflex is the labyrinthian righting reflex of the head which rights the head in relation to space. Chain reflexes originating from this reflex bring trunk and extremities to the best possible balance under given conditions." In the able-bodied, the equilibrium guarding is done automatically, and, in most instances, is not under the direct voluntary attention of the person. This is not the case in cerebral palsy, where the automatic control has not reached the sophistication of an able-bodied person (3). The cerebral palsy person has to voluntarily assess the effect of the force of gravity on his body and process the information to remain seated in an upright position.

STATE OF COMFORT

The state of comfort is not found in any one body alignment or position in space. It is, however, the result of changes in position. It is important to point out that significant short term gains in upper-limb function result from firm support (Fig. 4) at the sacrifice of long term tolerance. To prolong the state of comfort in a seating system, it is necessary to investigate articulating systems where the seats, back supports, foot rests, and other parts can be re-positioned as needed to sustain the state of comfort.

STATE OF RELAXATION

The state of relaxation is defined as the state of mind that makes us less tense, slackening the



Fig. 4. A CP Type 1 orthopedic seat insert. Right, patient before the fitting. Left, same patient after the fitting.

demands on the overall voluntary control system, and permitting us to concentrate on the task at hand.

PRESSURE AND DISCOMFORT

In CP seating, as in all other seats, prolonged or excessive pressure over any area of the skin can cause problems. The area over protuberances like the occiput and ischial tuberosity require especial attention. In his chapter on "Development of Sensory Function," Peiper (5) states ". . . the pain sense is well developed in a newborn. The reactions have the purpose of withdrawing the irritated skin area from the stimulus." Rigid seats can easily cause excessive pressure on the skin and generate pain reflexes that force the hips to extend in order to get away from the pain stimulus. This is not to minimize the importance of the extensor pattern reflex in CP's. Rogers (2) in his article on "Tissue Tolerance to Trauma" states that the subtrochanteric areas are much more tolerant to skin pressures than are the ischial tuberosities.

In view of this, considering the contour of the seat cushion, the tuberosities must be well relieved to prolong the seating time of the patient. At the same time, the head support must resolve a complex set of reflex influences. Skin protective reactions are best negated by the use of a doughnut-type head rest or a neck support only. The doughnut-type head rest avoids the stimulation of the occipital area and redistributes the pressure over a larger area.

FIRMNESS AND FEELING OF SECURITY

The general feeling of security and firmness of the seating system is not usually emphasized enough. The orthopedic seat insert and all other parts like arm rests, trays, head supports, and foot rests must be attached securely to the wheelchair. This promotes a feeling of security that sets the patient at ease. Peiper (5) describes the classic startle reaction that can occur when the seat insert is loosely attached to the chair. He demonstrates this fact by jarring the base on which an infant is lying. This should be proof

enough that instability or rocking of the base of support is very distracting and acts as a stimulus to the uncontrollable startle reactions, and thus interfering with activities of function. This is particularly important when the orthopedic seat insert has to act as a driver's seat for an electric wheelchair. Paradoxically, in the electric wheelchair application in this situation, the wheel base must necessarily move. Yet, this movement should not set off the startle reaction to the point that the person loses control.

GENERAL FEELINGS OF COMFORT AND SECURITY

The feelings of comfort vary from patient to patient, but the easiest way to assess comfort is to watch the patient. If something bothers him, he will fidget, or become generally less able to concentrate on the task at hand. The patient may become uncomfortable because of presence of excessive perspiration caused by use of a vinyl seat. To minimize this problem we encourage the parents to agree to have the seat upholstered with a heavy-weave cloth, like "Herculon," which allows more ventilation. When the patient is incontinent, the seat part is vinyl and the rest of the seat is cloth (Fig. 5). The use of cloth sometimes necessitates more frequent replacement of the upholstery, but this gives the orthotist a chance to adjust the seat for growth and improvement of the comfort level.

NECESSITY OF A MOCK-UP FITTING

It is common to see a parent or a therapist handle an involved child so that he maintains good posture and relaxation. The problem arises when we need to maintain the same posture and relaxation by using inanimate objects like foam, straps, and plywood. One way to objectively assess the maximum of relaxation and posture available from "non-people" supports is to use a "trial adjustable seat" or to construct a mock-up seat (Fig. 6).

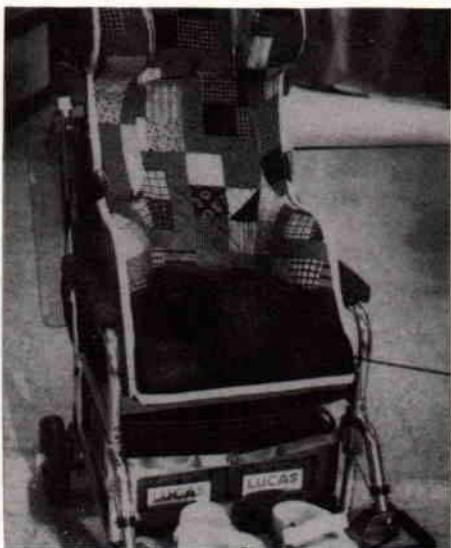


Fig. 5. Front view of upholstered orthopedic seat insert. The seat part is upholstered with vinyl for an incontinent patient; the rest is finished with cloth to provide comfort and keep perspiration to a minimum.

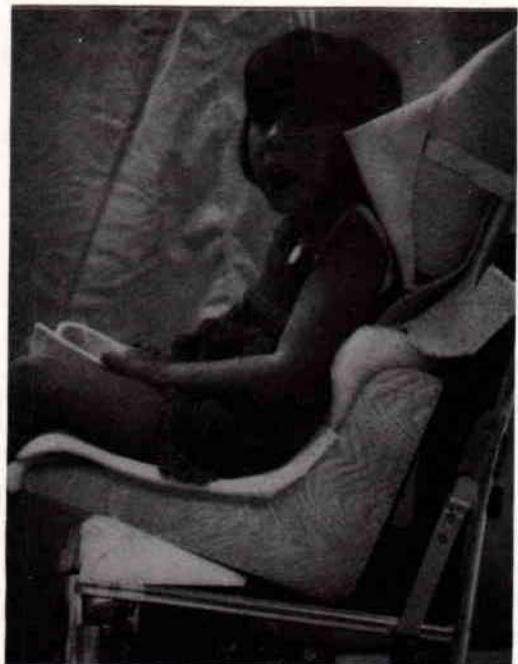


Fig. 6. Mock-up fittings are necessary to confirm the special alignment of the body segments. Much of the relaxing posture possible by handling the patient bodily is not necessarily reproducible with foam and straps.

ORTHOPEDIC SEATS FOR CEREBRAL PALSY PATIENTS

CP seats are prescribed primarily for the following three reasons:

1. To make maximum upper-limb function possible, i.e. create a driver's seat, or position in space for activity for function.
2. To discourage or maintain deformities, i.e. spine deformities and contractures.
3. To provide comfort and means of transportation for extremely severely contracted cerebral palsied individuals who cannot be positioned in a sitting posture. This is often done to facilitate transportation to school.

CP TYPE 1:

Orthopedic seat inserts that make possible maximum upper-limb function (Fig. 4) are based on the previously described philosophy of seating as a method of positioning and relaxation (Fig. 1) and are fitted to severely involved cerebral palsied people who need to control an electric wheelchair, communication device, or environmental control. This type of individual must be provided with a driver's seat that locates him properly in space, minimizes his inadvertent motion, diminishes his startle reflex, and inhibits his extensor patterns. A seat with all of these features is considered for short duration use and is primarily for activities of function, not an all-purpose seat (Table 1).

CP TYPE 2:

In some cerebral palsy cases it is advantageous to provide a well-fitting orthopedic seat insert with good thoracic support (Fig. 7) instead of an orthotic device like a body jacket. Because the seat must be fitted intimately to exert correcting forces on the spine, it fits rather tightly. Therefore, it will need a greater number of adjustments than other seats and may necessitate modification of clothing when it is to be used in colder climates.

As a general rule, the seat insert is considered

to be more comfortable and easier to use in everyday activities than a body jacket. The duration of tolerance in this case is usually from medium to long.

CP TYPE 3:

This is a well padded seat (Fig. 8) that allows position changes and shifting around as well as protection to the patient. A seat of this type can often include substantial well padded foot rests, well padded arm rests, and head rests. This seat then is considered a device in which the patient can be placed in the morning and sent on the school bus, stay in the seat during the school hours and return home in the evening. The seat is a long duration item, primarily suitable for teenagers or older children that have severe uncorrectable deformities, and need to spend many hours away from home.

ORTHOPEDIC SEATS FOR OTHER THAN CEREBRAL PALSY PATIENTS

The three types listed in Table I are used as follows:

- O Type 1: A general purpose seat to improve sitting stability and trunk balance.
- O Type 2: Positioning seat primarily for muscular dystrophy patients.
- O Type 3: A seat to improve tissue trauma tolerance primarily for people with desensitized skin i.e. paraplegia, quadriplegia, and spina bifida.

O Type 1

An orthopedic seat insert (Fig. 9) which optimizes sitting posture, security, and stability of the trunk is a base or foundation from which the person functions. The positioning of many patients with deformities of lower limbs, i.e. rigid hip, contractures, pelvic obliquities, and rigid deformed spine can often create difficulties in balancing oneself over the base of support. This type of insert usually consists of a

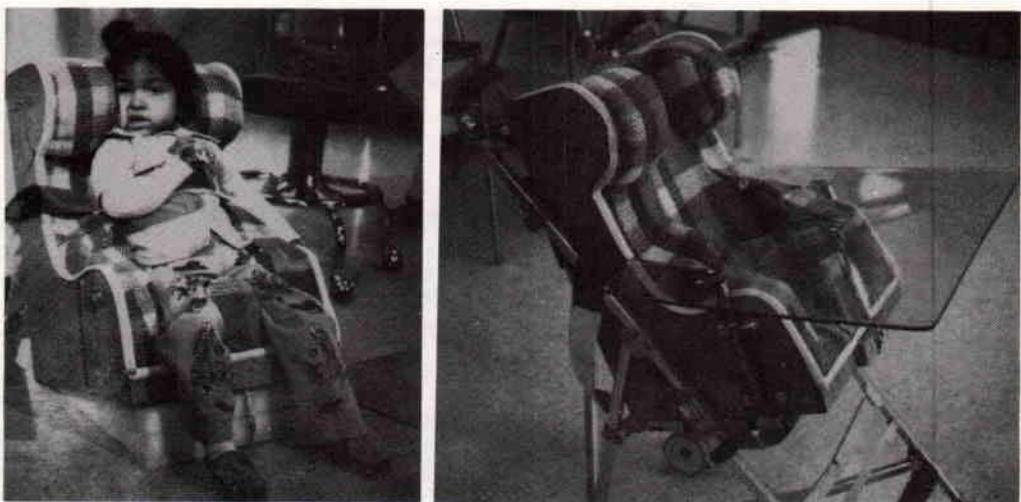


Fig. 7. Two views of the CP Type 2 orthopedic seat insert. Note the tight fit needed to maintain the spinal deformities and asymmetric tonic neck reflex.

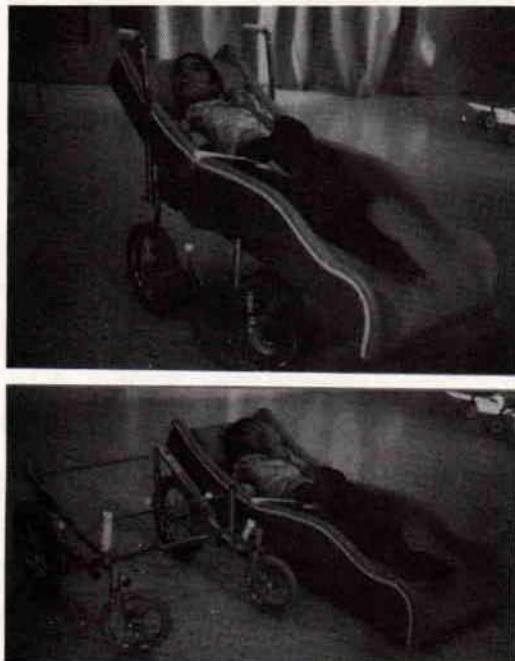


Fig. 8. An example of the CP Type 3 orthopedic seat insert. It is designed to provide comfort during transportation and school attendance.



Fig. 9. A combination of O Type 1 and O Type 3 seats. O Type 1 seat provides this bilateral hip-disarticulation amputee with trunk stability, and the O Type 3 seat redistributes the weight for tissue trauma management.

well-fitting seat portion that locates the patient firmly within the wheelchair and prevents the sliding and instability that is seen on water and jell cushions. This type of seat insert often includes build-ups for spreading of the thighs. It may include abduction blocks to prevent mentally impaired people from sliding out of the chair. It may include side supports as well.

O TYPE 2

An orthopedic seat insert (Figs. 10 and 11) primarily for muscular dystrophy is described by Dr. D. Gibson from Toronto. This type of chair differs from all others by the fact that it is shaped to have good lumbar arching built into the posterior support. The reason for this is that once the lumbar spine is arched, the spinal processes of the vertebrae lock up on each other

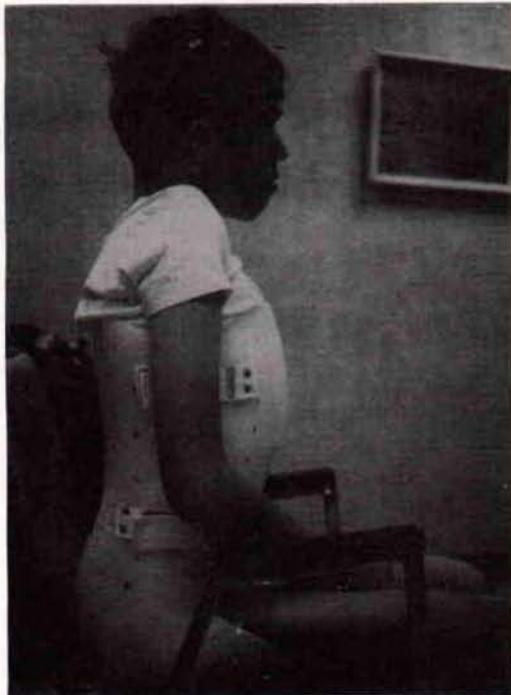


Fig. 10. An O Type 2 orthopedic seat insert for a muscular dystrophy patient. Note the exaggerated lumbar lordosis used to prevent the vertebrae from rotating on each other to prevent spinal curvatures.

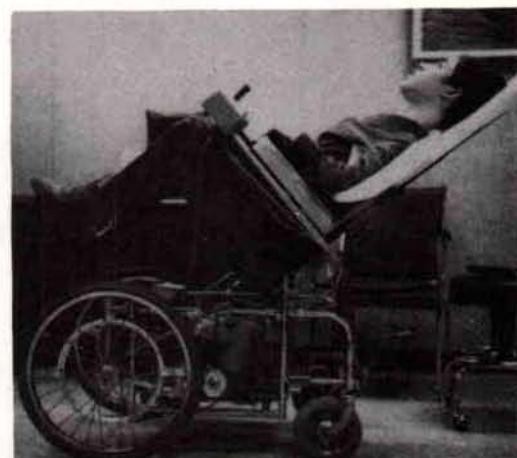


Fig. 11. An O Type 2 orthopaedic seat insert with a power-recliner wheelchair.

and prevent the vertebrae from rotating thus lessening the likelihood of scoliosis. This type of seat often includes reclining features as well as padded sides, trunk supports, and head rests. Frequently, the seat insert is positioned on an electric wheelchair base. Therefore, electric power recliners are recommended. A seat, consequently, needs to be connected to the recliner or be hinged posteriorly to allow for position change and to extend the duration of time for which the patient will be comfortable.

O TYPE 3

These orthopedic seat inserts (Fig. 12) are specially shaped seats that are part of a tissue trauma management routine. They are shaped to redistribute the pressure as evenly as possible over the weightbearing areas and to shift weight from ischial tuberosity and coccyx to other areas which are more tolerant to pressures. Often there are other devices used in this management routine, including suspension seats, height adjustments of arm rest, time sharing of different body areas for weightbearing, and height adjustment of the foot rest. Because the cost of healing a pressure sore can range between \$15,000 and \$30,000, any devices that can be created to eliminate this problem are apt to be extremely cost effective. Tissue trauma may result for many reasons. Most common are excessive pressure, excessive duration of pressure, tissue tension, patient's state of mind, state of health, condition of the skin, condition of the circulatory system, and the shape of the underlying bony protuberances. Of significance is the relationship between the pressure and the time. John Rogers quantitatively described the situation (2). It should be noted that as the pressure rises, the acceptable duration gets shorter and vice versa. In the tissue trauma clinic, the permissible pressure discussed is in the order of two pounds per square inch. This roughly rounded off number of two pounds per square inch can be used to describe the magnitude of the problem that a particular patient faces. If we consider a patient whose torso and upper limbs weigh 100 pounds and who is sitting on a 30 square inch area we can calculate as follows:

$$p = \frac{w}{a} = \frac{100}{30} = 3.3 \text{ psi}$$

In this case, the patient is exceeding his permissible pressure and thereby limiting his duration of sitting time. This means something rather substantial would have to be done to give him a day's use (8-12 hours) of his seat.

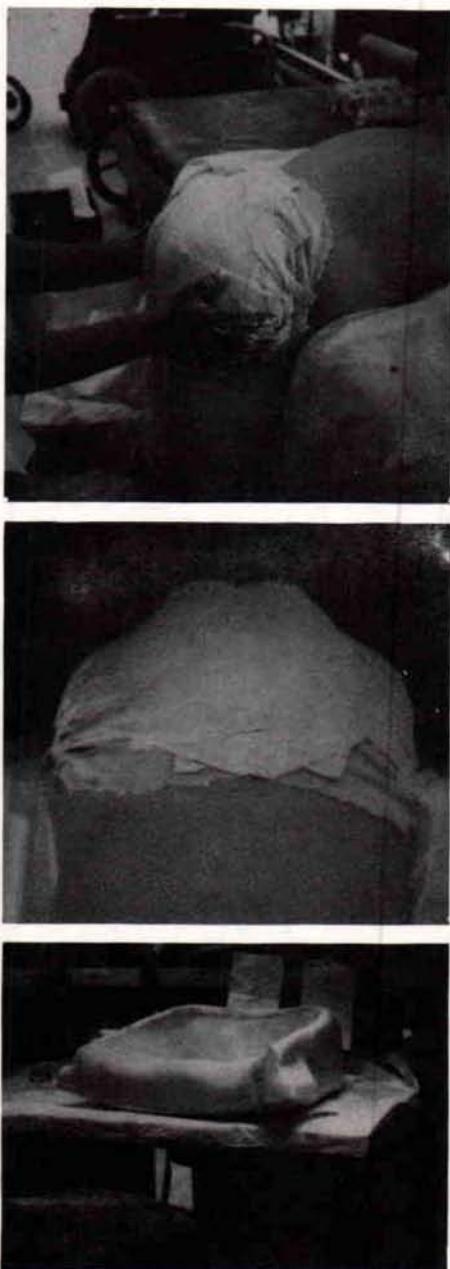


Fig. 12. The O Type 3 orthopedic seat. Top, cast taking technique; center, view showing the extent of protrusion of ischial tuberosities and sautrochanteric shelf; bottom, finished seat. Note that the contour of the bottom of the seat follows the sag of the wheelchair upholstery.

TABLE 1 CLASSIFICATION OF ORTHOPEDIC SEATS AND SEAT INSERTS

Sitting duration in the seat	<i>Cerebral Palsy Orthopedic Seat</i>	<i>Other than CP Orthopedic Seats</i>
SHORT Up to 3 hours	<p>(Fig. 4)</p> <p>CP TYPE 1</p> <p>Purpose: Driver's seat, operator's seat to maximize upper limb functions</p> <p>Fit: Snug, with spacial positioning to enhance the sense of balance and security. Ideal for electric wheelchair use.</p> <p>Growth Adjustments: Fairly frequent (every 1-3 yrs)</p>	<p>(Fig. 9)</p> <p>O TYPE 1 Balance improving seat</p> <p>Purpose: Wheelchair base/foundation from which the person functions. Usually for fused hips or rigid spine deformities, pelvic obliquity, sliding out problems.</p> <p>Fit: Fairly precise, good accomodation of protuberances and deformities.</p> <p>Growth Adjustments: Infrequent (every 2-3 years)</p>
MEDIUM Up to 6 hours	<p>(Fig. 7)</p> <p>CP TYPE 2</p> <p>Purpose: Deformity Management, Seat like an orthosis for deformities, contractures, sliding out of chair.</p> <p>Fit: Snug only in areas of force application.</p> <p>Growth Adjustments: Frequent (every 8-18 months)</p>	<p>(Figs. 10 & 11)</p> <p>O TYPE 2</p> <p>Purpose: Positioning of muscular dystrophy patients in lumbar lordosis posture to prevent spinal curvatures. (Toronto M.D. seats)</p> <p>Fit: Medium tight, good side supports, head supports, sometimes the back is hinged to allow power reclining.</p> <p>Growth Adjustments: Frequent (every 8-18 months)</p>
LONG Up to 10 hours	<p>(Fig. 8)</p> <p>CP TYPE 3</p> <p>Purpose: Comfort and safety for transportation and school use.</p> <p>Fit: Seat well padded, very loosely fitting to allow movement within chair. — Usually reclined to distribute pressure over large area to prolong sitting time.</p> <p>Growth Adjustments: Infrequent (every 2-4 years)</p>	<p>(Fig. 12)</p> <p>O TYPE 3</p> <p>Purpose: Tissue Trauma Management</p> <ul style="list-style-type: none"> — Redistribution of pressure — Relocation of weight-bearing areas usually supplemented by other tissue trauma management tools and techniques. <p>Fit: Precise over weight-bearing areas</p> <p>Growth Adjustments: Infrequent (every 2-3 years)</p>

SUMMARY

In summary, orthopedic seat inserts can be considered under six categories. It is important to establish the type of seat to be constructed before the features can be optimized for a particular patient.

ACKNOWLEDGMENTS

The author wishes to extend his sincere thanks to the patients and staff of the Rehabilitation Engineering Center for their kind help in preparation of this article. Special appreciation should go to Mr. Lee Strakbein and Mr. Michael Walsh for their untiring assistance in the seating and mobility program.

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TREATMENT OF PLANTAR FASCIITIS AND CALCANEAL SPURS WITH THE UC-BL SHOE INSERT^{1, 2}

John W. Campbell³, and
Verne T. Inman, M.D., Ph.D.⁴

The UC-BL Shoe Insert (Fig. 1) was developed at the Biomechanics Laboratory in San Francisco as a part of several research projects on the mechanisms of the human foot. The ability of the insert to modify and control these mechanisms led to its application to many foot problems. For example, it was considered that the insert should be able to take over, at least in part, the contribution of the plantar aponeurosis to longitudinal arch stability. Consequently, the tension on this fascia would be reduced.

It was felt that a reasonable approach to test this theory was to fit patients who had plantar fasciitis. If there were little or no tension on the plantar aponeurosis the symptoms of stress and pain should be alleviated. To this end a clinical program was initiated to have local physicians send to the laboratory those patients with plantar fasciitis whose condition was resistant to treatment by usual methods. A number of patients were fitted over the years with a statistically significant degree of success, which not

only proved that it was possible to unload the stress on the plantar aponeurosis in weight-bearing, but that use of the shoe insert constituted an ideal treatment for plantar fasciitis. Coincidentally, a number of patients with painful heel spurs were fitted to test the theory that the basic cause of both conditions was the

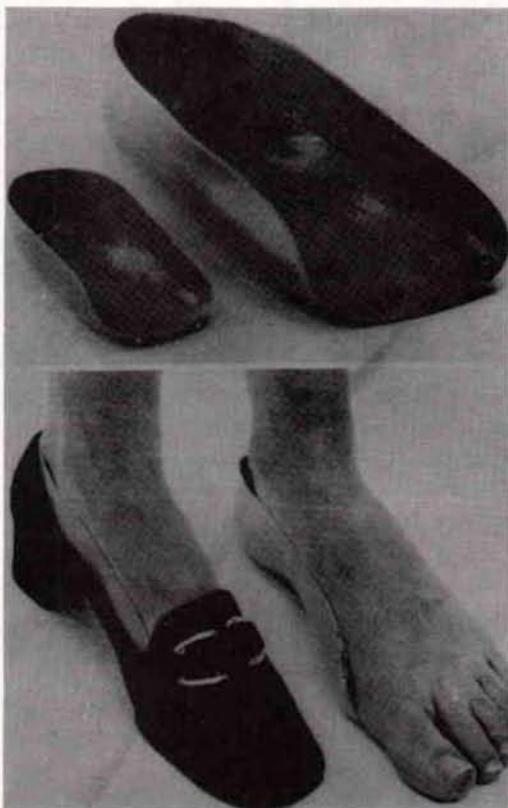


Fig. 1. The UC-BL Shoe Insert. (top) Child and adult sizes. (bottom) The insert in the shoe and on the foot. (Reproduced, with permission, from DuVries' Surgery of the Foot. Ed. 3. Inman, V. T. (ed.) St. Louis, C. V. Mosby Co., 1973.)

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²The UC-BL Shoe Insert was developed with the support of Office of Vocational Rehabilitation (later, Vocational Rehabilitation Administration) Research Grants RD-924-M and RD-1112-M. Further studies were made with the support of Social and Rehabilitation Service Research Grant RD-2860-M and Veterans Administration Contract V1005M-2075.

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same. The rate of success was extremely high for both conditions. This work was continued at the University of California, Los Angeles, with similar results, and is now included in the Prosthetic-Orthotic Education Program for Physicians, Therapists, Orthotists and Prosthetists.

PRESENT CONCEPTS

Plantar fasciitis and painful heel spurs of nonsystemic origin have been thought of as two separate entities. Plantar fasciitis was considered a simple strain. In the case of the painful heel spur many physicians considered that the heel spur itself injured the tissue on weight-bearing. The diagnosis was made by palpating the length of the plantar fascia and by x-ray. When x-ray revealed a heel spur and the area of the spur was painful the diagnosis was a painful heel spur, but when there was no heel spur, regardless of where the pain was elicited anywhere along the plantar aponeurosis, including its attachment to the calcaneus, a diagnosis of plantar fasciitis was made.

There is a second, more recent school of thought that attributes both conditions to a simple strain and maintains that a heel spur is just a further development of plantar fasciitis. The concept of this school is that when the strain occurs at the calcaneal attachment the resultant inflammatory process may stimulate a proliferation of bone into the fascia to secure the attachment, with the development of a heel spur. The continuing pull of the fascia in weight-bearing perpetuates the inflammation and a chronic situation develops.

These two schools of thought imply radically different treatment. If the first school is right and the heel spur irritates the soft tissue and causes the inflammation, then the logical approach is to remove the offending spur surgically. This treatment is questionable because of the varying degrees of success reported by surgeons and the number of times spur regrowth occurs.

If we consider the second school of thought,

that the tissue is continually embarrassed by the forces applied to the fascia on weight-bearing, then another approach is implied; that is, if we can reduce the tension on the plantar fascia in weight-bearing, injury will not recur and the healing process can take place.

THE FIRST HALF OF STANCE PHASE

The first consideration usually presented is that plantar fasciitis is most often observed in persons with at least some degree of pes planus. Since many people still associate this condition with weak intrinsic and extrinsic musculature, it is believed that exercise will strengthen these muscles and thereby maintain the arch and relieve the other soft structures. This concept is not supported by research done by electromyography. Basmajian (1) made simultaneous electromyograms of six muscles of a group of 20 subjects under static load of 45.4 to 181.4 kg. The muscles tested were the tibialis anterior and posterior, peroneus longus, flexor hallucis longus, abductor hallucis, and flexor digitorum brevis. The contribution of these muscles was considered insignificant until the load reached 181.4 kg, and even then some muscles remained inactive. Basmajian concluded that the passive structures (bone and ligament) are the only ones capable of sustaining an unremitting load. "The first line of defense of the arches is ligamentous" (p. 1190).

Mann and Inman (6) found that there was little if any significant activity of the intrinsic musculature during quiet standing. They also found that the plantar intrinsic muscles did not elicit a significant response until 30 percent of the gait cycle (midstance), or just prior to heel rise. Therefore, in the first half of stance phase the entire weight of the body is borne by the passive structures (bone and ligaments). At this point the arch has descended to its lowest point.

Cunningham (2) found that at about 15 percent of the gait cycle (foot flat) the foot is subjected to 120 percent of the body weight. This loading occurs before the intrinsic muscles

are active. With such loads supported only by the passive structures, fatigue and injury to the ligaments and particularly the plantar fascia should be common, as indeed they are — to the point that when standing for any length of time, a person shifts his weight to the outside of the feet, muscularly raising the arches, and relieving the ligaments, or he rises up on the toes to gain relief. In fact, when true injury occurs the patient may walk on his toes all the time.

THE SECOND HALF OF STANCE PHASE

In 1954 Hicks (4) described the powerful contribution of the plantar fascia in stabilizing the foot from heel rise to toe-off. Since the attachment of the plantar fascia is distal to the metatarsophalangeal joints, extension of these joints such as occurs with dorsiflexion of the toes causes tension on the fascia (Fig. 2). Hicks



Fig. 2. Dorsiflexion of the toes causing tension on the plantar fascia. (Reproduced, with permission, from DuVries' Surgery of the Foot. Ed. 3. Inman, V. T. (ed.) St. Louis, C. V. Mosby Co., 1973.)

called this mechanism the windlass effect of the plantar aponeurosis. If this is true why do we rise on our toes to relieve the plantar fascia? There are two events in this part of the walking cycle which have modified the previous situation. First, obviously, the intrinsic muscles have assumed some of the load as they all contract in the second half of stance phase. Second, the arch is now at its highest point, held there by the plantar fascia and the intrinsic muscles, both acting as the truss of the bony arch. At this high-arch position the tension on the truss required to support the arch is less than it would be in a low-arch position. This can be demonstrated in the model in Figure 3. As the toes are dorsiflexed the arch must rise and the effective length of the truss (intrinsic musculature and plantar fascia) is shortened. The mechanics of an arch held in a fixed position by a truss supporting a given weight are that the tension in the truss is dependent on the angle a and the length of the truss b . A more acute angle a , with the resultant shortening of the truss b , reduces the tension in the truss necessary to support a given weight. Therefore, not only is the tension on the truss divided between the plantar fascia and the intrinsic musculature,

there is also a mechanical advantage derived from the high-arch position in the second half of stance phase.

ELEVATION OF THE ARCH TO RELAX THE PLANTAR FASCIA

There are several ways to achieve an elevated arch. The most common usually occurs by accident, when the foot is wrapped in plaster after a spur has been surgically removed. This plaster wrap is commonly done in a non-weight-bearing position which automatically relieves the plantar structures; the rigidity of the plaster holds the foot in a relaxed attitude, relieving the tension on the soft structures, including the plantar fascia. When such a cast is made into a walking cast with a rubber heel the patient walks on a pylon or stilt with the lever action of the foot completely bypassed. We suspect that those surgeons who have had success with surgical removal of a heel spur obtained most of their good results not by surgery, but by leaving the postsurgical cast on long enough for the healing process to be completed. They might very well have been equally successful if they had omitted the surgical procedure and simply used a walking cast.

The second most common way to elevate the arch is the use of an arch support in its many variations. However, the arch support, although it may elevate the arch, does not relax the plantar fascia. Consider that the arch support is lifting the arch vertically through all the soft structures until it can make its effect on the bony structures. This produces a bowstring effect. The arch of a bow can be increased by pulling or pushing on the bowstring; however, one must increase the tension on the bowstring. Hypothetically, we can consider the bony arch of the foot as the bow and the soft structures (such as the plantar fascia) as the bowstring. The reacting force of the arch support pushing on these structures creates a tension which pulls the arch to a higher position (Fig. 4). This does not relieve the tension on the fascia and, therefore, raising the arch in this case does not create the desired effect.

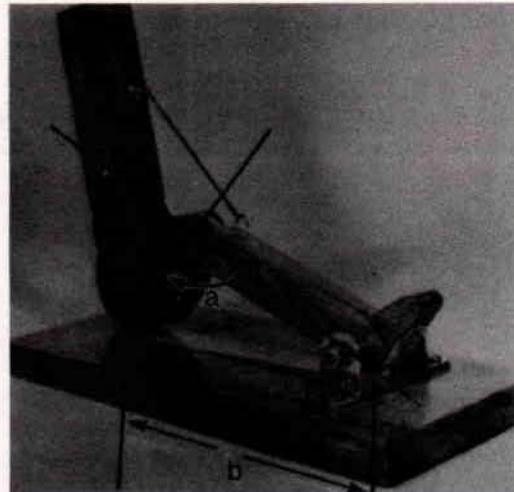


Fig. 3. Model illustrating how dorsiflexion of the toes, with shortening of the plantar fascia, raises the longitudinal arch of the foot. See text for explanation of mechanical factors involved.

THEORY OF THE UC-BL SHOE INSERT (AN ALTERNATE WAY TO ELEVATE THE ARCH)

Because of the oblique position of the axis of the subtalar joint, this articulation acts like a mitered hinge connecting the leg and foot. Rotation of the leg about a vertical axis causes the foot to pronate or supinate. This can be readily demonstrated on oneself or on a patient by rotating the leg and observing the behavior of the foot. External rotation of the leg causes the heel to invert and the forefoot to supinate while the longitudinal arch rises simultaneously. Palpation will reveal that with this maneuver tension is reduced in the plantar fascia. The theory of the UC-BL Shoe Insert is to hold the foot in a position that relieves tension on the plantar fascia; this is accomplished by holding the heel in inversion and applying forces against the navicular and the outer side of the forefoot, without direct pressure on the soft tissues under the longitudinal arch. In order to construct the insert properly, a plaster wrap of the foot is

taken. Before the plaster cast sets, the patient is asked to stand with partial weight upon the involved leg. The leg is then externally rotated while the forefoot is held in pronation and slight adduction (Fig. 5). No pressure is applied to the plaster cast under the longitudinal arch.

When a plaster wrap is obtained, a plaster positive is made from this negative. Finally a plastic shell is made by laminating layers of nylon and fiber glass over the plaster positive. The plastic shell holds the foot in the position in which it was cast and it is thin enough to slip into the patient's shoe. For details of the whole casting and fabrication procedure, see Reference 3.

RESULTS IN PATIENTS WITH PLANTAR FASCIITIS

In the last five years in the Biomechanics Laboratory, a total of 23 patients have been fitted with the UC-BL Shoe Insert for plantar fasciitis. In the last 15 months a total of 10

Fig. 4. Bowstring effect resulting from upward force on plantar fascia exerted by an arch support.

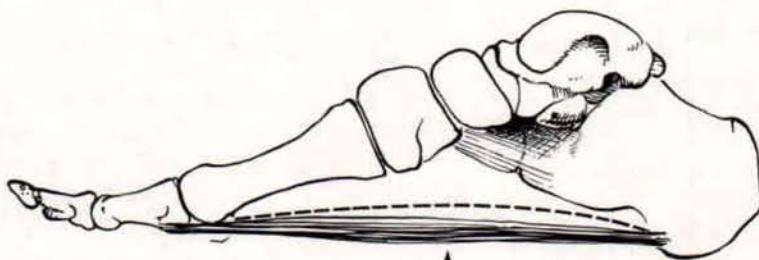
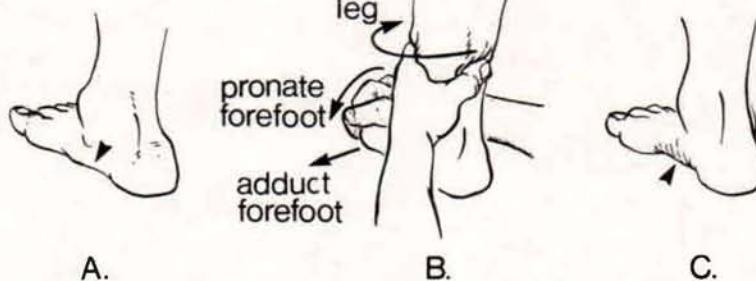


Fig. 5. Position of foot for taking plaster cast for shoe insert. A, Initial position of weight-bearing foot. B, Manipulation to desired position. C, No pressure exerted on plantar fascia and longitudinal arch.



patients have been fitted with the insert at the UCLA Rehabilitation Center in Los Angeles. Most of these patients had been treated previously with arch supports, heel cushions, steroids, and phenylbutazone, without success. In all but 2 cases the relief from discomfort with the shoe insert was almost instantaneous and the patients were able to bear weight on their heels. The two unsuccessful cases were those of a patient with an undiagnosed Reiter's syndrome and a patient who had arthritic changes in the talocrural joint.

Most patients with plantar fasciitis who are treated with steroids and phenylbutazone have relief, with no further treatment necessary. In the severe cases, however, only temporary relief appears to be obtained from these treatments, and the patients go on from one treatment to another and are finally reduced to sitting until the inflammation subsides. This severe type of condition is the one for which we have prescribed the UC-BL Shoe Insert. The majority of these people wore the insert from 1 to 3 months and were then able to walk unaided. However, since plantar fasciitis tends to

recur the patients wear the insert at the first sign of recurrence and continue its use until the symptoms have abated.

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CLINICAL EXPERIENCE AND FUNCTIONAL CONSIDERATIONS OF AXIAL ROTATORS FOR THE AMPUTEE

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James W. Breakey, M.Sc.¹

Throughout the growth of the prosthetics profession numerous components that have appeared promising for the amputee have been developed. However, after clinical evaluation the component was often shelved because of poor function, high costs, lack of reliability, excess weight, and poor cosmesis.

The objective of this paper is to examine the clinical use and acceptance of the axial rotation component of an artificial leg. We define a rotation unit as that device which allows external and internal rotation to occur when a transverse rotational force is applied at the prosthesis-floor interface, and permits the foot to return to its aligned position when the force is removed.

During normal walking transverse rotations in the lower limb occur with relation to the pelvis, the hip joint, the femur, and the tibia. These rotational forces are somewhat absorbed at the joints of the lower limb and finally resolved at the torso of the body.

In the below-knee and above-knee amputee, these rotational forces are absorbed at the interface between the socket and the residual limb creating shear forces on tissue. Also, instability can occur (especially in bilateral lower-limb amputees) as a result of the rotational forces causing a transverse rotation between the foot and the ground.

Three axial rotation devices are presently commercially available (Table 1); the Weber-Watkins design, the STAR (Shank, Torque Ankle Rotator), and the Hosmer Modularrotator. All three devices perform the same

function in that they allow axial rotation to occur along the longitudinal axis of the prosthesis and each returns the prosthetic foot to the aligned position once the axial torque is removed.

EVALUATION OF AXIAL ROTATORS

In order to draw any conclusions as to the indications for use and acceptance of a component, it is first necessary to define its need and function. Then one can compare the definition with actual clinical use, receiving feedback from both prosthetist and patient.

Generally, rotators are designed to provide a substitute for the lost axial rotation and to provide axial rotation when necessary prosthetic components (i.e. BK side joints and thigh lacer or hip joint and pelvic belt) restrict motion of the residual limb.

Normal gait requires a total of approximately 23 deg. (2) of axial rotation between the foot, the tibia, the femur, and the pelvis. Because the below-knee amputee retains natural knee rotation (except when side joints and thigh lacer are used), the above-knee amputee will receive greater rotational benefits from an axial rotator unit, especially when an external hip joint and metal pelvic band are used.

Can an axial rotator device reduce the shear force on the tissues of the residual limb? Lamoreux and Radcliffe (3) (Fig. 1) compared the axial torques occurring in an above-knee prosthesis with and without an axial rotator unit operating. An approximate 60 percent reduction in external torque on the shank of the prosthesis was found in mid-stance phase, and an approximate 76 percent reduction of internal torque

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TABLE 1
DESCRIPTION OF COMMERCIALLY AVAILABLE AXIAL ROTATOR UNITS

WEBER-WATKINS:

1. First commercially available unit, in late 1971.
2. Weight is approximately 700 gms, but now is available in a lighter endoskeletal model.
3. Problems have included weight, cosmesis, special installation, and reliability.

STAR:

1. Developed at Rancho approximately mid 1974 in conjunction with United States Manufacturing Co. of Glendale, California.
2. Weight of crustacean type is approximately 450 gms.
3. Problems have included breakage and slow return of foot to aligned position. Both initial problems appear to have been resolved.

HOSMER MODULOROTATOR:

1. Developed in mid 1974 from experience gained by U. C. Berkeley with their axial rotator.
 2. Lightest of available units, approximately 300 gms.
 3. Most cosmetic — in crustacean type of prosthesis it is located at the junction of the foot and ankle.
 4. Problems have included breakage and noise. Both these initial problems appear to have been resolved.
-

upon the prosthetic shank was found in late-stance phase on the amputated side.

We consider the amount of time lapsed between the maximum external torque without torque absorber in mid-stance phase and the maximum internal torque in late-stance to be as significant as the magnitudes of the torques (Fig. 1) in causing injury to the soft tissues of the residual limb. The amount of time elapsed was approximately two-tenths of a second when the amputee was walking at a cadence of 85 steps per minute (1). We consider that the addition of a torque absorbing device besides reducing the magnitude of shear forces on the residual limb also reduces the abruptness of the forces, thus providing a smoother transition of forces to the residual limb during the application of external and internal torques to the prosthesis during walking.

Lamoreux and Radcliffe (2) found that the relative internal-external rotation between pelvis and AK socket increased during stance phase with an axial rotation unit operating (Fig. 2). They attribute this increased rotation to the effects of muscle action within the AK socket acting about the long axis of the prosthesis. As a result, incorporation of an axial rotation device in a prosthesis allows the socket to move freely to relieve the pressures and torques caused by cyclic action of the musculature.

Without a rotator, the amputee during stance phase attempts to maintain a level pelvis by action of the hip abductors. Also, the amount of external rotation between the socket and pelvis is less compared to the same patient using a rotator. This produces a total restriction of hip joint motion as the amputee moves his body through space during mid-stance. With a

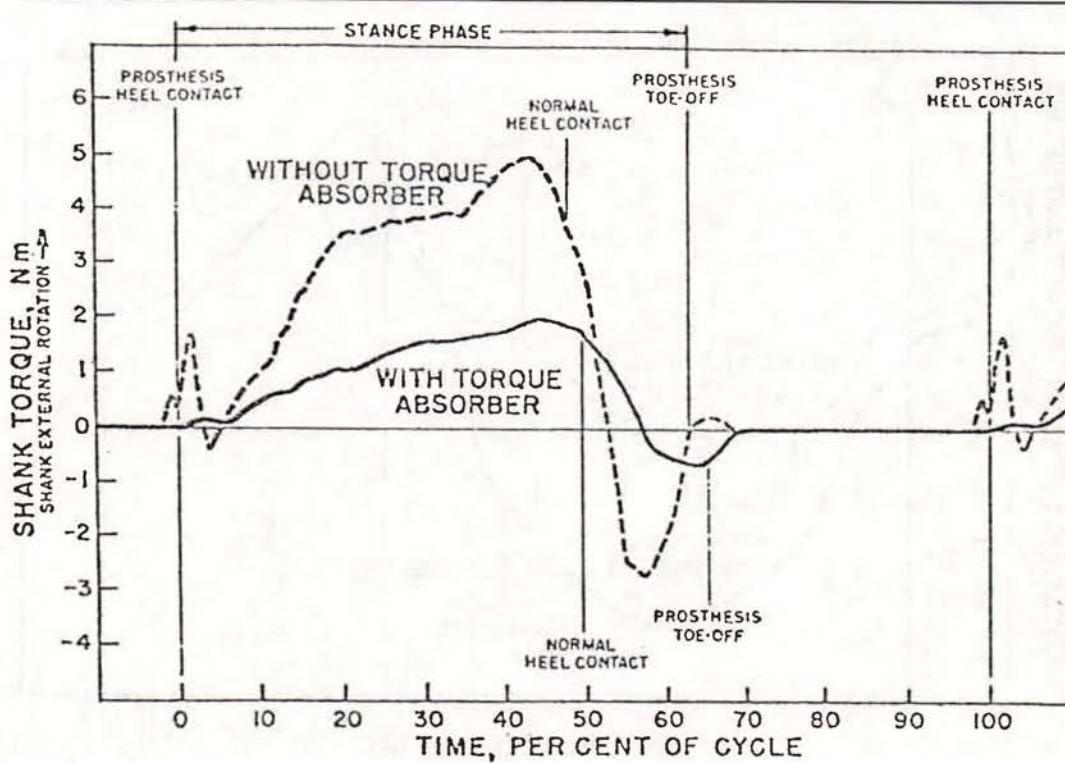


Fig. 1. A comparison of axial torques occurring in an above-knee prosthesis with and without the Axial Rotation Unit operating. (From Lamoreux and Radcliffe, 1974).

rotator, the amputee is able to rotate his pelvis in relation to the prosthesis allowing a smoother shift of his center of gravity over the prosthesis during mid-stance, and thus improving the appearance of the gait.

The biomechanical advantage mentioned above allows the active amputee to perform a full range of transverse rotation movements for such activities as golf and dancing. Also, kneeling is easier as the foot will rotate in relation to the floor when the rotator is placed below the knee joint.

CLINICAL EXPERIENCE

To determine the use and acceptance of rotators, ten prosthetic facilities in California were questioned. A total of 130 units were used

over an 18-month period. Patient distribution was as follows: 60 on above-knee amputees, 65 on below-knee, and the remainder on knee- and hip-disarticulation cases. The units used were: 38 Weber-Watkins, 61 STAR, and 31 Hosmer Modulorotators. All types of artificial feet were used including the SACH, single-axis, and the Greissinger Five-Way foot. In most cases the SACH foot was indicated because it is lightest and has the lowest maintenance requirements. Many of the younger BK patients with long residual limbs and well suspended prostheses were very enthusiastic about the freedom and the added movement they had with the combined use of the rotator and Greissinger foot.

We draw to the readers attention that gait training periods have been necessary to gain maximum effects of the rotator unit, especially for amputees who were converted to an above-

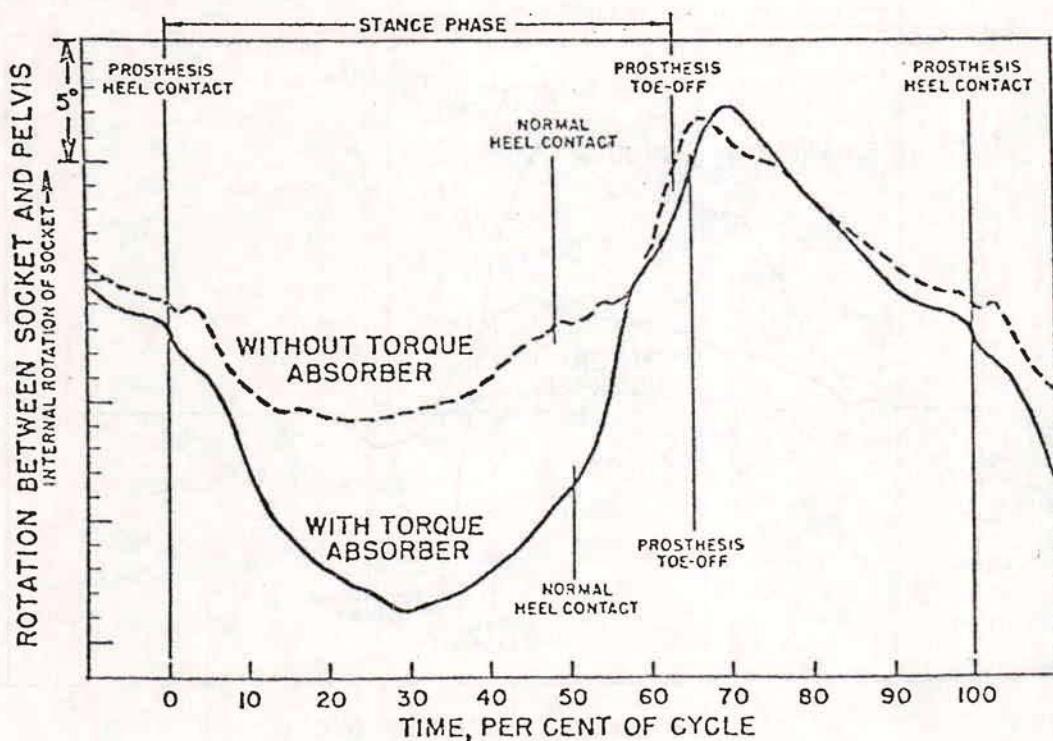


Fig. 2. A comparison of relative axial rotation between the pelvis and the socket of an above-knee prosthesis, with and without the Axial Rotation Unit operating. (From Lamoreux and Radcliffe, 1974).

knee prosthesis with a rotator installed after years of previous ambulation without a rotator. The patients had to learn to eliminate previous gait compensation patterns such as avoiding weight on the prosthetic foot while changing directions. Although most previous wearers initially commented they felt "unstable" or "off balance", after approximately one-half hour of training they quickly adapted and appreciated the increased freedom of motion.

BELOW-KNEE PATIENTS

The PTS design was used in the majority of below-knee patients in which the rotator devices were installed. PTB cuff suspension was also used but allowed too much movement to occur between the residual limb and the socket

as compared to the prosthesis incorporating supra-condylar brim suspension.

Many of the 65 BK amputees using rotators were fitted with side joints and thigh lacers. Patients reported that the rotator allowed them to carry or lift loads with less residual limb stress and generally were more comfortable during a long active work day.

Acceptance of the rotator devices has been favorable by the below-knee amputee group. Good suspension was a "must" to combat the added weight.

All the BK amputees reported feeling less shear on the residual limbs and less restriction of motion in performing their varied activities of daily living.

Prosthetists reported a reduction of previous problem areas seen on the residual limb of the patients.

The Modulorotator was the most effective in below-knee prostheses because it is suitable for all lengths of residual limbs, lightest in weight, and the most cosmetic for the crustacean type of prosthesis. The STAR was used in several patients where length of residual limb allowed room for the unit. Weight of the Weber-Watkins was a contra-indication for its use in BK prostheses.

ABOVE-KNEE PATIENTS

The patient wearing an above-knee prosthesis appears to receive the most benefit from incorporation of a rotation device in the prosthesis. Most of the AK patients were suction socket wearers who experienced relief from discomfort in the proximal socket brim area (both medial and posterior) previously experienced before the rotator was installed in the prosthesis. Many patients reported that troublesome skin abrasions in the ischial tuberosity and ischio-pubic ramus regions cleared up and generally they experienced less residual limb soreness. Patients wearing pelvic joints, belt, and prosthetic sock commented on a much "freer", less restricted feeling while turning, sitting, getting in and out of cars, and many other twisting type of activities. They also concurred with the

suction socket wearers in feeling less socket discomfort.

SUMMARY AND CONCLUSIONS

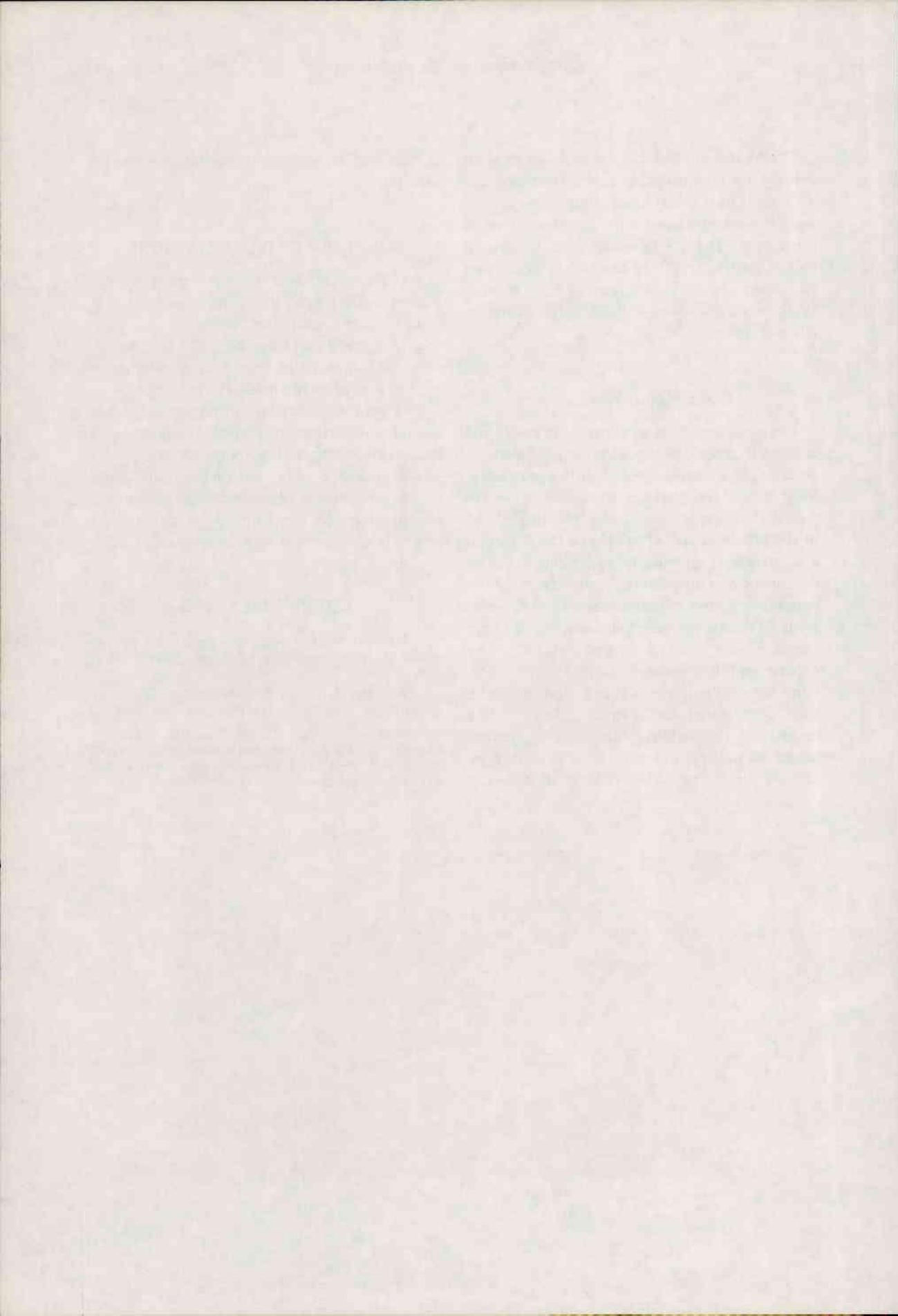
Axial rotators have been accepted by our patient group for the following reasons:

1. Greater socket comfort
2. Improved gait symmetry
3. Reduction in the frequency of occurrence of skin trauma in the residual limb.
4. Improved freedom of movement when changing direction of motion, working at a bench or counter, and in sports activities.

We conclude from our findings that axial rotator components offer functional advantages to the amputee and should be considered routinely during prosthetic prescription.

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AN ORTHOSIS FOR THE FLAIL ELBOW

Michael Lefton, C.P.O.¹

Luke Mizell, C.P.¹

With the availability of thermoplastics it is now possible for the imaginative orthotist to apply with advantage prosthetic principles to the design and fabrication of orthotic devices. Thermosetting plastics recently have been used extensively in lower-limb orthotics in the formation of quadrilateral and PTB sockets to unweight the lower limb. Plastics have been used in upper-limb orthotics, but the application has been confined primarily to orthoses used about the hand and wrist.

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The Flail Elbow Orthosis described here, made by vacuum forming sheet polypropylene, was designed to control rotation, flexion and extension, adduction and abduction, and any combination of these motions in an abnormal elbow. The patient, a seventy-year-old female, had undergone several operations involving reconstruction of her elbow. No articulating surface was left, and thus there was no possibility of either further reconstruction or total elbow replacement.

The orthosis (Fig. 1) was designed to hold the hand in a neutral position while allowing flexion of the elbow joint but no other motions.

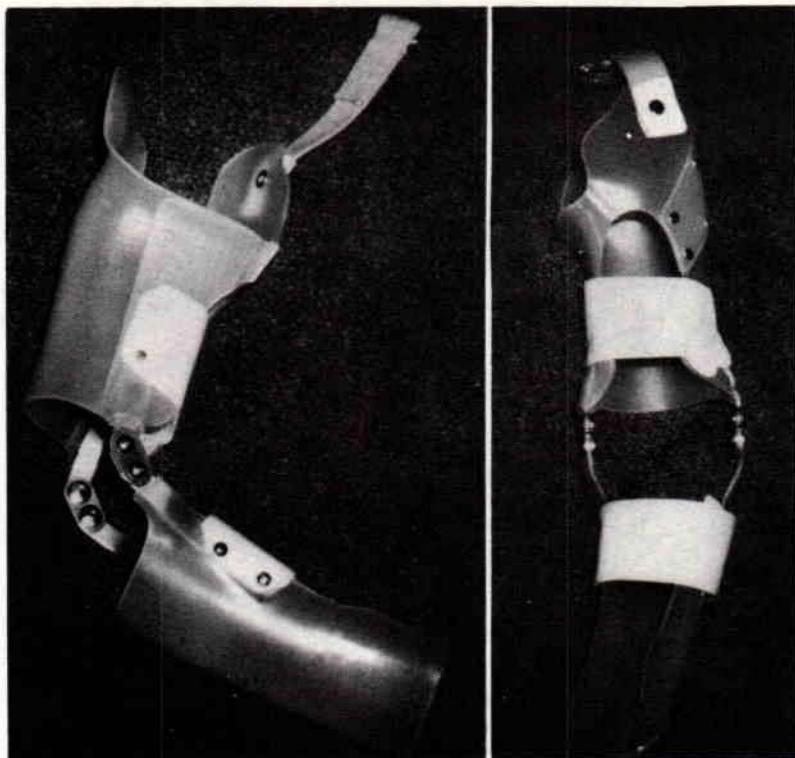


Fig. 1. Medial and anterior views of the flail elbow orthosis.

The wrist is held in position by incorporating the "screw driver" principle to prevent rotation of the radius, ulna, and humerus. Prosthetic polycentric elbow joints were incorporated to follow closely the flexion-extension motion of

the normal elbow. The proximal section was fabricated using the open shoulder, above-elbow principle (1), which allows for control of rotation of the ulna, radius, and humerus in the extended position (Fig. 2).

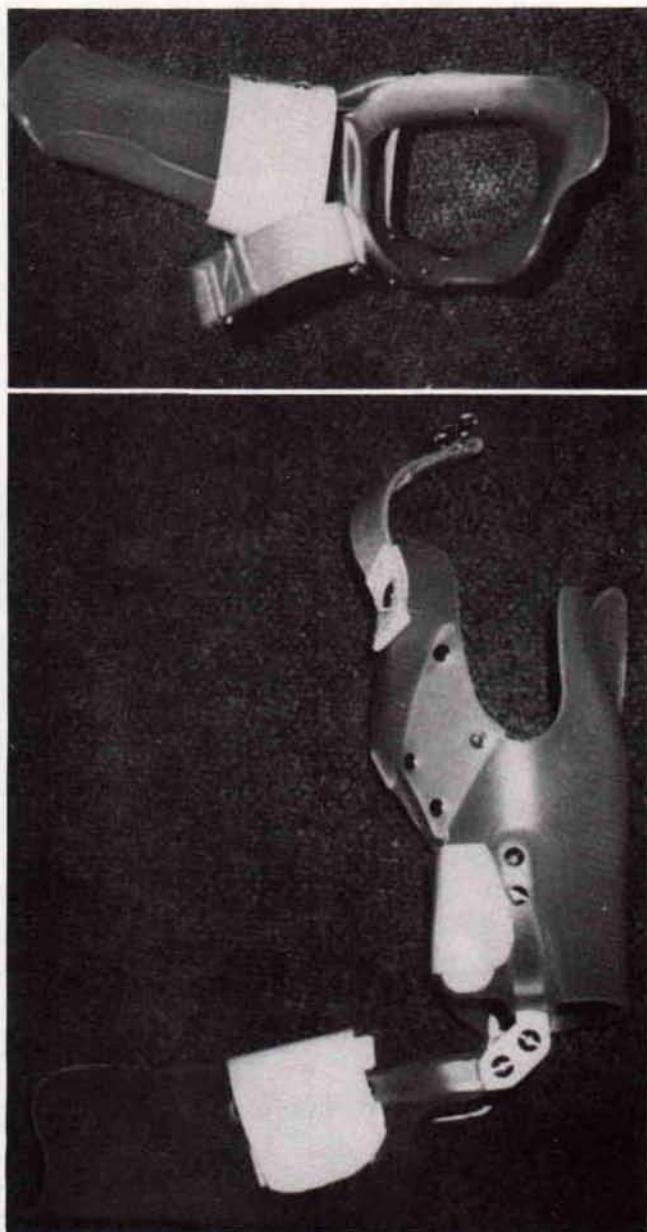


Fig. 2. Top and lateral views of the flail elbow orthosis.

A figure-nine harness was used for suspension (Fig. 3). The patient was able to perform activities such as washing dishes and cooking, which, prior to use of the orthosis, had been impossible.

Thermoplastics have allowed more latitude to the orthotist in fulfilling the needs of the patient. Application of prosthetic principles can result in simplicity, function, and improved patient activity.

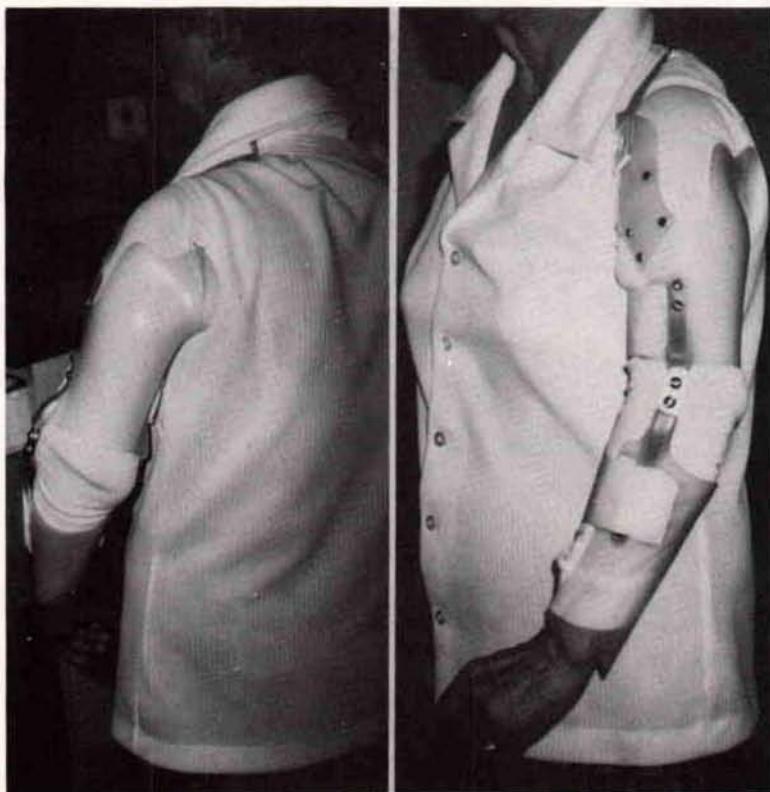


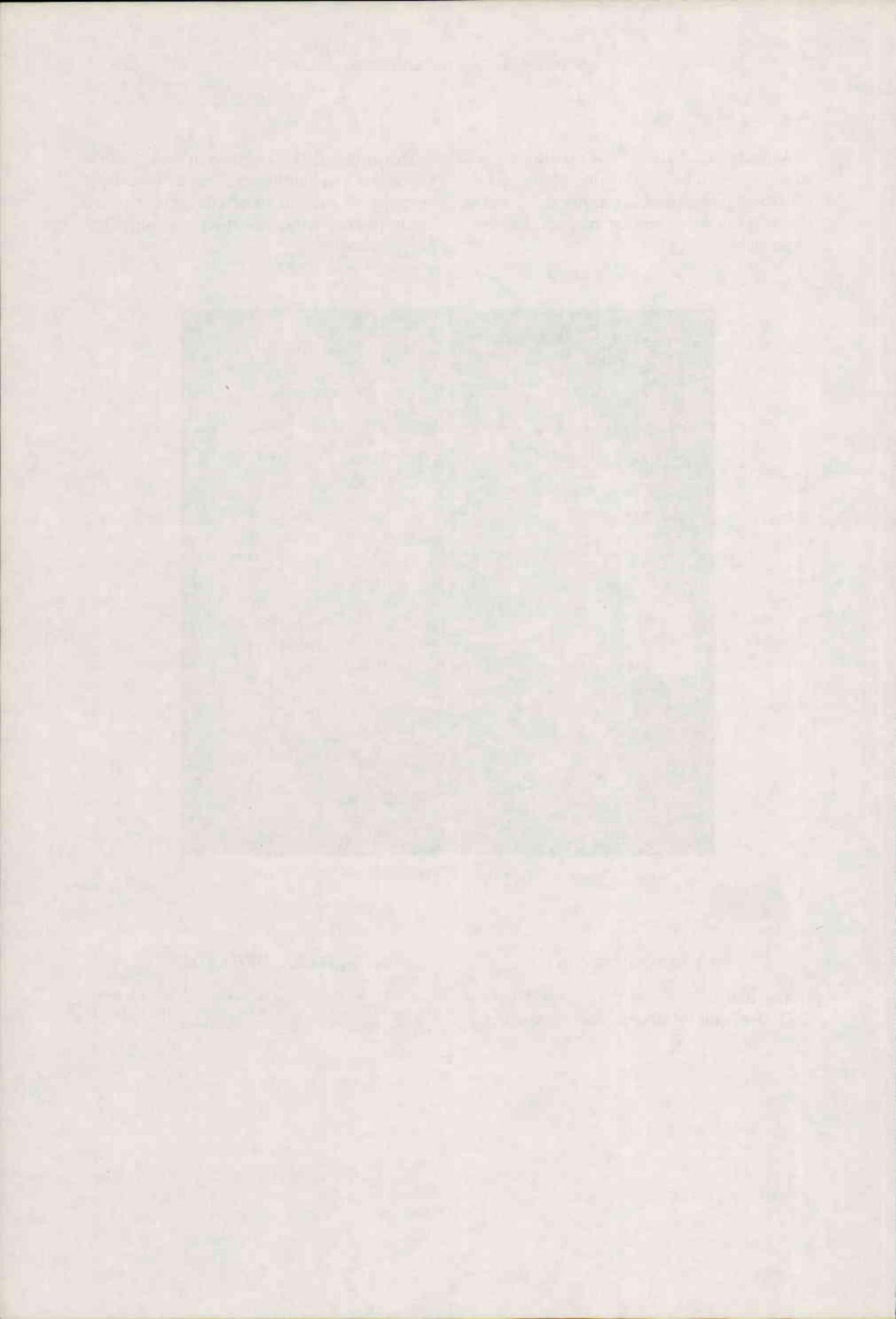
Fig. 3. Two views of the flail elbow orthosis applied to the patient.

ACKNOWLEDGMENT

The authors wish to thank David Owens, C.O., for his invaluable advice and assistance.

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PROSTHETIC MANAGEMENT OF A BELOW-ELBOW AMPUTATION WITH BRACHIAL PLEXUS INJURY¹

Alan J. Dralle, C.P.²

Although amputation of an upper limb due to brachial plexus injury is common, it is usually performed above the elbow and a shoulder fusion is carried out at the same time. In a recent case, a young man who had sustained a brachial plexus injury at the C7-T1 level was amputated below the elbow. This presented an uncommon set of prosthetic fitting problems, which are described in this report, along with the solution achieved.

The C7 root was intact, and the biceps were functional at grade 4; triceps were "trace"; deltoid, grade 4; shoulder girdle, 3+ to 4; forearm and hand 0. The patient after consultation had elected to have a below-elbow amputation, but he did not wish to be fitted for a prosthesis at the time of surgery since he had been without the use of his hand for two or three years and felt at the time that a prosthesis would not be of value to him.

He returned to the clinic one year later, however, and asked to be fitted with a functional prosthesis. A standard below-elbow prosthesis was not appropriate because the absence of triceps function resulted in an elbow without stability. The line of force from a control cable passing anterior to the center of elbow rotation would result in flexion of the patient's elbow when he attempted to use the terminal device, and, thus, the only time he would be able to open the terminal device would be when his

elbow was fully flexed. This problem was discussed with the clinic team, and since the patient wished to do repair work on his car we felt a mechanical elbow lock would be appropriate. Other design options would have been to have the control cable pass posterior to the patient's joint, negating the bending moment applied to the elbow joint by cable excursion. This was regarded as not being feasible since the patient's elbow would still be unstable in most activities of pushing or holding an object against a fixed surface.

The prosthesis of choice was a BE arm with a double wall, total-contact socket, half-cuff, and figure-of-eight harness (Fig. 1). By incorporating an E-2500 outside locking hinge joint for elbow-disarticulation amputations (Fig. 2), the required stability was provided throughout the full range of flexion and extension. The hinge was modified by cutting off the socket attachment strap and contouring the forearm straps to fit the shape of the BE socket. The prosthesis was laminated using standard procedures (*I*).

RESULTS

After initial fitting and harness adjustment, the patient was able to operate the prosthesis easily, except for the elbow lock. With a maximum of two rubber bands on a 555 Hosmer-Dorrance hook, the elbow lock was not necessary for full terminal device function since the weight of the prosthesis and terminal device prevented elbow flexion. However, as additional rubber bands were applied, he could not

¹This study was supported in part by Grant #16-P-56818 from the Social and Rehabilitation Service, DHEW

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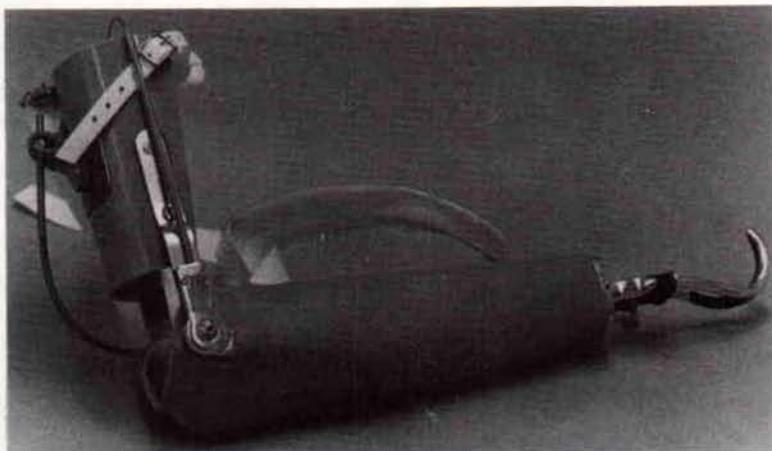


Fig. 1. The completed prosthesis.

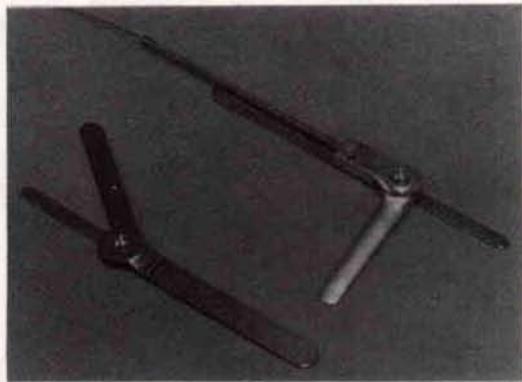


Fig. 2. The E-2500 outside locking elbow joints used in the prosthesis shown in Figure 1.

open the hook without inadvertant elbow flexion unless the lock was engaged.

Use of the elbow lock mechanism by the patient posed a slight training problem because the absence of triceps function limited his active humeral extension. The lock was finally activated by a combination of shoulder depression and abduction motions.

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NEW PUBLICATIONS

THE ADVANCE IN ORTHOTICS, edited by George Murdoch, Edward Arnold (Publisher) Ltd., London, 602 pp. £27.50.

This book contains 61 papers presented at a Conference held in Dundee, Scotland in 1973, and which was organized by George Murdoch, Orthopaedic Surgeon, Surgeon-in-Charge Dundee Limb Fitting Centre. In spite of the lag between the time of the Conference and publication, this book is quite timely because of the emphasis given to principles in orthotics and related fields.

This book is divided into 11 sections:

- INTRODUCTION (History and Philosophy)
- PRESENT ORTHOTIC PRACTICE (Upper and Lower Limbs)
- RECENT ADVANCES (Upper and Lower Limbs)
- SPINAL ORTHOTICS
- WHEELCHAIRS
- SPECIAL ORTHOTIC PROBLEMS
- EVALUATION
- TRAINING OF THE ORTHOTIST
- A REVIEW OF RESEARCH
- AN INTERNATIONAL VIEW
- ADMINISTRATION, SUPPLY, & THE CLINIC TEAM

The essence of the discussion that followed each session is included at the end of each section.

The 61 papers emanated from nine countries — Canada, Denmark, England, India, Iran, Israel, Poland, Scotland, and the U.S.A., and it can certainly be said that they for the most part reflect the more advanced practices and ideas in the Western World in the field of orthotics. The editing, presentation, and printing is excellent. To achieve all of this is, no doubt, the reason for what seems like a long lapse in time between conference and publication. At any rate this volume is well worth the wait and even the relatively high price of £27.50.

It is a must for all who are engaged in teaching, research, development, and manufacture. It is also well worth the time of clinicians — physicians, surgeons, therapists, and orthotists. In addition many administrators could profit from reading certain sections of this timely volume.

ARTHROSCOPY OF THE KNEE, R. W. Jackson and D. J. Dandy, Grune and Stratton, 102 pp., \$17.50.

This concise monograph presents a complete picture of knee arthroscopy; its history, the equipment available, how to use it, and when. The authors are certainly qualified by experience in knee arthroscopy to provide an authoritative text, and they have carried out the task in a most scholarly and readable form.

The basic contents are:

- Chapter 1 The History of Arthroscopy
- Chapter 2 Equipment
- Chapter 3 The Normal Examination
- Chapter 4 Pathological Conditions
- Chapter 5 The Problems
- Chapter 6 Applications of Arthroscopy
- Chapter 7 The Impact of Arthroscopy

The chapters are supplemented by a foreword by Dr. S. Ward Casscells, a comprehensive 77-entry bibliography and an index.

This book will be of interest to only a limited number of orthotists and prosthetists, but certainly will be of tremendous interest to all orthopaedic surgeons.

INFORMATION FOR AUTHORS
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EDUCATION

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3. Indicate BIBLIOGRAPHICAL REFERENCES by means of Arabic numerals in parentheses (6).
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6. Use the word "Figure" abbreviated to indicate references to illustrations in the text (. . . as shown in Fig. 14)

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- Authors will be supplied with 25 reprints.

RESOLUTION CONCERNING THE METRIC SYSTEM

The following resolution was adopted by the Board of Directors of the American Orthotic and Prosthetic Association at its meeting in San Diego October 3, 1973:

WHEREAS by Act of Congress it has been determined that the United States should proceed towards adoption of the metric system as used almost universally throughout the rest of the world, and

WHEREAS the technological professions and many segments of the health professions have commonly used the metric system over an extended period of time, and

WHEREAS it is important for members of the orthotic/prosthetic professions to interact with their colleagues in the medical and technological communities for optimum patient service be it hereby

RESOLVED that the American Orthotic and Prosthetic Association endorses the use of the metric system: by its members and other orthotic and prosthetic practitioners in the United States, and in witness of this endorsement and Association urges the editors of its journal *Orthotics and Prosthetics* to commence the dual reporting of weights and measurements in both the English and metric systems at the earliest possible date with the objective of employing the metric system solely by the time of the 29th Volume in 1975.

METRIC SYSTEM Conversion Factors

LENGTH

Equivalencies

angstrom	$= 1 \times 10^{-10}$ meter (0.0 000 000 001 m)
millimicron*	$= 1 \times 10^{-9}$ meter (0.000 000 001 m)
micron (micrometer)	$= 1 \times 10^{-6}$ meter (0.000 001 m)

To Convert from	To	Multiply by
inches	meters	0.0254†
feet	meters	0.30480†
yards	meters	0.91440†
miles	kilometers	1.6093

AREA

To convert from

square inches	square meters	0.00063616†
square feet	square meters	.092903

VOLUME

Definition

1 liter = 0.001† cubic meter or one cubic decimeter (dm^3)
 (1 milliliter = 1† cubic centimeter)

To convert from	To	Multiply by
cubic inches	cubic centimeters	16.387
ounces (U.S. fluid)	cubic centimeters	29.574
ounces (Brit. fluid)	cubic centimeters	28.413
pints (U.S. fluid)	cubic centimeters	473.18
pints (Brit. fluid)	cubic centimeters	568.26
cubic feet	cubic meters	0.028317

MASS

To convert from

pounds (avdp.)	kilograms	0.45359
slugs‡	kilograms	14.594

FORCE

To convert from

ounces-force (ozf)	newtons	0.27802
ounces-force (ozf)	kilogram-force	0.028350
pounds-force (lbf)	newtons	4.4732
pounds-force (lbf)	kilogram-force	0.45359

*This double-prefix usage is not desirable. This unit is actually a nanometer (10^{-9} meter = 10^{-7} centimeter).
 †For practical purposes all subsequent digits are zeros.

STRESS (OR PRESSURE)

To convert from	To	Multiply by
pounds-force/square inch (psi)	newton/square meter	6894.8
pounds-force/square inch (psi)	newton/square centimeter	0.68948
pounds-force/square inch (psi)	kilogram-force/square centimeter	0.070307

TORQUE (OR MOMENT)

To convert from	To	Multiply by
pound-force-feet	newton meter	1.3559
pound-force-feet	kilogram-force meters	0.13826

ENERGY (OR WORK)**Definition**

One joule (J) is the work done by a one-newton force moving through a displacement of one meter in the direction of the force.

$$1 \text{ cal (gm)} = 4.1840 \text{ joules}$$

To convert from	To	Multiply by
foot-pounds-force	joules	1.3559
foot-pounds-force	meter-kilogram-force	0.13826
ergs	joules	$1 \times 10^{-7}\dagger$
b.t.u.	cal (gm)	252.00
foot-pounds-force	cal (gm)	0.32405

TEMPERATURE CONVERSION TABLE

$$\text{To convert } ^\circ\text{F to } ^\circ\text{C} \quad ^\circ\text{C} = \frac{^\circ\text{F} - 32}{1.8}$$

${}^{\circ}\text{F}$	${}^{\circ}\text{C}$
98.6	37
99	37.2
99.5	37.5
100	37.8
100.5	38.1
101	38.3
101.5	38.6
102	38.9
102.5	39.2
103	39.4
103.5	39.7
104	40.0

*A slug is a unit of mass which if acted on by a force of one pound will have an acceleration of one foot per second per second.

PHOTOGRAPHIC GUIDELINES FOR CONTRIBUTORS TO *ORTHOTICS & PROSTHETICS*

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

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

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

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

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

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

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

Suggested sources of inexpensive photographic work:

- 1) If you are located at or near a college or university, contact the student newspaper. Student photographers often do work equal to or better than that of commercial studios, and usually for far less money.
- 2) If you are near the National Office in Washington, D.C., contact the Director of Informational Services about having the staff photographer handle the job. Requests for this work must of course come at least 2 months in advance of the actual printing deadline.

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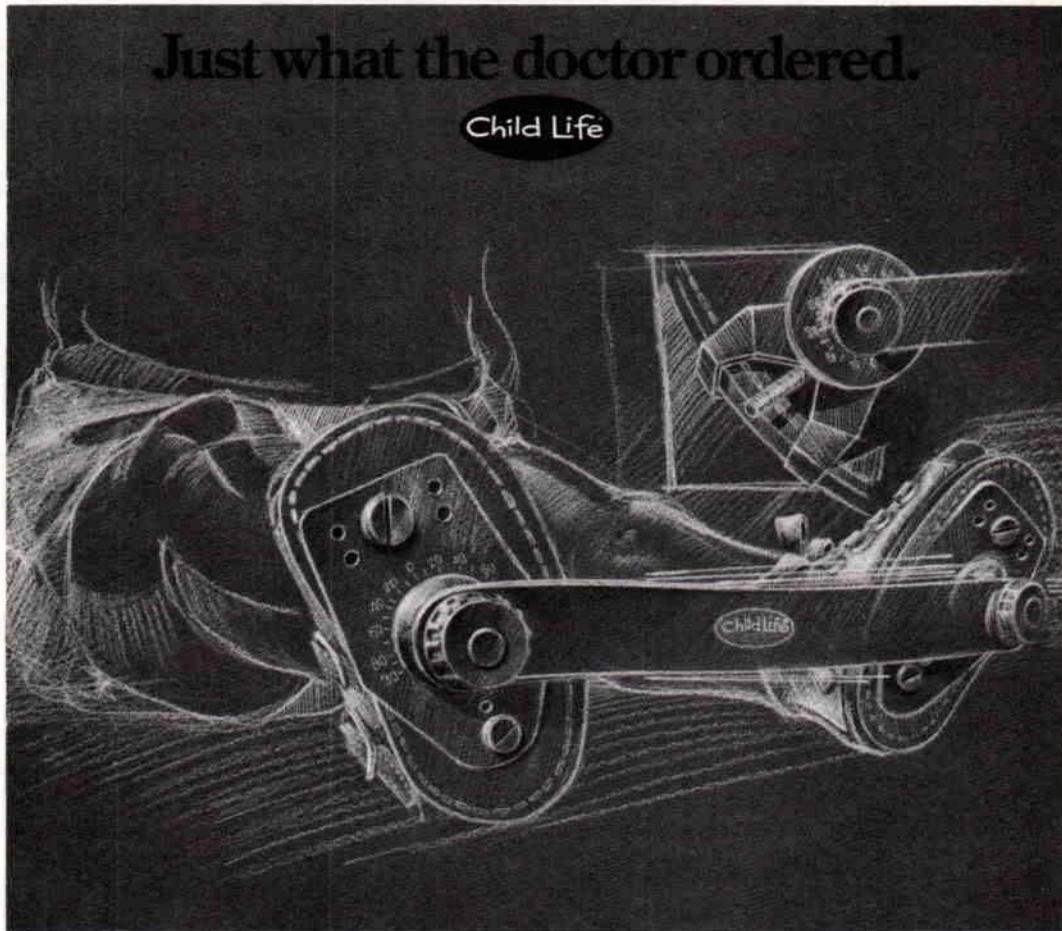
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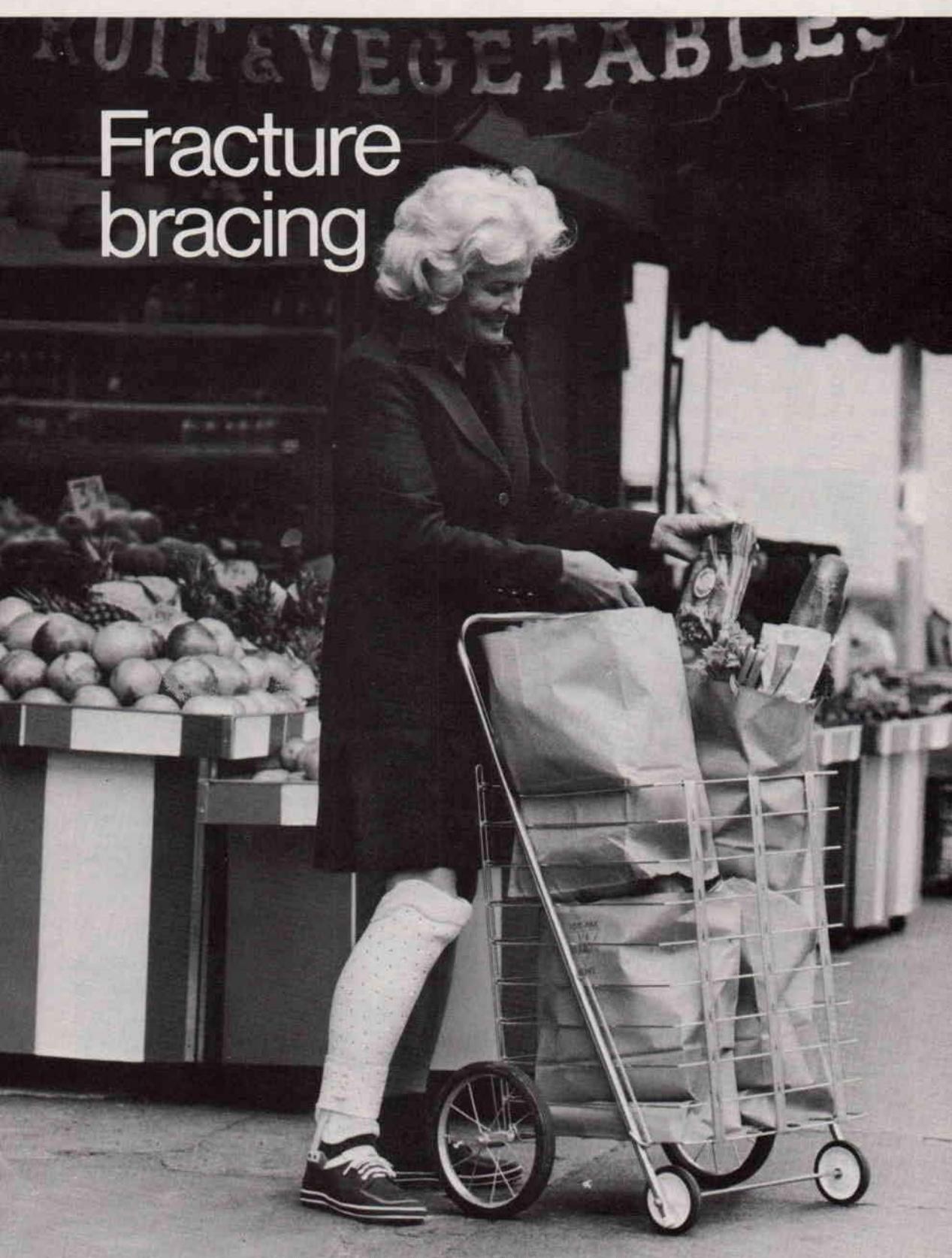
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References: 1. Sarmiento, A.: Functional below-the-knee brace for tibial fractures, *J. Bone Joint Surg.* 52-A:295, 1970. 2. Sarmiento, A.: Functional bracing of tibial and femoral shaft fractures, *Clin. Orthop.* 82:2, 1972. 3. Sarmiento, A., Cooper, J., and Sinclair, W.F.: Forearm fractures, *J. Bone Joint Surg.* 57-A:297, 1975. 4. Sarmiento, A., et al.: Colles' fractures, *J. Bone Joint Surg.* 57-A:311, 1975. 5. Sarmiento, A.: Functional bracing of tibial fractures, *Clin. Orthop.* 105:202, 1974.

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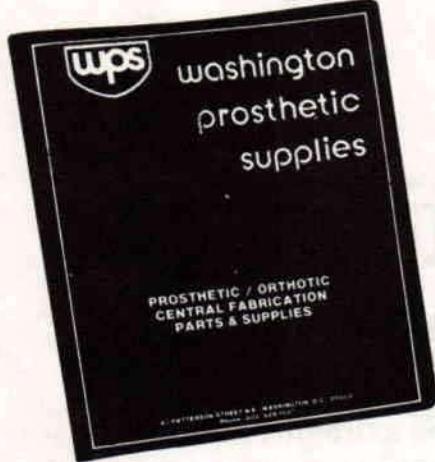
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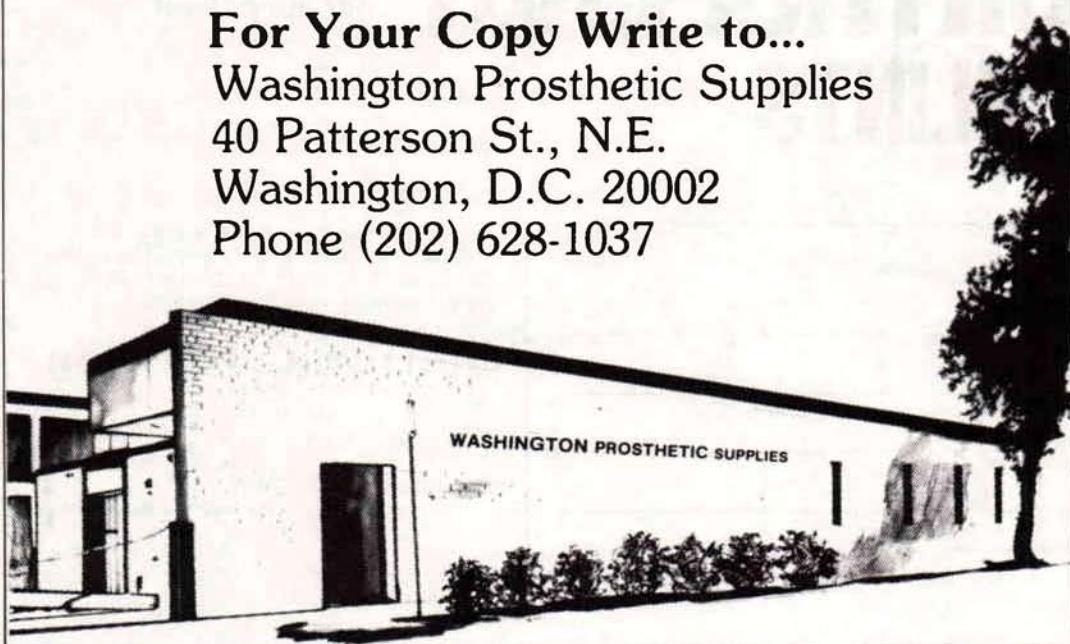


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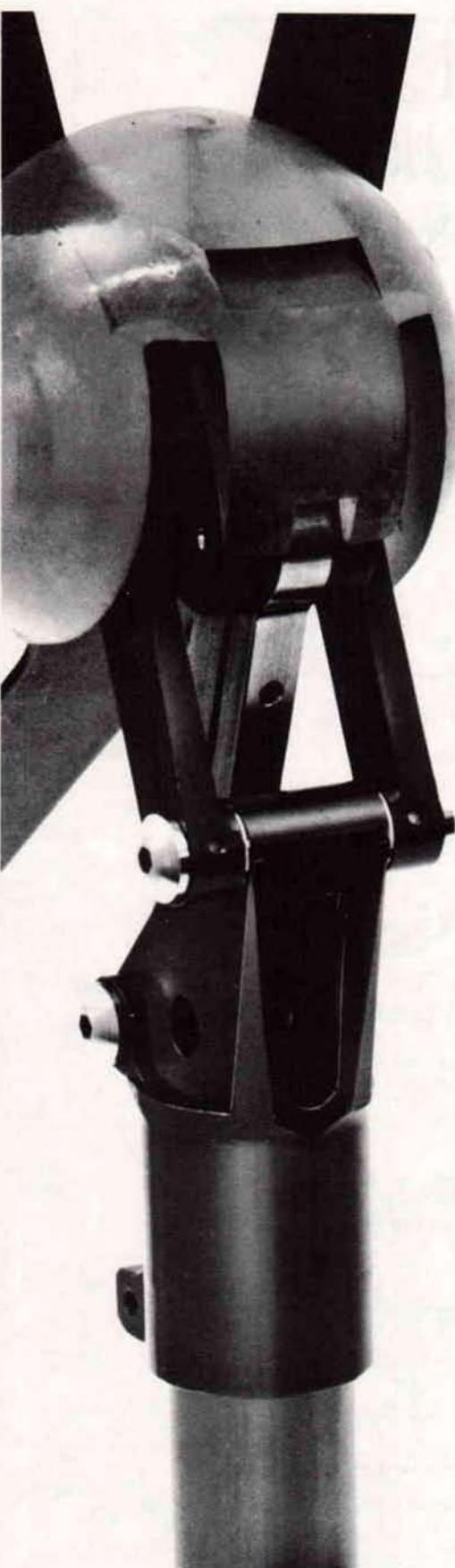
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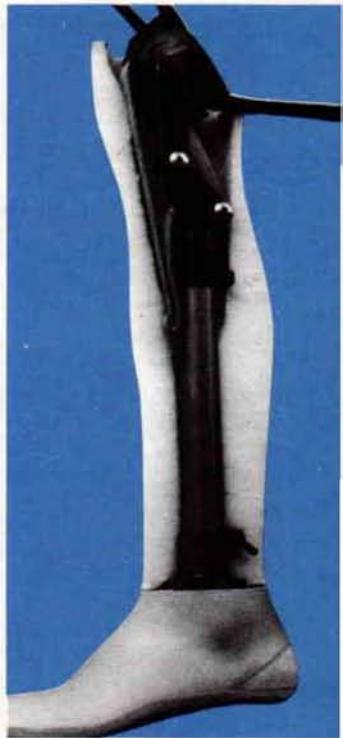
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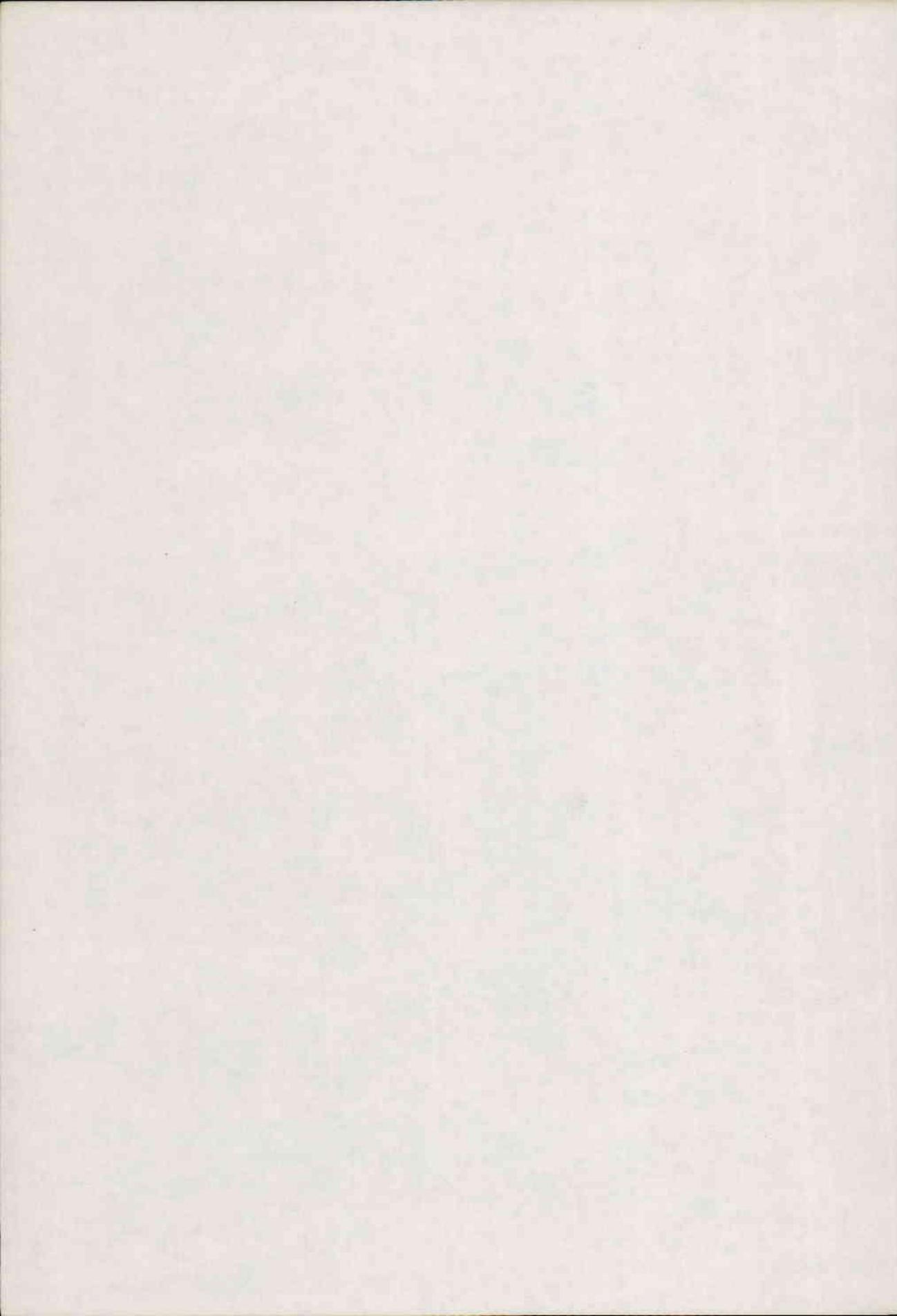
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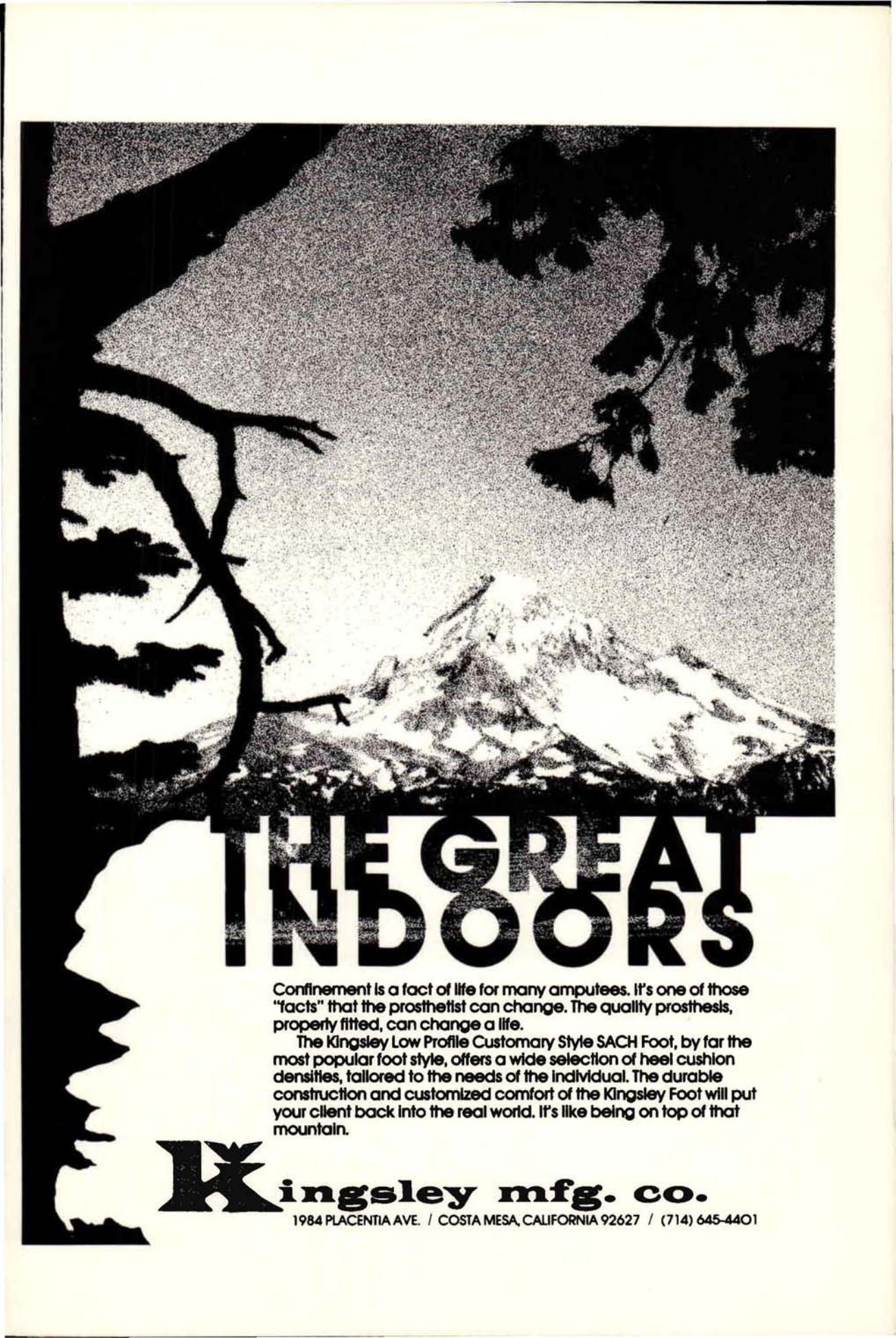
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