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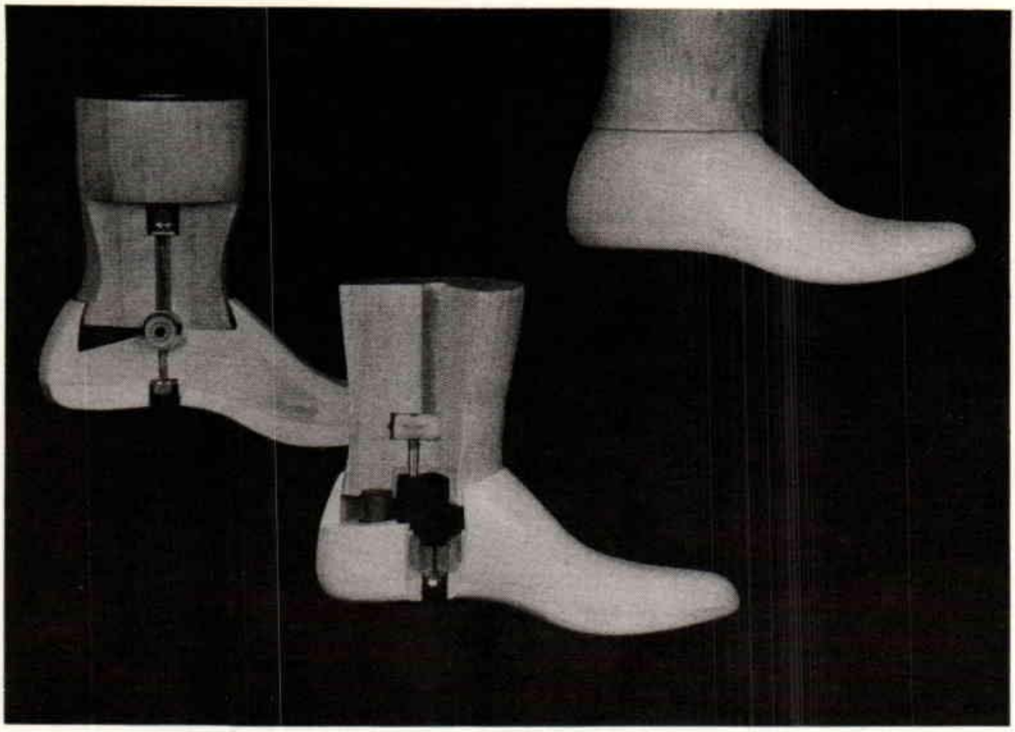

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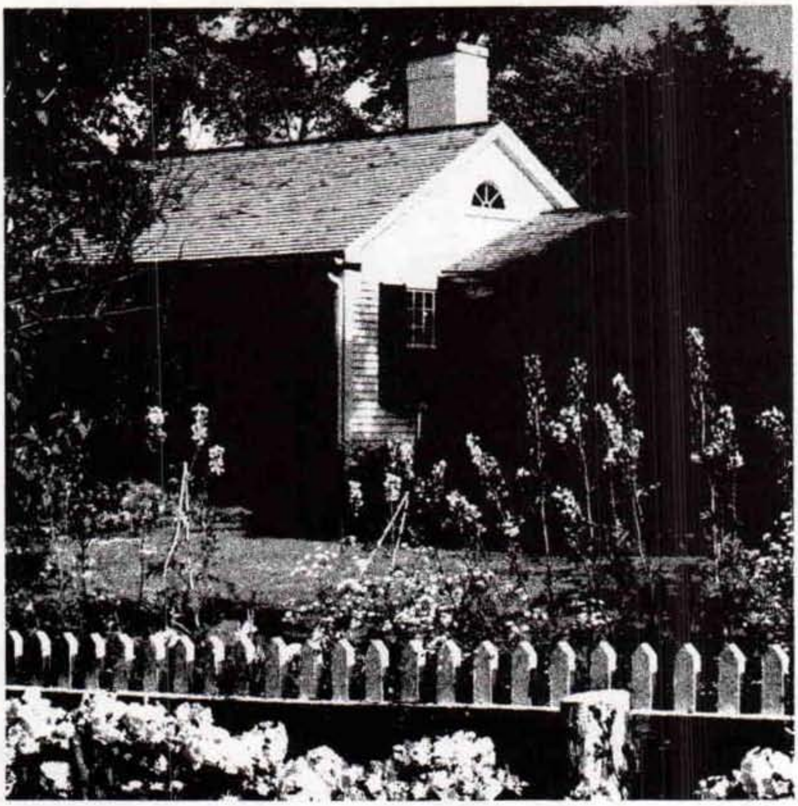

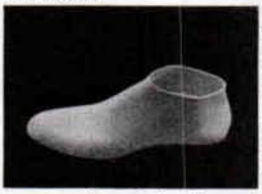

1978

ROUND-UP SEMINAR

AMERICAN ACADEMY of ORTHOTISTS and PROSTHETISTS

AAOP

HYATT HOUSE
ORLANDO, FLORIDA

January 19-21, 1978

FOREWORD

Orthotics and Prosthetics has kindly consented to devote this entire issue of the Journal to publication of the proceedings of a workshop entitled "The Current Status of Prosthetics and Orthotics and Trends for Future Research and Development" which was held in Miami, Florida on April 1-3, 1977. This was the final workshop in a series of such meetings on topics related to rehabilitation engineering, sponsored by the Rehabilitation Services Administration and the Veterans Administration. This particular workshop was co-sponsored by the Department of Orthopaedics and Rehabilitation of the University of Miami.

Fifty seven participants from the United States, Canada, and Europe gathered for this meeting representing some of the most knowledgeable people in the world in the field of orthotics and prosthetics. Included were practitioners and researchers in the prosthetic-orthotic profession, physicians, engineers, educators, manufacturers, government representatives, and allied health personnel.

The purpose of the workshop was to identify the current state of the art in prosthetics and orthotics, to define the present needs in each of several areas, and insofar as possible to make recommendations for future research and development based upon these needs.

A total of two and one-half days was spent in deliberations by this group. Position papers were given in six major areas—upper limb prosthetics, lower-limb prosthetics, upper-limb orthotics, lower-limb orthotics, spinal orthotics, and delivery of prosthetic-orthotic services. These papers were then used as the basis for discussion by five workshop panels. Charges to the panels included a definition of the current state of the art, identification of recent major advances, a definition of the availability of recent products of research and development, a statement of the most urgent needs in the field and their priorities, and finally recommendations regarding future research and development and methods of improving the delivery of services.

It is hoped that the proceedings of this workshop and, more importantly, the recommendations issuing from the panels, will serve to establish guidelines for members of the prosthetic-orthotic profession and for involved governmental agencies in the important work or providing improved technology and services to our handicapped population. It is obvious that much has been achieved over the past few years, but it is equally as obvious that we still have a long way to go.

Newton C. McCollough, III, M.D.
Ronney Snell, C.P.O.
Co-Chairmen

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Orthotics and Prosthetics, Vol. 31, No. 4, pp. 3—5, December 1977

SYNTHESIS

WORKSHOP ON EXTERNAL PROSTHETICS AND ORTHOTICS

General Observations and Recommendations Common to All Panels

1. A tremendous void has been left by the departure of the Committee on Prosthetics Research and Development.
   Some of the functions that are missed which were provided by CPRD are:
   a. Central clearing house for information
   b. Evaluation program for devices and techniques
   c. Organization of workshops, conferences, etc.
   d. Peer review of research and development
   e. Correlation of activities
   It is recommended that a new group be established to carry out these functions.
2. The curricula of the formal prosthetics and orthotics education programs need to be brought up to date. The education programs should be more deeply involved in research and evaluation than is the case presently, if the schools are expected to continue to meet the needs of the national rehabilitation program.
3. The American Academy of Orthotists and Prosthetists should expand its role in continuing education, and should become involved in evaluation of new devices and techniques as they emerge from research and development groups and practitioners.
4. The buyers of services need to be better informed about prosthetics, orthotics, and the potentials of prophylaxis. Representatives of third party payers often seem to have a very narrow view of the benefits possible by treatment that falls outside of present regulations.
5. Special Centers are needed to provide for the requirements of the severely handicapped. Research and teaching should be included in the responsibility of these Centers.
6. Improved cosmesis is needed in practically all aspects of prosthetics and orthotics. Cosmetic covers have presented problems, especially economical ones, for years.
7. Improved connections between the patient and the appliances are indicated. More information about the effects of pressures on human tissues is needed in order for significant progress to be made in this area. Support of work on skeletal attachment of prostheses should be continued.
8. Improved sensory feedback is needed for practically all types of externally powered prostheses and orthoses. Without sensory feedback, the patient is not able to control his appliance without conscious thought and visual cues, and even highly motivated patients often discard their appliances, feeling that the effort required for operation is too great to warrant the functions obtained.

RECOMMENDATIONS OF THE PANELS

Upper-Limb Prosthetics

1. A more efficient mechanical (body-powered) hand is needed.
2. Provisions should be made for interchangeability of externally powered hands and hooks.
3. An improved joint for the elbow-disarticulation prosthesis is needed. The strength of present joints is marginal.
4. An "active" elbow for the endoskeletal above-elbow prosthesis is needed. Present devices are passive, and therefore provide very little function.
5. Multifunctional control systems are needed for above-elbow, shoulder-disarticulation, forequarter, and high bilateral cases.
6. An externally powered shoulder joint is needed. All shoulder joints available are passive.
7. A study in socket design for shoulder-disarticulation and forequarter patients is needed. Present designs are uncomfortably warm and possibly unnecessarily restrictive. The designs suggested by Ring and Kiessling should be evaluated.
8. Studies to improve sensory feedback are needed. No doubt the low acceptance rate of externally powered prostheses and orthoses is due to the low order of sensory feedback present.
9. The effects of weight reduction in upper-limb prostheses should be studied. This aspect of upper-limb prosthetics has been overlooked completely.
10. Harnessing techniques and power transmission systems need study and improvement. The harness systems for the above-elbow unilateral amputee is notoriously uncomfortable and inefficient.
11. The osteotomy technique developed by Marquardt to provide better connection between humeral stump and prosthesis should be evaluated.
12. Systems consisting of both externally powered and body powered components should be considered. Such hybrid systems may be able to take advantage of the positive attributes of both body power and external power.
13. Research and development in externally powered systems should be continued with emphasis on sensory feedback, including proprioception and control by myographic and neuroelectric signals.

Lower-Limb Prosthetics

1. A workshop is needed to provide the basis for an advanced text on amputation surgery. The latest experiences in amputation surgery need to be published to provide the latest guidelines for all surgeons who are to perform amputations.
2. Definitive sockets that can be adjusted readily for daily changes in stump volume are needed. Sporadic attempts have not been successful, but it is felt that if an appropriate group concentrating on the problem it could be solved.
3. Studies of the design of artificial feet need to be reinstituted. Scientific inquiry into the design of artificial feet seems to have subsided after the introduction of the SACH foot.
4. An up-to-date protocol for management of patients pre-, during, and postsurgery including prescription principles needs to be published.
5. The effects of weight and weight distribution of artificial legs needs to be studied. The need for light artificial legs seems to have been obscured by the introduction of improved methods of fitting, alignment, and knee-control units. Such studies are possible and practical now that ultralight lower-limb prostheses are available.
6. Improved hip joints for the hip-disarticulation and hemipelvectomy patients are needed. Although the present designs are well received it is felt that refinements are possible.
7. An improved knee joint to provide braking is needed. Refinement of present designs seems possible and practical.
8. An adjustable leg that can be controlled remotely, and also by the patient, is

needed. Hobson, et al demonstrated that such an approach has the potential for providing useful information.

9. A workshop is needed to bring up to date above-knee casting, fitting, and alignment procedures. Although the basic principles set forth by the University of California in the late '50s are still valid a number of refinements in procedures have been introduced but have not been published adequately for teaching.
10. A workshop on training patients to use lower-limb prostheses is needed. The available texts on training lower-limb amputees to use their prostheses are more general than it seems that they need to be.
11. An electronic knee unit that permits voluntary control of the knee by above-knee amputees is needed. Presently, the above-knee amputee has less than adequate control of the artificial knee. Experience with myoelectric control systems and microcomputers suggests that voluntary control of the artificial knee might be possible and practical.
12. A workshop on management of partial-foot and Symes amputees is needed. Many refinements and some significant advance have been made since the last guidelines for management of these patients were published.
13. A survey should be made concerning the PTB socket modifications currently in use. It is well known that a number of variations of the PTB are being used successfully throughout the world but no comprehensive evaluation has been made of the individual techniques. Data useful in teaching could be obtained by a comprehensive survey.

Upper-Limb Orthotics

1. A study of the prehension patterns of quadriplegic patients is needed to determine better approaches to prehension that might be provided by orthoses.
2. The use of electromyographic and neuroelectric signals for control of orthoses should be studied. Experience with EMG in prosthetics should be helpful. New information concerning the neuroelectric signals should be investigated with respect to application to control of orthoses.
3. Hybrid systems should be developed and evaluated. Combinations of external power and body power should be explored to determine if the advantages of both systems can be preserved in one, at least on an interim basis.
4. Manipulators should be evaluated. Several systems designed to provide functions to the quadriplegic, but not connected to his body, are available in the prototype stage.
5. The development of more functional orthoses for quadriplegics with lesions at about the C-6 level should be given priority.
6. Improved arm swing designs should be developed.
7. An elbow flexion assist for ambulatory patients with flail arms is needed.

Lower-Limb Orthotics

1. Improved designs for joints, especially knee joints, are required. A special joint for patients with spasticity is needed.
2. Systems for maintenance of the integrity of the knee joint, such as the Martin, Lenox Hill, and Veterans Administration systems should be evaluated.
3. The shoe should be considered as a component in the lower-limb orthotic system in the education programs.

Spinal Orthotics

1. Methods of objective evaluation using bioengineering principles need to be developed for spinal orthoses to accomplish this, some basic research will probably be required.
2. A method to "unload" or distract the spine and immobilize the head that does not require skull pins is needed.
3. Better methods for immobilization of various parts of the trunk, spine, and pelvis with respect to each other are needed.
4. Orthoses for more effective management of scoliosis and kyphosis for all types of patients are needed.
5. An increase in the quantity and quality of information to orthotists is needed through both formal and informal programs.

Orthotics and Prosthetics, Vol. 31, No. 4, pp. 6—9, December 1977

UPPER-LIMB PROSTHETICS CURRENT STATUS AND FUTURE NEEDS

Maurice A. LeBlanc, C.P.

This paper is an attempt not so much to give the current status of upper-limb prosthetics but to develop the direction where research and development efforts should be pointed in the next few years to solve the most pressing clinical needs for patients.

Current Status

The history (Figure 1 and Reference 1) and development of upper-limb prosthetics is presented in the *Orthopaedic Appliances Atlas* of 1960 and will be updated by the revision to that volume now in progress and expected in 1978. In addition to the 1960 *"Atlas,"* the *Manual of Upper Extremity Prosthetics* (2) and *Prosthetic Principles—Upper Extremity Amputations* (3) have been used as teaching manuals and resource books to provide state-of-the-art service to amputees.

Background

The 1971 report *Rehabilitation Engineering—A Plan for Continued Progress* (4) made specific recommendations for future research and development in arm prosthetics. Subsequent efforts since that time also have tried to answer the question "What research work should we be doing to best help arm amputees?" (5, 6, 7) Past recommendations centered mostly on the areas listed below:

- Restudy of body powered prostheses
- Continuation of development of externally powered prostheses
- Improvement in appearance of hooks, hands, and arms
- Surveys of the upper-limb amputee population
- Formation of specialized centers for severely disabled arm amputees
- Increased emphasis on control and sensory feedback

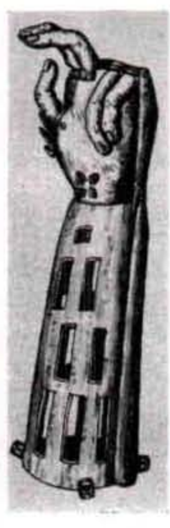

Fig. 1. The Alt-Rupin Hand.

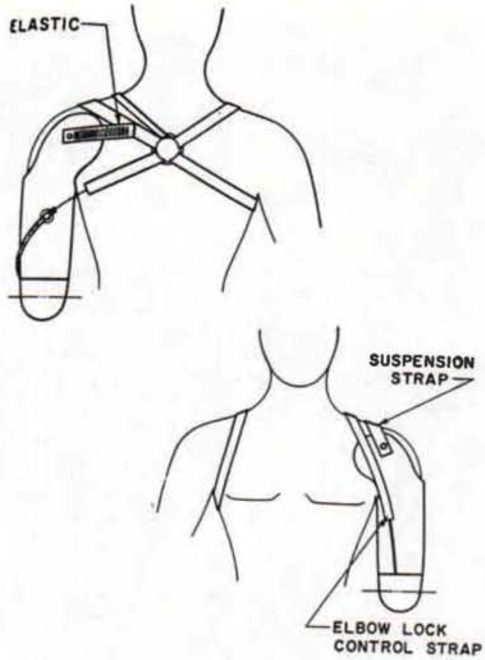

Fig. 2. The Ontario Crippled Children's Centre Open-Shoulder Above-Elbow Socket.

Recent Progress

In the last several years, accomplishments have been made in the following areas:

- Sockets: OCCC[1] open shoulder socket for above-elbow amputees (Figure 2 and Reference 8). Northwestern University self-suspension socket for below-elbow amputees (Figure 3 and Reference 9). Northwestern University atmosphere-pressure suspension socket for above-elbow amputees (Figure 4 and Reference 10).
- Components: Externally powered hands and hooks (Figure 5 and Reference 11). Externally powered elbows (Reference 12). Otto Bock wrist rotator (Figure 6).
- Control: EMG Control (Reference 13 and 14). Hybrid body/electric control (Reference 15). Sensory feedback (Reference 16).
- Cosmesis: Endoskeletal prostheses (Figure 7 and Reference 17).
- High Bilaterals: Coordinated feeder arms (Figure 8).

1.) Ontario Cripple Children's Centre, Toronto, Canada

Fig. 3. The Northwestern University Self-Suspension Socket for Below Elbow Amputees.

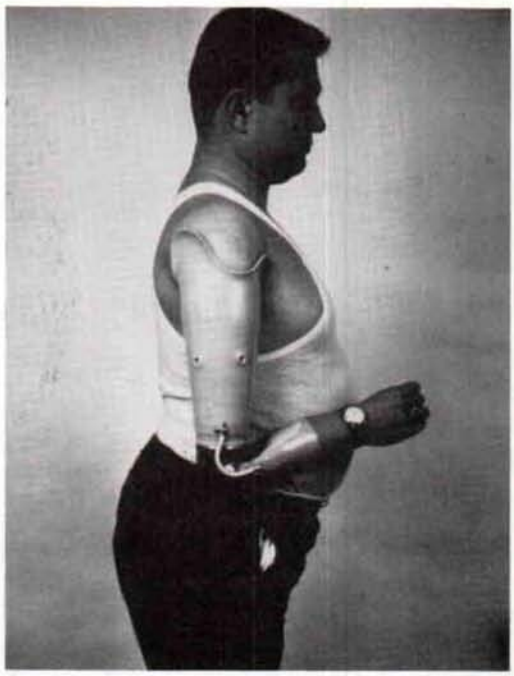

Fig. 4. The Northwestern University Atmosphere-Pressure Suspension Socket.

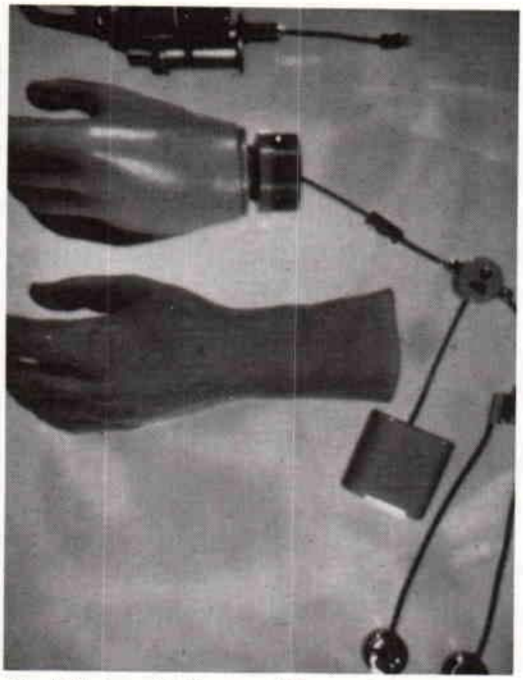

Fig. 5. Externally Powered Terminal Devices.

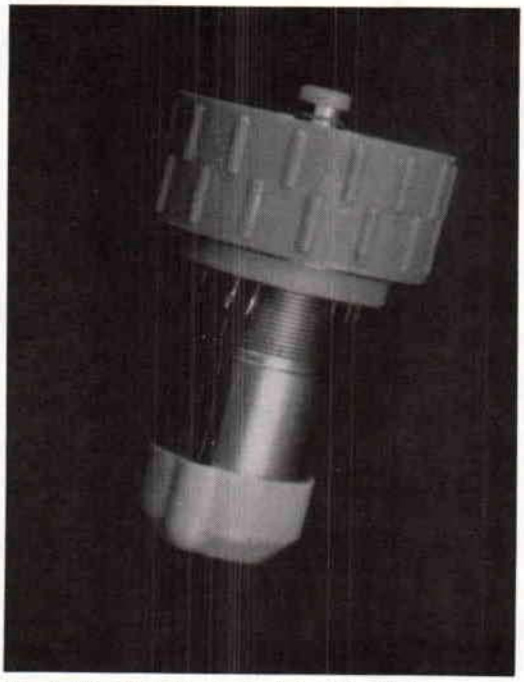

Fig. 6. The Otto Bock Electric Wrist Rotator.

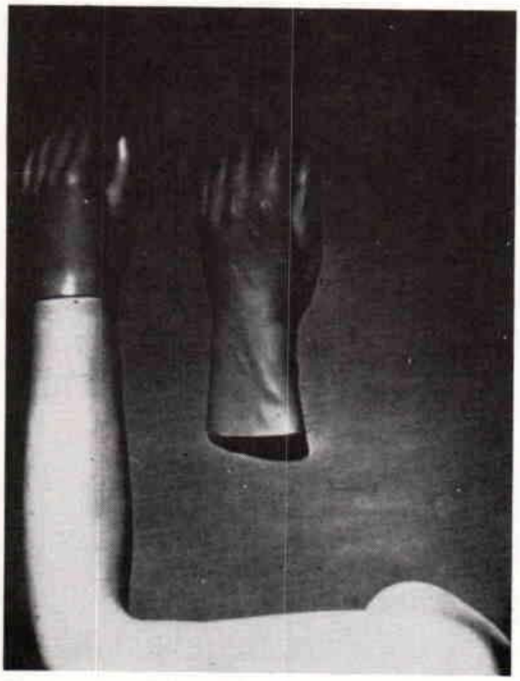

Fig. 7. The Otto Bock Endoskeletal Upper-Limb Prosthesis.

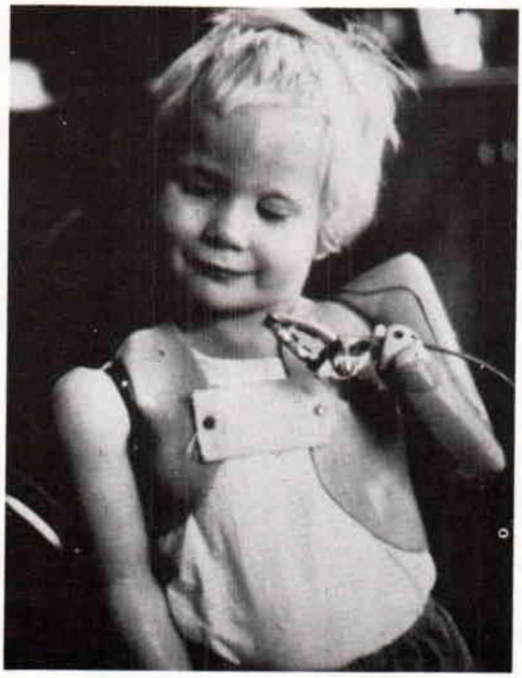

Fig. 8. Electrically Powered Prosthesis With Coordinated Motion Between Wrist and Elbow.

Future Needs

There are several old but good and yet undone ideas for improvement of upper-limb prostheses. Considering recent accomplishments as well, I see future needs for the field as falling into two major items:

• Packaging: Only an estimated 50 percent of arm amputees wear prostheses. Ned Sharples' study (20) revealed that whatever we can do mechanically (functionally) for unilateral arm amputees is not nearly as important as what we can do for them cosmetically (socially). With this in mind, it seems to me that we have to "package" prostheses better to achieve greater amputee acceptance. This includes work 1) on improved prosthetic skin material, 2) self-suspension, 3) self-containment, and 4) general aesthetics.

• High Bilateral Prostheses: It is readily acknowledged that high bilaterals—children and adults—present a most serious and difficult problem. In contrast to unilateral arm amputees and some low level bilateral amputees, the challenge to increase function of these people is a large one. I see future needs including 1) assistance in enabling them to use their feet wherever possible, 2) increase in function of components, 3) increase in control capability without added encumbrance in mental work necessary by the amputee, and 4) commercial availability of components and systems.

Goals

It seems to me that the goals are difficult to achieve, but can be stated simply as:

• For unilateral arm amputees: making them feel good about themselves!

• For bilateral arm amputees: giving them a measure of independence!

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Orthotics and Prosthetics, Vol. 31, No. 4, pp. 10—13, December 1977

THE CURRENT STATUS AND FUTURE NEEDS IN LOWER-LIMB PROSTHETICS

Alvin Muilenburg, C.P.O.

The current status of lower-limb prosthetics deserves high praise as a result of years of hard work by dedicated individuals in the areas of research, development, and education. In 1946, when I first became involved in prosthetics, there were no formal education program available. Training on the job was the only way to become involved.It was about this time that the American Orthotic and Prosthetic Association began to develop into a more professional organization, and thus began to coordinate more effectively the efforts of individual prosthetists and orthotists.

In 1947 and 1948 the Veterans Administration and the American Orthotic and Prosthetic Association sponsored a series of above-knee suction socket "schools," that were held at selected locations throughout the country.

AOPA recommended the establishment of the American Board for Certification in Orthotics and Prosthetics in 1949 to ensure that prosthetists, orthotists, and facilities specializing in prosthetics and orthotics meet certain standards of excellence.

In 1953, the first of the formal university-level short term courses began at the University of California in Los Angeles. In 1955, the pilot course in above-knee prosthetics fitting and alignment was held at the University of California, Berkeley. This was followedby a series of courses at the University of California at Los Angeles and New York University, and later at Northwestern University.

The studies in locomotion and biomechanics made at Berkeley gave a new and understandable meaning to lower-limb prosthetics, especially in fitting and alignment, which led to the above-knee quadrilateral socket, the patella-tendon-bearing below-knee prosthesis, and the use of the adjustable leg and transfer equipment. These techniques and devices are still in use today.

The continuing education type of course offered by the universities enabled the practicing prosthetist to improve his ability to communicate with others in the medical field. The team approach to management of amputees was introduced and accepted. Good pre-prosthetic care and correct fitting of the socket, correct alignment of the components, along with proper training of the amputee resulted in more functional prostheses. Very little stress was put on special knee joints and exotic materials. Friction-type knee control for above-knee prostheses and a well aligned foot and ankle provided the basic necessities.

Prosthetists gained more confidence in fitting, and I could fit most amputees except those with very poor stumps, those in poor physical condition, or those that were psychologically mal-adjusted. However, as we all know, no prosthesis is good enough. It can always be better; a challenge that intrigues not only the prosthetist but the physician, therapist, and engineer as well. Over the past years many new components and materials have been developed through programs sponsored by the Veterans Administration, the Rehabilitation Services Administration, the National Institute of Health, the Children's Bureau, the Departments of the Army and the Navy, and by individual prosthetists and private manufacturers. Until recently the overall program was coordinated by the Committee on Prosthetics Research and Development of the National Academy of Sciences. CPRD deserves much credit for the progress made by providing stimulation and guidance to the various research and development groups.

The prosthetist has available a wide selection of components and materials, and at times it is difficult to determine which to use. Even with help of CPRD we still have many items that have never proven to be quite satisfactory. Prosthetists who have tried the new items still have many of them on their shelves after field testing proved them not to be satisfactory. We also have many components already designed which could be more satisfactory if design changes to improve function and reliability were incorporated. Extensive evaluation of all new components for prostheses is essential.

Even with a satisfactory state-of-the-art we are still searching for improvements—as we should. During this meeting we are here to make decisions as to future needs in lower-limb prosthetics. This is not any easy task. I have been actively engaged in fitting prostheses for 30 years and still find it difficult to define accurately individual needs. To help in our discussion on lower-limb prosthetics, I mailed a questionnaire to 150 randomly selected prosthetists. I received 50 returns. Many of these respondents went to considerable effort to express their opinion as to the current needs.

Before we discuss the results of the returns, let us first consider the component which is common to all lower-limb prostheses—the foot. Everyday, all active prosthetists discuss shoes and prosthetic feet with new and old wearers. The problem of heel-height adjustment affects every amputee. This lack of adjustment together with questionable foot and ankle functions of the devices available today leaves the door open for further research. As Charlie Dankmeyer so aptly stated, "The SACH foot is not the panacea for all the prosthetic foot problems."

During the past several years what developments have been the greatest aid towards your fitting of the lower-limb amputee in each of the following categories listed on a priority basis? (Some listings will show the percentage of comments related to the total.)

Fitting techniques and procedures:
Casting techniques (2 and 3 piece BK)
Adjustable legs and biomechancis
PTB and PTS type prostheses
Check sockets (transparent)
Total-contact sockets
Expandable liner for Symes' prosthesis
Vacuum forming
Ultralight BK prostheses

Components:
Modular Systems
Knee mechanisms (Safety, OHS, Multiplex, etc.)
Feet (Greissinger and Bock molded single axis)

Materials:
Thermoplastics (Pelite, polypropylene, etc.)
Foams (Bock duplciating)
Acrylic resins
Ultra-Dip

If you were given the time and resources to do research on projects relating to lower-limb prostheses, what would be your choices?

Casting techniques (AK and BK)
Suspension in general, and specifically for the geriatric patient
Cosmesis—Endoskeletal, soft tissue and skin
AK knee joints
Socket materials
Ankle Joints

During your daily practice when do you find yourself saying, "There must be a better way"?

Casting AK
Suspension (geriatric AK)
Maintaining fit (volume changes)
Patient information and/or misinformation
Geriatric fitting
SACH foot

What developments in components do you think are most needed for:

Below-knee prostheses?
Foot lightweight, articulating
Socket and insert materials—smooth, resilient, and tough
Cosmetic covers
Suspension for obese patients and others
Modular components

Knee-disarticulation prostheses?
Knee mechanism
OUtside joints with friction
Cosmetic covers
Strong modular components

Above-knee prostheses?
Lightweight components
Knee mechanisms
Hydraulic devices
Cosmetic covers
Hip joints
Knee mechanisms for children
Stronger modular designs

Hip-disarticulation prostheses?
Stronger hip joint
Better cosmetic cover for endoskeletal prostheses
Casting technique

Other?
Cosmetic covers
Symes' feet
Hydraulic ankle
Better tools for inside measurements

In what areas is there the most need for improvement in measuring and fitting techniques?

25% - Above-knee casting and measuring
5% - Above-knee volume measuring
Obese patient handling and tissue
Tissue evaluation

In your experience what is your opinion concerning the present general status of the following services as they affect lower-limb fitting?

Surgical
28% Good
34% Needs improvement
.06% Poor

Pre-prosthetic care
.08% Good
32% Needs improvement
26% Poor
.04% None

Post-prosthetic care
22% Good
26% Needs improvement
30% Poor

What changes or additions to our educational programs do you think could be made to improve patient handling of the lower-limb amputee?

14% - More courses on proper patient handling
12% - More courses for therapists and nurses
Medical terminology
Better internship programs for prosthetists
More information about the cause and effect of vascular problems and skin disorders as they relate specifically to amputees wearing prostheses.

SUMMARY

In summary, the future needs in lower-limb prosthetics is not too much different than it has been for years. There is a need for improvement of components, especially knee joints for above-knee limbs, better feet, stronger but lighter modular components, better soft tissue and skin covering, etc. We hope that research will be continued and close communication among the people involved will be maintained. The evaluation program should be renewed.

The respondents to the questionnaire stressed the need for better methods to evaluate tissue tissue as it reacts to the prosthesis during use. We need better methods for measuring and making impressions. This is an area that has not been stressed in research program during the past few years.

Many are concerned about the concentration on components and more expensive items when patient handling skills are more important. I would like to quote Greg Gruman, who added this comment to the questionnaire:

"I think we can do a much better job even with no improvements in techniques or components. People who receive prosthetic care who are property fitted and trained will have good success. Those who get off to a bad start may never be able to recover. Emphasis on 'total care' is needed.

Too often a patient will blame poor performance on the prosthesis, i.e., 'This socket never did fit right!' They seem to feel that if they had a different foot or belt or other changes, that they would walk normally, or feel that a different prosthetist or facility would make them walk better. This wishful thinking, or hoping for a miracle, only causes problems for everyone involved.Maybe we as fitters also have too great a faith that new components will solve our problems, something that only improved skills can accomplish."

Thoughts were also expressed that too much time and money can be spent developing expensive items. We don't want to build a six-million dollar prosthesis when funds are not available in a great many cases to pay for what can be fitted at the present time.

Perhaps some of the thoughts expressed are too conservative. However, the panels involved are well selected and we hope that they will develop ideas and projects that will lead to better prostheses and better patient care for a majority of lower-limb amputees.

Orthotics and Prosthetics, Vol. 31, No. 4, pp. 14—20, December 1977

UPPER-LIMB ORTHOTICS

H. Richard Lehneis

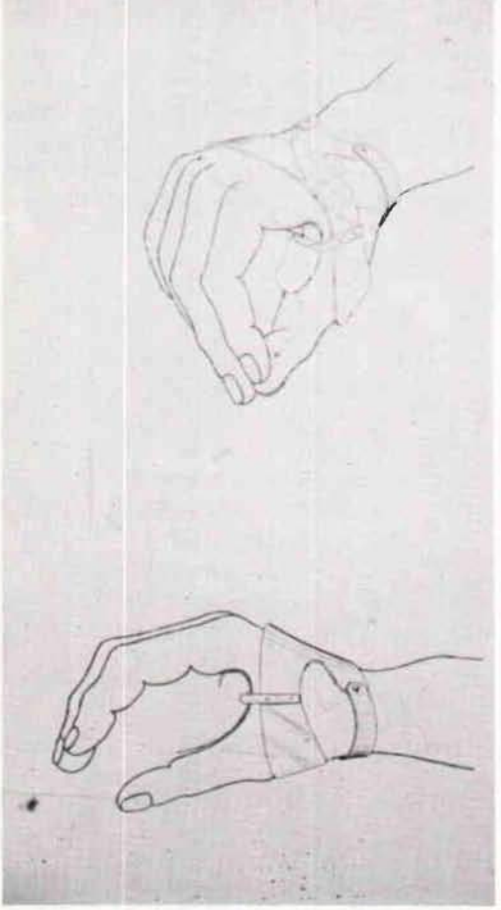


Fig. 1. Warm Springs-type basic opponens orthosis

The complexity of the functions provided by the hands and upper limbs necessarily makes upper-limb orthotics a very extensive and diverse area in practice. An attempt is made here to categorize the various areas of upper-limb orthotics.

Upper-limb Orthotic Systems

A number of institutions have developed a system of upper-limb orthotics which in all cases is based on a basic opponens orthosis to which various components are added for ameliorization of specific individual impairments (2). All systems include various prehension orthoses, including externally energized systems for various levels of quadriplegia.

These systems are best suited in the management of peripheral nerve injuries and other diseases, e.g., polio, Guilian Barre, in which partial or complete recovery is anticipated, as well as for quadriplegic patients. The systems are applied not only to enhance function, but also to protect the hand in a functional position and to prevent contractures while recovery takes place.

Listed in chronological order of development, the systems are:

1. Warm Springs System, developed at the Georgia Warm Springs Foundation (Fig. 1).

2. Rancho Los Amigos System, developed at the Rancho Los Amigos Hospital, Downey, California (Fig. 2).

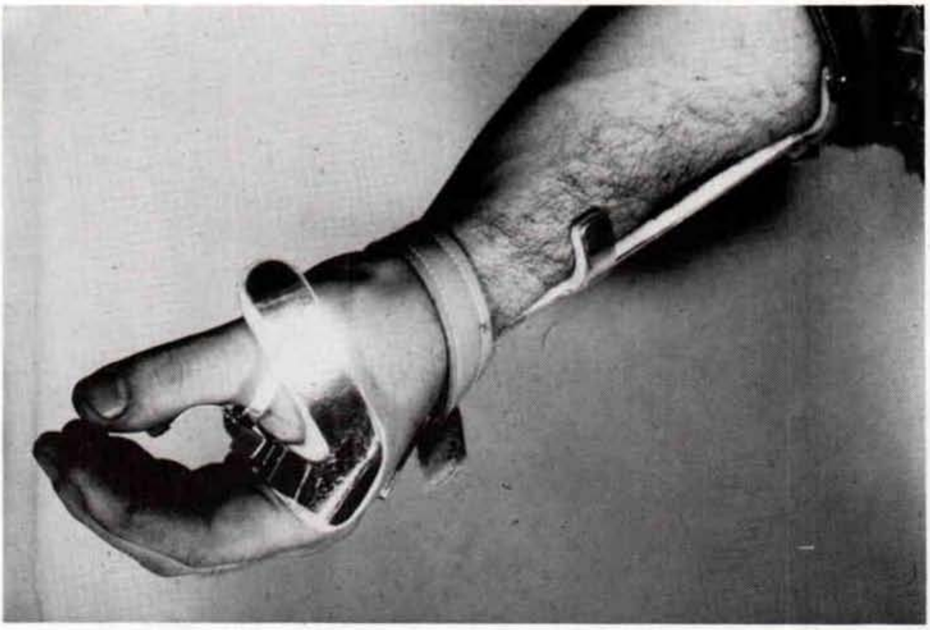


Fig. 2. Rancho-type opponens orthosis with dorsal-wrist support

3. Engen System, developed at the Texas Institute for Rehabilitation and Research, Houston, Texas (Fig. 3).

4. IRM-NYU System, developed at the Institute of Rehabilitation Medicine, New York University Medical Center (Fig. 4).

Components for the latter two systems are available through suppliers for individual adaptation to patients.

Pre-fabricated Splints

This category includes ready-made splints, available from a number of manufacturers such as Bunnell splints from Weniger, various resting and positioning splints from OEC, Zimmer, etc., and other devices for activities of daily living from RTC, Sammons, and others (8). While some of these devices serve a very useful function, e.g., adaptive devices for activities of daily living, some splints may in fact be considered harmful because of improper positions imposed by certain designs.

Acute (Temporary) Splinting

Considered in this area are devices which are applied in cases where immediate splinting is demanded, e.g., soft tissue trauma, burns, etc., or in cases where progressive changes in joint alignment are necessary. Most often this kind of splinting is provided by practitioners other than the orthopedic surgeon (7), i.e., occupational and physical therapists, general practioners, and nurses. Materials used for these purposes are:

1. *Low Temperature Thermoplastics*

An increasing number of low temperature thermoplastics has become available which, in general, lend themselves very well to this application since they are easily handled and require a minimum amount of equipment (Fig. 5). Each possesses unique physical characteristics such as color, stiffness, transparency, temperature range, etc.

2. *Plaster of Paris*

Plaster casts are often applied as a tempor-

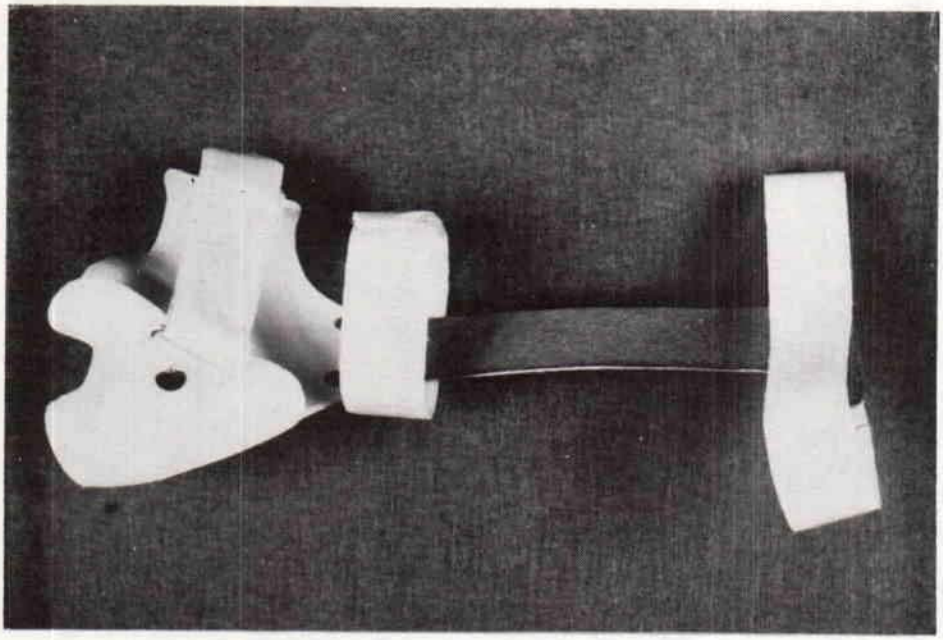
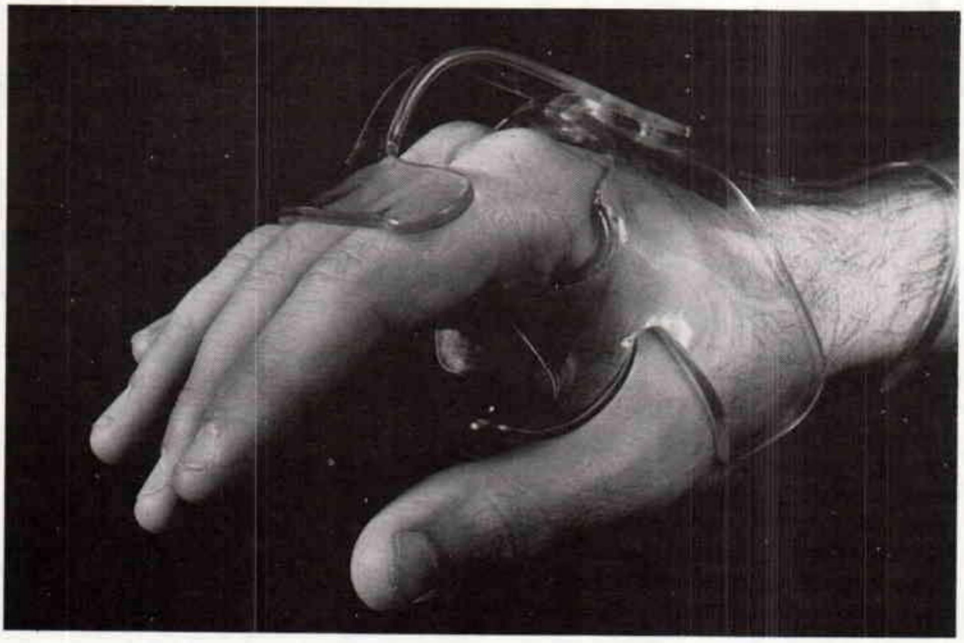


Fig. 3. Engen-type opponens orthosis with volar-wrist support



Fit. 4. IRM-NYU type opponens orthosis with dorsal-wrist support and metacarpal phalangial extension stop

ary measure in an emergency setting to stabilize a joint, or in progressive correction of contracted joints.

Pre-fabricated splints are useful when the prognosis for patient recovery is good, indicating short term use of an orthosis, or in cases when the patient awaits the fitting of a more permanent orthosis from the orthotist.

Special Cases

While most upper-limb impairments and injuries can be managed with orthoses and splints included in the three categories cited above, there are certain special cases in which very little progress has been made and in which orthotics management is considered generally poor. These cases are:

1. *Hemiplegia*

Current orthotic management of hemiplegia patients is confined to the fitting of a static hand-wrist orthosis to prevent flexion contractures and/or the fitting of an arm support sling to prevent shoulder subluxation and/or pain. Occasionally, passive prehension orthoses which are manually operated have been fitted to selected patients with mixed success.

2. *Rheumatoid Arthritis*

Both the Georgia Warm Springs Foundation under the direction of Dr. Robert Bennett and the University of Michigan have developed a number of orthoses specifically designed for the rheumatoid arthritic patient. However, there is a general lack of a systematic approach to orthotic management of the various pathomechanical conditions produced by rheumatoid arthritis.

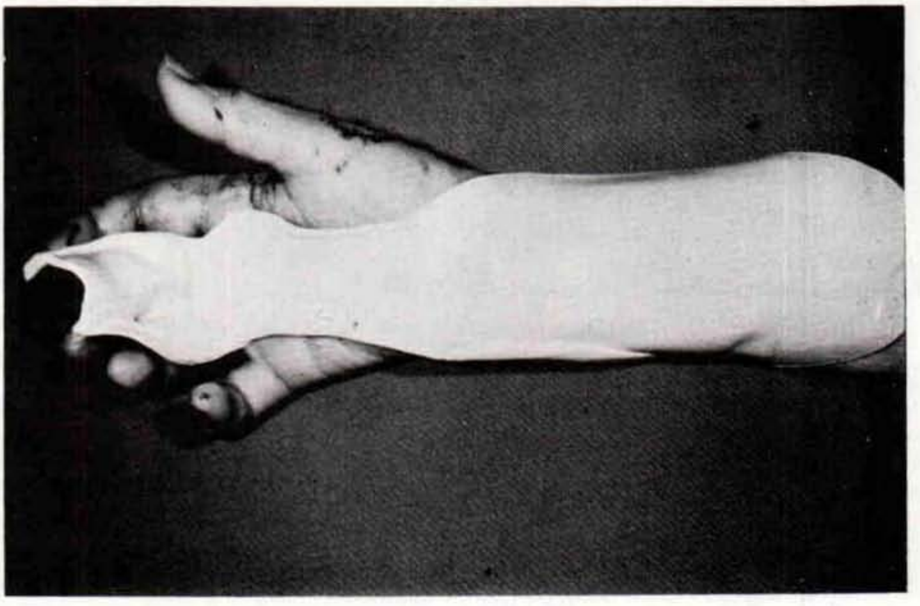


Fig. 5. Low temperature plastic splint (courtesy Maude Malik, OTR).

3. *Burns*

While some exciting work has been done in special burn centers and in particular by Maude Malick in splinting the burned upper limb to prevent contractures, patients seen in other locales are probably not treated optimally with orthoses.

Trends for Future Research and Development

There are three major areas which require future research and development.

Orthotics in Spinal Cord Lesions

Due to improved medical care, many more spinal-cord-injured patients survive than was the case in the past. Consequently, we are seeing more quadriplegic patients (9), and, the demand for improved and extended orthotic services is increasing.

1. *Review of Prehension Patterns for Orthotics*

Traditionally, the design of functional upper-limb orthoses is based on earlier research in prosthetics which resulted in a three-jaw chuck type of pinch, which is the most frequently used prehension patterns in normal use (1). It should be recognized that the quadriplegic patient is anything but normal in the terms of the kinematics of upper-limb function due to weakness in practically all elements of the kinematic chain.

Furthermore, the patient lacks sensory feedback and must rely entirely on visual feedback to handle objects. With this in mind it would be extremely useful to review, or conduct a new study of, prehension patterns specific to the quadriplegic patient, considering his overall weakness and other features unique to him, e.g., the need for transfer activity from wheel-chair while wearing the orthosis because it gets in his way or it may be damaged in the process. This discourages patients from using an orthosis full-time. Based on such basic motion research, orthoses might be designed to provide prehension patterns, e.g., lateral pinch, which would not, or only minimally, interfere with other activities, yet enhance visual feedback.

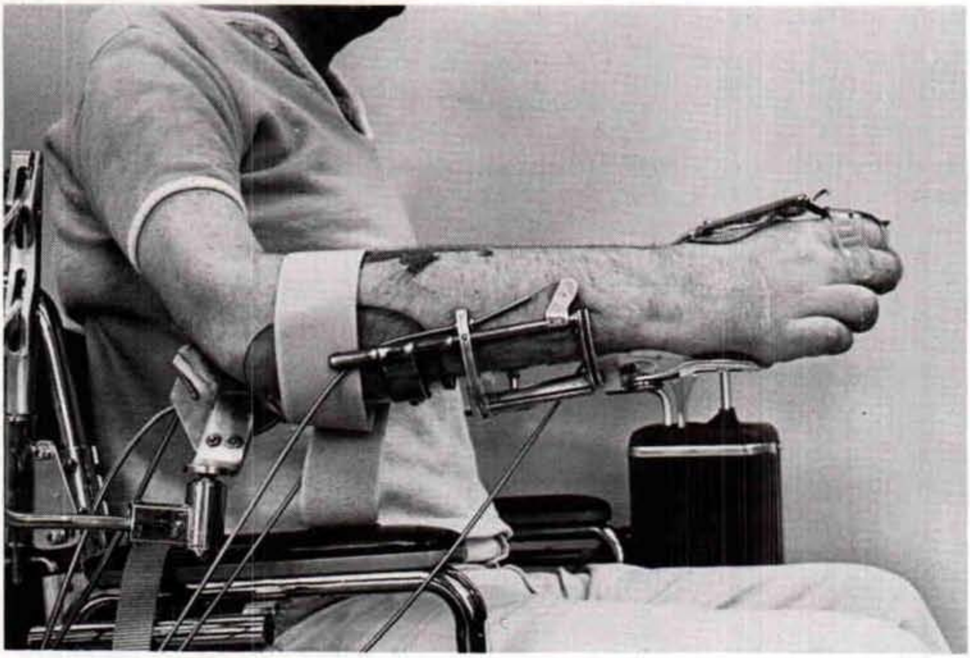


Fig. 6. IRM-NYU multiple degree of freedom electric arm orthosis

2. *Develop Multi-degree of Freedom System for High-Level Quadriplegics*

While multiple degree of freedom orthoses have been developed by various institutions, namely Rancho Los Amigos Hospital (10), TIRR (3), and IRM-NYU (5), only a few patients have benefitted from such devices. Further, it appears that there is a need to evaluate these orthoses comparatively and to incorporate the best features of the systems in an orthosis which is based on kinematic considerations of the quadriplegic as suggested above. Also, consideration should be given to a system which guides the hand with the prehensile device through an X-Y-Z coordinate system, by-passing the anatomical joints. Such a system may reduce the number of controls necessary and is, conceivably, a simpler mechanical system.

3. *Evaluation of Manipulators*

The evaluation of manipulators which ignore the patient's existing extremity completely has been initiated recently at the University of California, Los Angeles (9). This should be encouraged so that their usefulness can be determined and further development be undertaken if indicated in lieu of, or as an alternative to, orthoses.

4. *Evaluation of Environmental Control Systems*

An increasing number of environmental control systems is becoming available commercially and through research laboratories. A great need exists to delineate the advantages of the various systems with specific indications for use not only between the various environmental control systems, but also in comparison to externally energized upper-limb orthoses or manipulators.

5. *Design and Development of Control Systems*

For the most part, electromechanical control systems have been used in orthotic devices (Fig. 7). These are, however, limited because actuation of the transducers requires a certain magnitude of force and displacement. It is, therefore, believed that further investigation of other control systems should be explored such as:

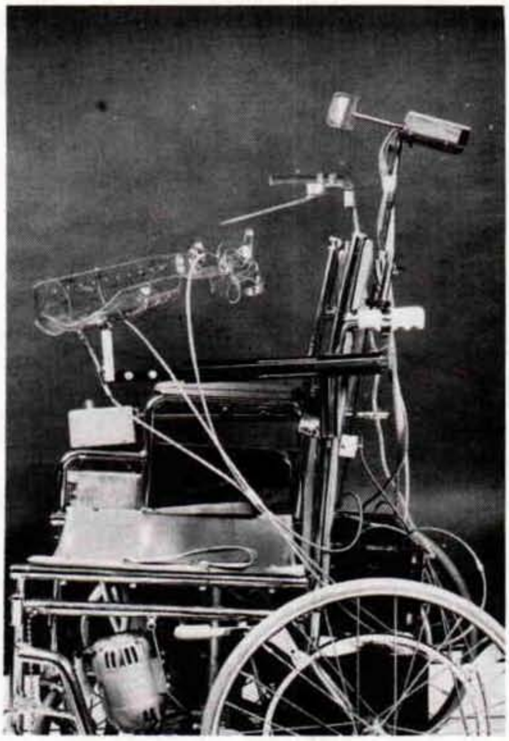


Fig. 7. Electromechanical head and shoulder control switches for multiple-degree-of-freedom powered electric arm orthosis

a. Myoelectric mapping of the facial and neck areas to determine which muscles are best suited for the control of an orthotic device or environmental control system without interference of other functions or inadvertent operation(11). This should include the study of conduction phenomena which has been demonstrated experimentally in picking up myoelectric potentials from muscles through remotely located electrodes. This would aid in the cosmetic considerations of electrode placement in the neck and facial areas.

b. *Electroencephalographic control*

Kalkstein at IRM-NYU(4) recently demonstrated the temporal relationship between EEG and EMG output in real time through filtering of extraneous noise. This development appears to have real potential in devising a control system based on EEG. Further research in this area should be encouraged to design a computerized recognition system of the EEG signal in quadriplegic patients for controlling orthotic or other devices.

Special Cases

1. *Hemiplegia*

Present research conducted under the Rehabilitation Services Administration and the Veterans Administration in electrical stimulation of the hemiplegic hand and arm at Rancho Los Amigos Hospital, the University of Ljubljana, and Case Western Reserve University should be continued.

2. *Rheumatoid Arthritis*

Research in this area should be greatly accelerated to provide this type of patient with an orthosis which not only prevents further deformity, but also enhances function without interfering with activities of daily living. At present there seems to be no systematic approach to this problem.

3. *Burns*

The role of orthotics in treatment of burns to prevent contractures should be clearly defined. The methods presently available at burn centers should be disseminated to all practitioners dealing with the orthotic management of burns.

Service Delivery

Delivery of orthotics services for the upper-limb should be improved through the following.

Central fabrication facilities should be encouraged to provide this service.

Pre-fabricated orthoses and splints should be vastly improved to conform with accepted principles of hand position and function and be made available to the medical, orthotics, and therapies professions.

Professional roles of the occupational therapist and orthotist should be more clearly identified in terms of the type of services provided by each profession.

Training of orthotists and other professionals providing orthotics services should be greatly accelerated, particularly in view of the ever-increasing sophistication of multi-powered and environmental control systems. This is a particularly crucial area since servicing of such systems will ultimately become problematical if orthotics training does not include consideration for these systems.

Early fitting of orthotic devices is at least as essential as it is in prosthetics to prevent contractures and to enhance maximum utilization of orthotic devices.

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LOWER-LIMB ORTHOTICS

Melvin Stills, C.O.

The practice of lower-limb orthotics varies considerably throughout North America. However, there are three basic types of orthoses available: conventional metal-and-leather, molded plastic, and electrical stimulation devices.

The design of conventional metal-and-leather systems has not changed much over the past several years. The use of aluminum and preformed component parts probably represents the most significant improvement achieved in this approach to orthotics. Conventional metal-and-leather orthoses still enjoy widespread usage throughout North America, but plastics have begun to attain popularity in the fabrication of many types of lower-limb orthoses, particularly for correction of ankle and foot problems.

The *Orthopedic Appliance Atlas* (6) published in 1952, refers to over a dozen different types of plastics for use in orthotics, but most of these materials proved not to be very useful in orthotics and prosthetics, and plastics did not find mush usage in the field until 1968, when Gordon Yates published a paper in *Orthopaedics: Oxford* (13) in which he discussed the use of polypropylene and ABS in orthotics. Following Dr. Yates' visit to the United States in 1969, the use of thermoplastics began to increase, slowly at first, but by the mid-70's, some form of plastics could be found in most orthotic facilities in North America.

Thermosetting resins such as the polyesters, acrylics, and epoxies were applied with considerable success in prosthetics, and were carried over naturally into orthotics. However, thermosets could not withstand the continued high impact and flexion stresses that occur in an orthosis during ambulation and, thus, considerable breakage occurred.

When thermoplastics such as polypropylene, polyethylene, ABS, etc. were first used in orthotics, manufacturers were as unfamiliar with their application as were orthotists. Research workers found that thermoplastics had varying degrees of flexibility, impact strength, color, and formability. Selection of the appropriate material was difficult. Today, we have over 100 different usable materials to choose from, and numerous variations of each.

Polymers, both thermosetting and thermoplastic, are now used widely in the field of orthotics.

Dr. Richard Lehneis and his staff at the Institute of Rehabilitation Medicine (5) have contributed much to the advancement of the use of thermosets in orthotics. Dr. Lehneis did not simply substitute plastics for metals, but he used a concept of total contact to improve function by applying pressure directly. The solid-ankle orthosis (Fig. 1), the supracondylar knee-ankle-foot orthosis (Fig. 2), the supracondylar knee orthosis, and the laminated above-knee orthosis are but a few examples.

Fig. 1. Laminated solid ankle-foot orthosis

The solid-ankle orthosis is designed to immobilize the ankle-foot complex and is indicated in cases where ankle motion produces pain or to control or reduce severe spasticity. It was found that the total contact, and the fact that pressure is distributed over a large area, cause the patient to gain better position sense through sensory feedback.

The supracondylar knee-ankle-foot orthosis (SKA) can be used as a substitute for the conventional knee-ankle-foot orthosis (KAFO). It permits free knee flexion, provides a knee extension moment in the stance phase, provides rigid ankle control in both the medio-lateral and the anterior-posterior planes; the extension above the knee provides M-L control, and pressure in the popliteal area prevents excessive recurvatum. An additional advantage is that various types of shoes can be worn with this system without modification of the shoes.

The supracondylar knee orthosis (SKO) is a spin-off from the SKA. By virtue of its design, the knee is controlled in the M-L plane, and by application of a three-point-pressure system, genu recurvatum is controlled.

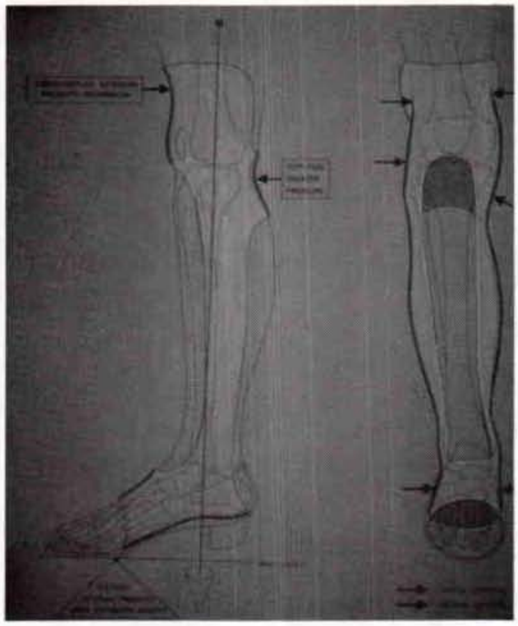

Fig. 2. The supracondylar knee-ankle-foot orthosis laminated

With the addition of conventional metal knee joints, the laminated single-bar orthosis (Fig. 3) and the laminated double-bar above-knee orthosis (Fig. 4) were developed. The single bar is applied in cases of severe genu valgus or varus, and recurvatum is easily controlled. The plastic-laminate knee-ankle-foot orthosis can be substituted for the con-

Fig. 3. Laminated single-bar knee-ankle-foot orthosis.

Fig. 4. Laminated double-bar above-knee orthosis

ventional metal-and-leather orthosis, and the laminated quadriceps section provides greatly improved function through more comfortable weight-bearing, better control of the hip, improved cosmesis, and the ability to interchange a wide variety of shoes.

Two methods have been devised for the handling of thermoplastics: hand-forming or vacuum-forming techniques. Hand-forming is commonly used when working with acrylic nylons such as Plexidur because of difficulties that occur in vacuum-forming.

The IRM spiral AFO (Fig. 5) is one example of a hand-formed thermoplastic device. This system is intended for the totally flail ankle-foot complex. The orthosis completes a 360 deg. turn around the extremity and provides controlled plantarflexion, dorsiflexion, eversion, and inversion of the foot. The hemispiral is a modification in that it makes a 180 deg. turn around the limb and is designed to provide control against equino varus.

Polyolefins, such as polypropylene and polyethylene, are easily adapted to orthotics and can be molded either by hand or by vacuum forming techniques.

Fig. 5. The spiral ankle-foot-orthosis developed at the Institute for Rehabilitation Medicine, New York University. This particular unit was formed from polypropylene. The original design used the clear acrylic nylon thermoplastic known as Plexidur.

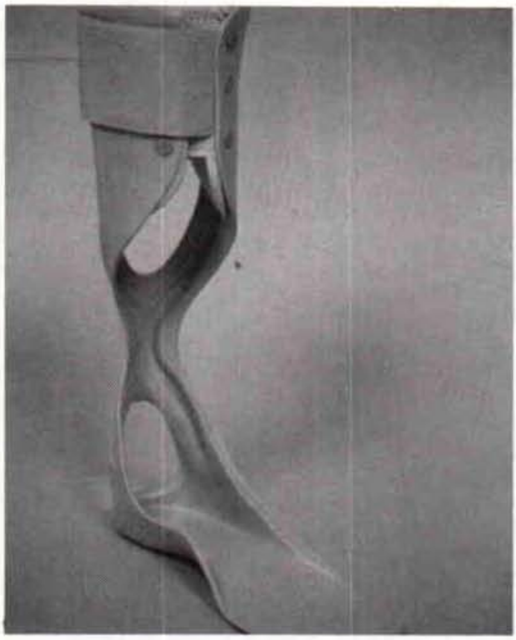

Fig. 6. The molded polypropylene ankle-foot-orthosis developed at the Texas Institute for Rehabilitation and Research.

The polypropylene corrugated dorsiflexion assist, or TIRR AFO (3) (Fig. 6) as it is popularly referred to, was developed about 1968 by Thorkild Engen at the Texas Institute for Rehabilitation and Research. The present day TIRR ankle-foot orthosis evolved from several different designs over a period of time. Mr. Engen used total contact and the ability to control rigidity in the orthosis to effect control of the ankle-foot and to improve ambulation. The TIRR device provides dorsiflexion assist and added mediolateral control of the ankle. The system weighs approximately 4 oz. and permits a large selection of shoes as long as heel height is maintained. Mr. Engen has carried the concept of the polypropylene corrugated dorsiflexion assist to include other designs such as knee-ankle-foot orthoses having either standard metal knee joints or plastic joints.

Various vacuum forming techniques have been utilized in the development of orthotic systems. One method allows for the hand draping of the material over the model and the application of a vacuum through the model.

Numerous orthoses of varying designs have been developed using these two techniques. The molded ankle-foot orthosis (Fig. 7) is in total contact with the posterior and plantar surface of the foot and is an effective means of controlling the ankle, subtalar, and forefoot. Rigidity is controlled by geometric

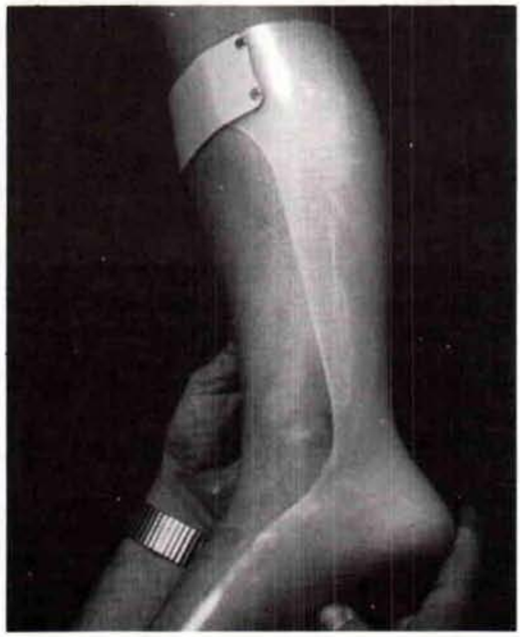

Fig. 7. Molded polypropylene ankle-foot orthosis.

shape, cross-sectional area, and selection of materials. The use of thermoplastics and vacuum forming techniques permits the fabrication of orthoses with varying amounts of rigidity about the ankle (Fig. 8). In addition, ankle positioning can be used effectively to produce either a knee flexion or extension moment during the stance phase of gait (Fig. 9). Total contact improves cosmesis in that the orthosis can be covered with a stocking or a boot, or it may be painted (10).

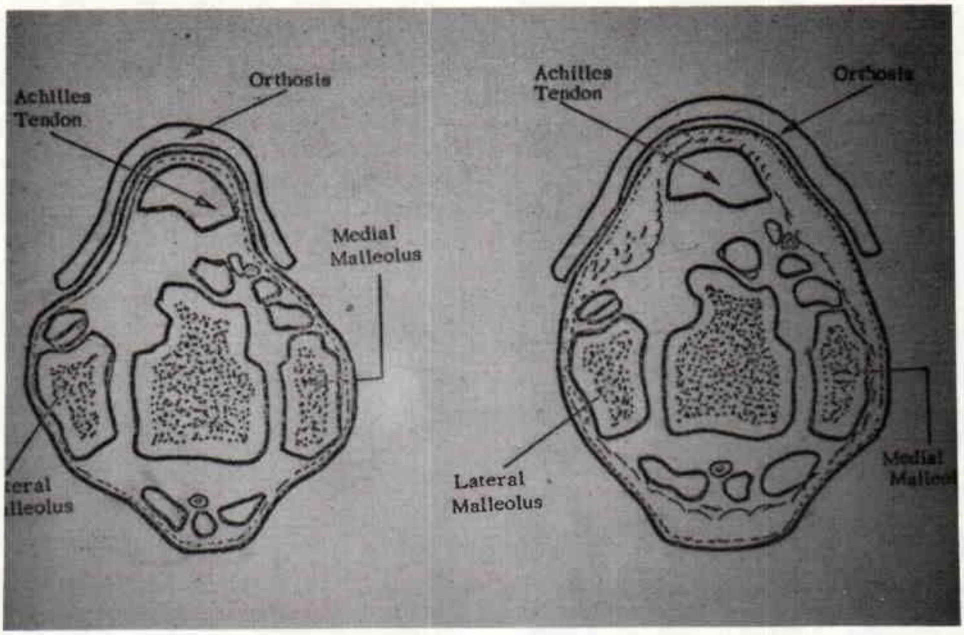

Fig. 8. Rigidity about the ankle of a molded AFO is controlled by geometric shape, thickness, and properties of the material used.

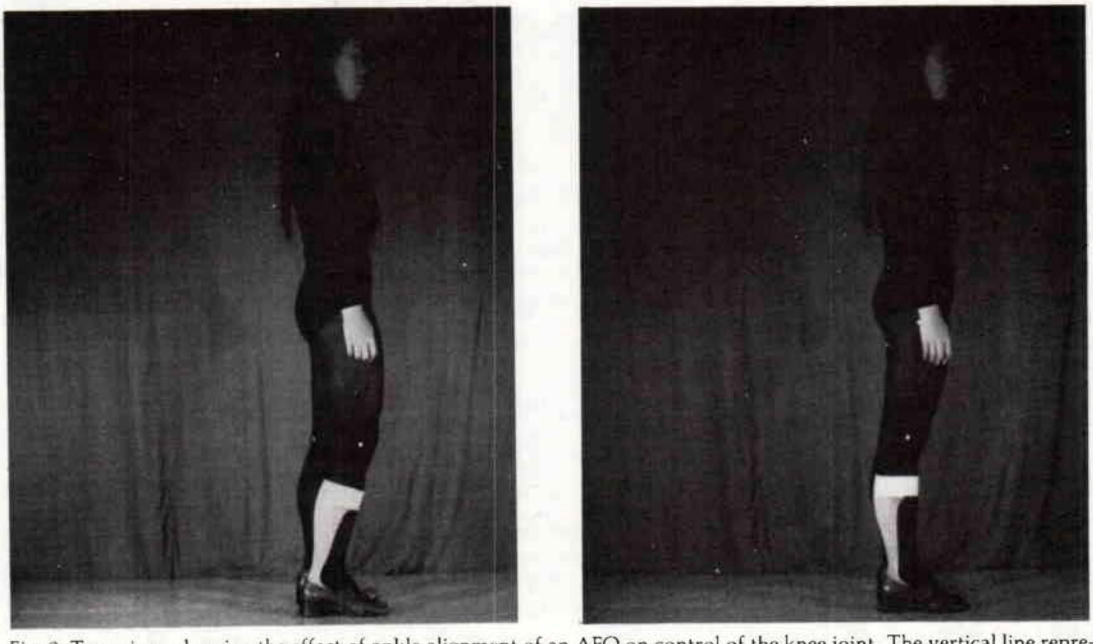

Fig. 9. Two views showing the effect of ankle alignment of an AFO on control of the knee joint. The vertical line represents the actual weightline of the subject.

The staff at Rancho Los Amigos Hospital has developed an adjustable ankle-foot orthosis (Fig. 10) which enables the evaluation of the effectiveness of ankle positioning during ambulation, and at the same time, maintains the advantage of light weight.

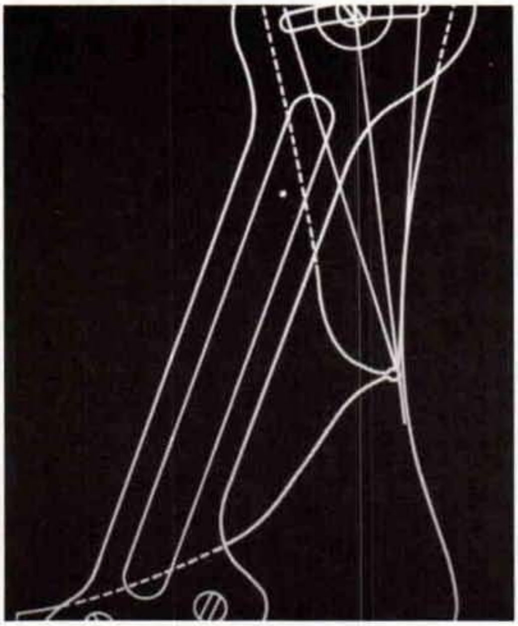

Fig. 10. Adjustable ankle-foot orthosis developed at Rancho Los Amigos Hospital.

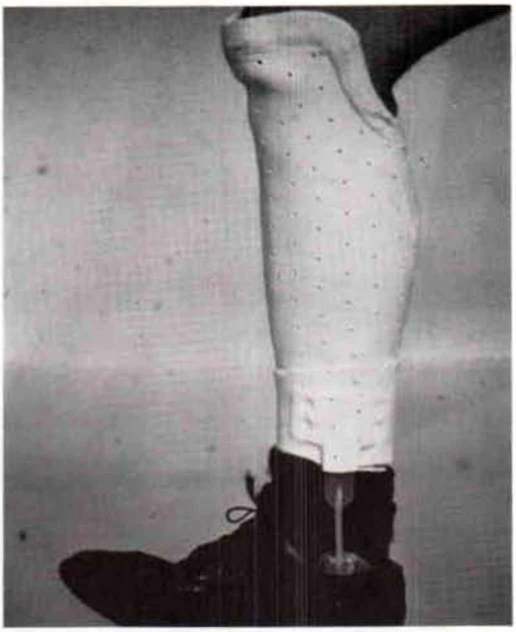

Fig. 11. Ankle-foot orthosis custom molded in place with synthetic balata used for management of tibial fractures.

Thermoplastics have also been used effectively in the treatment of fractures of the long bones of the lower limb. Dr. Augusto Sarmiento, University of Miami, is using Orthoplast, a synthetic balata, to provide circumferential control of a fracture site (Fig. 11). He has found that it is not necessary to unload totally an extremity in order to provide good management of fractures (1). The staff of the Krusen Center for Research and Engineering, has found that the addition of an anterior section to the molded ankle-foot orthosis (Fig. 12) achieves circumferential control, as well. Both of these management techniques permit the patient to assume more normal activity inasmuch as conventional footwear may be worn, the patient can bathe regularly, the systems are light in weight, and open wound areas are easily cared for while bony alignment is maintained (11).

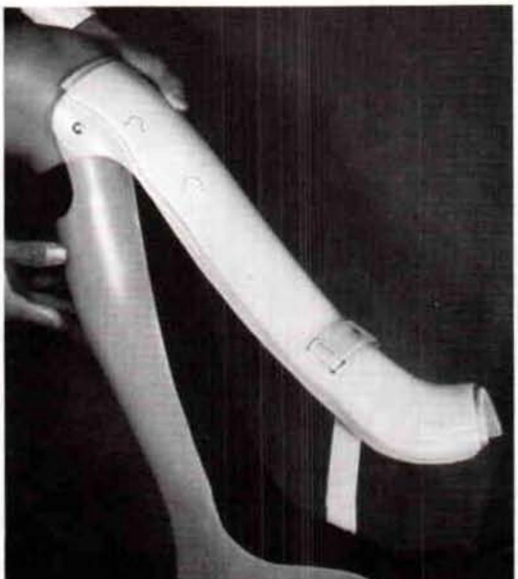

Fig. 12. Ankle-foot orthosis custom molded of polypropylene for management of tibial fractures.

Thermoplastics are especially useful in the orthotic management of the knee. The use of materials such as polypropylene and low

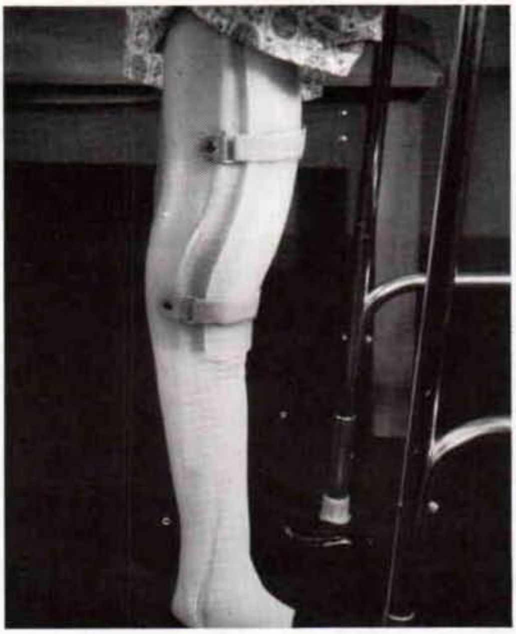

Fig. 13. Molded low density polyethylene KAFO for total immobilization of the knee joint.

density polyethylene permit the development of systems that can totally immobilize the knee joint against flexion, extension, valgus, and varus (Fig. 13). Low-density polyethylene is very useful when rigidity and flexibiltiy are desired in the same orthosis. Geometric shape, due to contouring of the limb and the addition of corrugation, causes the orthosis to be rigid in both planes, but circumference can be increased or decreased to accomodate swelling that might occur as a result of quadriceps rupture or joint bleeding secondary to hemophilia. Lightweight systems of this same design have been used in the orthotic management of patients with muscular dystrophy and arthrogryposis.

Molded knee-ankle-foot orthoses (KAFO's) with mechanical knee joints (Fig. 14) have found widespread usage because total contact provides better control of the ankle and knee. They are light in weight, approximately 960 grams or just over 2 lbs., depending upon the size and weight of the patient. Bilateral molded KAFO's improve and increase mobility, and better limb control and increased endurance are facilitated by their use.

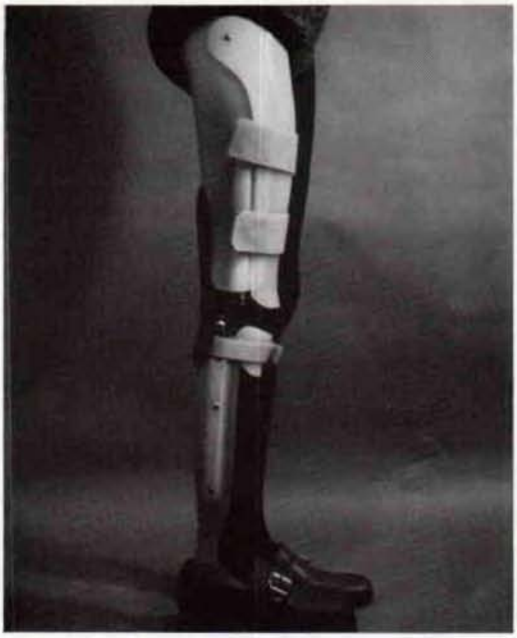

Fig. 14. Molded polypropylene-polyethylene KAFO.

Fractures of the femur have also been managed by the use of the molded KAFO, but the staff at Rancho Los Amigos Hospital (9) has taken a rather unique and somewhat different approach in that they permit full knee and hip flexion while providing full circumferential control (Fig. 15). Total hip control has been provided with thermoplastic pelvic hip femoral devices. Extensive bracing, such as thoracic-hip-knee-ankle-foot orthosis can provide almost complete immobilization of the long bone without adding excessive weight or bulk.

Unique systems are also available for orthotic management of children, by simply modifying the systems developed for adults.

Fig. 15. KAFO used in management of femoral fractures. Pelvic hip femoral orthosis for proximal femoral fracture immobilization.

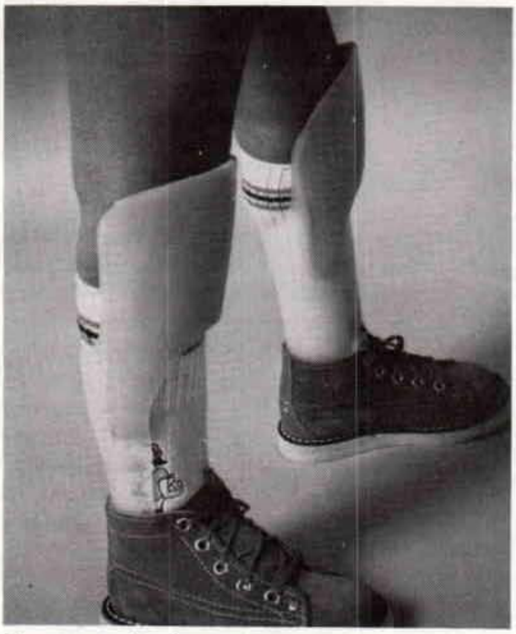

Fig. 16. Ankle-foot orthosis with anterior support used for patients with myodysplasia.

Circumference can be increased easily to accommodate for growth, and if maximum length of the lever arm is provided at the initial fitting, growth of 2 to 3 inches can be accomodated.

The use of molded plastics with children requires close supervision to prevent the occurrence of pressure areas, and the development of deformity may be reduced.

The conventional method of bracing the child that has myelodysplasia is with metal-and-leather in the form of a hip-knee-ankle-foot orthosis (HKAFO). John Glancy (4) has described an alternate method using thermoplastics (Fig. 16). The "solid-ankle" orthosis uses the floor reaction principle to produce a knee extension moment during the stance phase of gait.

Mobility aids for children also fall under the heading of lower-limb orthoses; they are supportive, corrective, and assistive. The child with spina bifida must encounter the same daily life experiences as a normal child in order to have normal psychological growth, but the child with spina bifida requires special care from birth. Systems have been developed by Colin McLaurin, Douglas Hobson, Wally Motloch, and Dwight Driver, (8,12,7) to provide mobility to this class of patients. With these systems (Figs. 17 and 18), the child can be held safely, can sit and learn about his surroundings by use of head and eye movements, sit independently and use his arms and hands, move about and explore, then stand, and for the first time not be required to always look up.

The most recent new approach to bracing has been in the form of functional electrical stimulation (FES) for patients with upper motor neuron disorders (2). Two systems are available: surgically implanted and externally applied (Fig. 19). The fact that the patient's reflex arc is intact enables the peripheral nerves and muscles to receive stimulation. Stimulation is triggered by a foot switch as the heel leaves the ground. The anterior muscles are stimulated, causing dorsiflexion, until heel strike occurs again. Both external and internal systems require considerably more research and development before routine clinical application can be expected. Research is also being con-

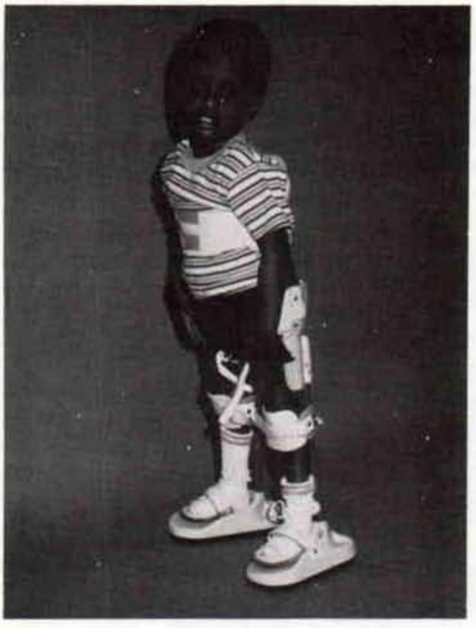

Fig. 17. Memphis Rehabilitation Engineering Center plastic upright positioner orthosis—(PUP).

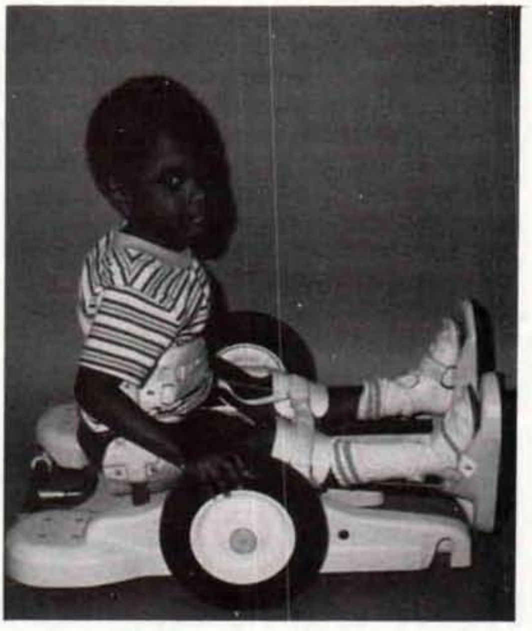

Fig. 18. PUP system with mobility cart.

ducted to assess the effects of FES in conjunction with external orthotic management. Muscle response varies among patients, but appears more effective in the proximal joints and seems to improve overall ambulatory function.

The current decade has been one of tremendous change in the field of orthotics. Methods of patient evaluation have improved, resulting in more accurate detailed description and classification of patients' dysfunction. New materials are becoming available that lend themselves to unique orthotic management. Techniques of fabrication are changing, permitting custom designing of orthotic systems, which may appear simple and uncomplex, but actually require considerable knowledge for prescription development and fabrication. The orthotist of today cannot be just an artisan, skilled at fabrication, but he or she must be knowledgeable in the areas of anatomy physiology, materials, and engineering principles.

Fig. 19. Patient with peroneal functional electrical stimulation device in place. The electrodes in this case are external to the body.

In addition, there must be free and open communication among all members of the clinical team—physicians, surgeons, orthotists, nurses, therapists, engineers, and psychologists. Research dissemination and educational programs are mandatory in order to facilitate the utilization of orthotic systems and techniques. The American Academy of Orthotists and Prosthetists has assumed responsibility for content and administration of continuing education in the United States, not only for the orthotist, but for any member of the clinical team. Practitioners are kept up to date with new techniques, procedures, materials, and systems as they are developed.

The responsibility for education of those who are entering the field of orthotics is left to the universities. It is not the purpose of the university to teach fabrication of every device available, but to develop a basic knowledge of concepts and principles of orthotic management and, through good affiliation programs, round out the students' education. Like all other professions, the orthotist's experience really begins when he or she enters clinical practice and continues throughout the professional career.

Advancement in lower-limb orthotics is dependent not only upon our continuation of research but also on our ability to disseminate and transfer knowledge gained through research to the orthotic practitioner. Without the transfer of information, our research will be of little value.

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SPINAL ORTHOTICS

Allen S. Edmonson, M.D.

There are at least two pertinent questions which can serve as an introduction to this topic. First, is it possible to actually immobilize the spine with an orthosis that the patient can tolerate? Second, in attempting to immobilize the spine with an orthotic device, can the normal differences in posture of the spine from standing to sitting be accomodated in the fit?

We should continue to ask more questions than we answer, choose some of the better ones and get on with it.

Keeping these questions in mind, we will look at spinal orthoses of two basic types: 1) those for general immobilization of the spine and 2) those which have specialized goals. By general immobilization, I mean the orthoses for painful backs, postoperative orthoses and postinjury orthoses. Under orthoses for specialized goals, we will discuss those concerned with specific problems such as scoliosis, kyphosis and spinal cord injuries.

Spinal orthoses generally are classified according to the anatomical areas to which they are applied. We will discuss them under cervical, thoracic, thoracolumbar and lumbosacral (and I am aware of CTLSO). The presentation of each area will be broken down into orthoses which are now available and orthoses for future needs. For those now available, we will ask what they actually accomplish and if there are deficiencies.

ORTHOSES NOW AVAILABLE FOR THE CERVICAL SPINE

Beginning at the top with cervical orthoses, those which are now available are of several types: the various types of collars including the full-molded plastic collars, the four-posters, the two-posters, the SOMI's and, by extending the definition of orthoses, the halo jacket and halo cast.

Collars (Figs. 1A-B) have been used for a long time and can be reasonably comfort-

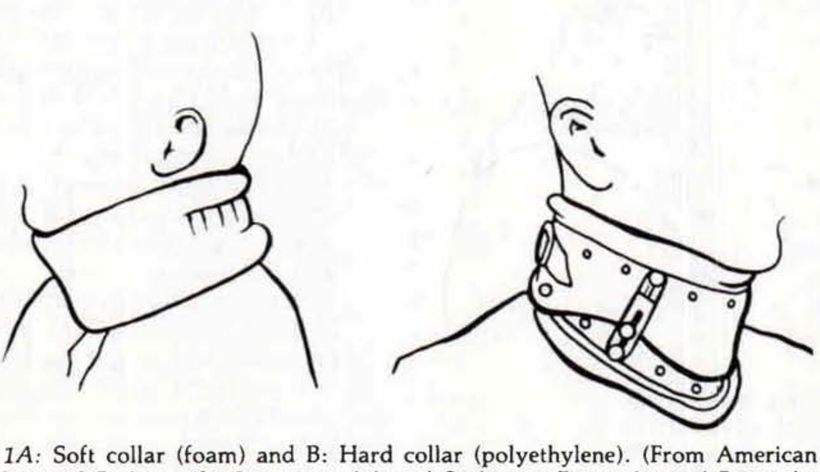

Fig. 1A: Soft collar (foam) and B: Hard collar (polyethylene). (From American Academy of Orthopaedic Surgeons: *Atlas of Orthotics: Biomechanical Principles and Application,* St. Louis: The C. V. Mosby Co., 1975, p. 361.)

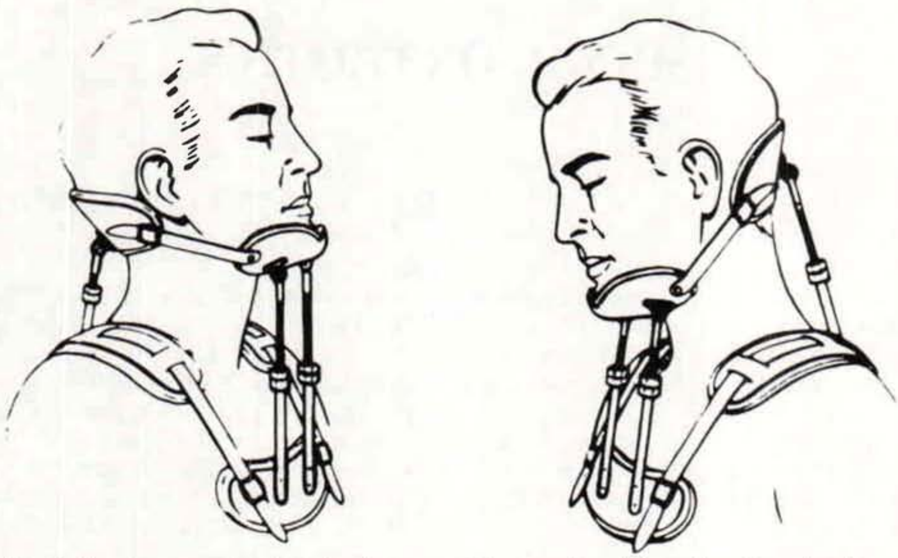

Fig. 2: Four-poster orthosis in A: flexion and B: extension. (From American Academy of Orthopaedic Surgeons: *Atlas of Orthotics: Biomechanical Principles and Application*, St. Louis: The C. v. Mosby Co., 1975, p. 362.)

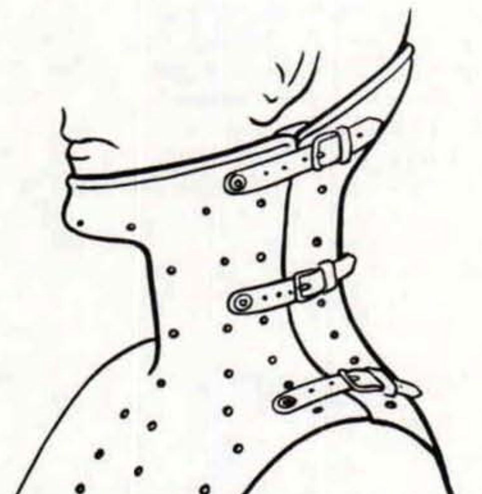

Fig. 3: Custom-molded orthosis. (From American Academy of Orthopaedic Surgeons: *Atlas of Orthotics: Biomechanical Principles and Application*, St. Louis: The C. V. Mosby Co., 1975, p. 363.)

able. They limit either flexion or extension and can be designed or adjusted to do one or both, but they don't immobilize. They do very little to limit rotation. They are removable by the patient for comfort and for hygiene.

The four-poster brace (Fig. 2), and some better two-poster braces, are more complicated devices which generally give better control of the head with limitation of rotation. When fitted tightly against the chin and occiput, they are relatively uncomfortable for the patient and many require frequent realignment. The SOMI brace also accomplishes the same function and is possibly a little more comfortable, but like the others is removable by the patient. In general, the efficiency of this group of braces is directly related to the amount of chin-occiput pressure for which they are fitted.

Of the removable collars, the Philadelphia or molded orthosis (Fig. 3) which encloses the neck, chin, occiput and base of the neck is probably the most efficient. It gives better limitation of rotation combined with limitation of flexion and extension than the ordinary collars. It can be made reasonably comfortable.

Fig. 4: Halo cast.

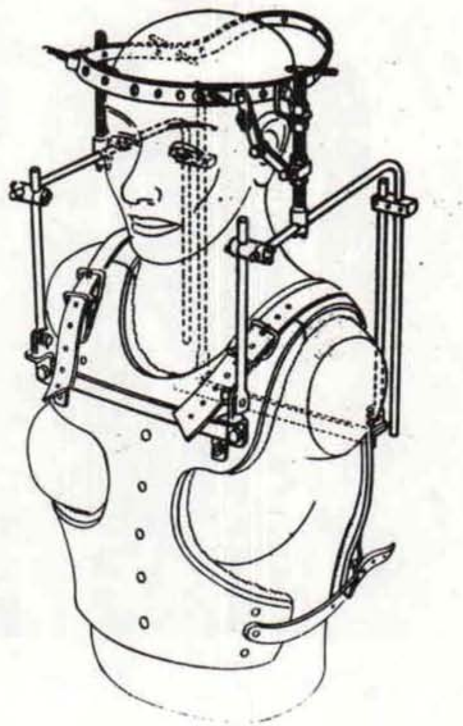

Fig. 5: Halo-vest assembly (halo jacket). (From brochure on "Halo Traction Equipment," Ace Orthopedic Co., Hawthorne, California.)

The only orthosis, if I may call it that, which comes close to the theoretical "total immobilization" is the halo cast (Fig. 4). The head is rigidly held by the halo which is attached to a snug cast on the torso. It obviously does not "totally immobilize" the cervical spine, but is very efficient.

The removable halo jacket (Fig. 5) which is being marketed, and with which I have had no first hand experience, at least potentially can be harmful. If by applying a halo to the skull, you imply that the instability of the cervical spine is significant, then an efficient immobilization device is needed. The halo jacket system allows the possibility of loosening or partial removal of the jacket by the patient and dangerous alteration of position of the head. The long lever arm attached rigidly to the head just above the spinal instability, would seem to magnify the risk and stress to the unstable segments. This is an empiric concern, and I don't really know whether it has proven to be real. Perhaps, some of the participants of this workshop can shed light on this.

Future Needs in the Cervical Area

From the physician's standpoint, I would like to see a method of immobilization of flexion, extension and rotation without skull penetration. From the patient's standpoint, three qualifications should be met: 1) the orthosis should be reasonably comfortable, 2) the patient should have the ability to continue his occupation, and 3) the patient should have reasonable ability to remain clean.

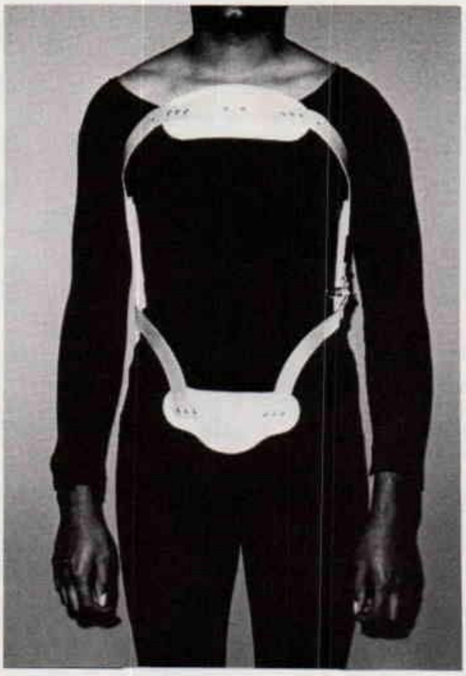

Fig. 6A: Jewett Brace—front.

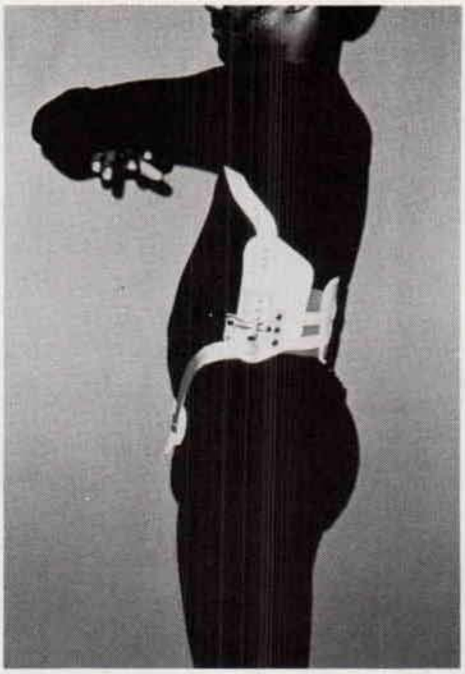

Fig. 6B: Jewett Brace—side.

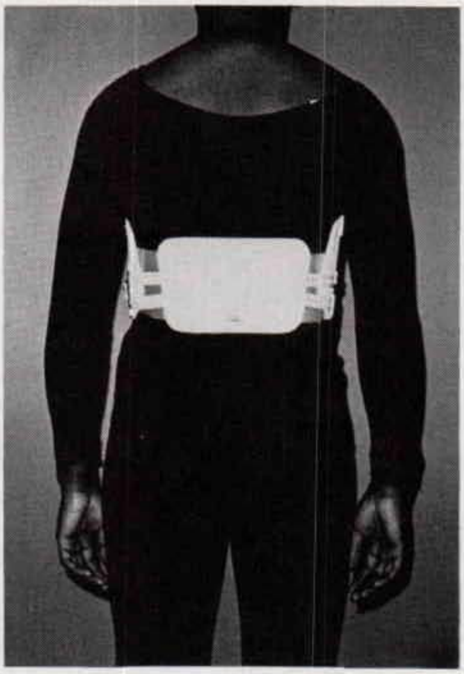

Fig. 6C: Jewett Brace—rear.

ORTHOSES NOW AVAILABLE FOR THE THORACIC AND THORACOLUMBAR SPINE

I will discuss these together. We have three basic types: 1) the Jewett (Figs. 6A-C), which prevents flexion primarily in the thoracolumbar area, 2) the long Taylor (Figs. 7A-C), which is reasonably efficient in preventing flexion, extension and lateral motion, and 3) the cow-horn brace, which accomplishes much the same. There are basic deficiencies in orthoses for the thoracic spine in that unless a cervical orthosis is attached rigidly, there is little support or immobilization above T-7 or T-8. The orthoses which are designed to limit flexion are reasonably efficient when properly fitted. Long Taylor orthoses can support the spine in extension also but are efficient only when very tightly applied around the shoulders and the axillae.

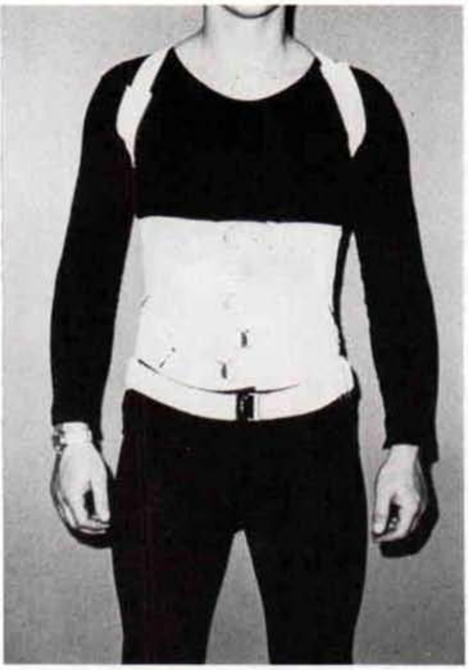

Fig. 7A: Long Taylor Brace—front.

Fig. 7B: Long Taylor Brace—side.

Fig. 7C: Long Taylor Brace—rear.

Future Needs in the Thoracic and Thoracolumbar Area

Future needs for the physician are: 1) better methods of immobilization of the upper half of the thoracic spine, and 2) some means of maintaining immobilization and support while allowing changes in posture from standing to sitting. Again, the patient is looking for reasonable comfort, the ability to continue his work and reasonable means of maintaining good hygiene.

LUMBOSACRAL ORTHOSES PRESENTLY AVAILABLE

I have grouped these since a good orthosis for the lumbar spine which does not include the pelvis probably doesn't exist. There are at least three general types: 1) the Knight, chairback or low Taylor type, 2) the William's flexion brace and 3) the rigid molded plastic jackets, many of which are flexion jackets. The Knight (Figs. 8A-C), chairback or low Taylor brace does a reasonable job of

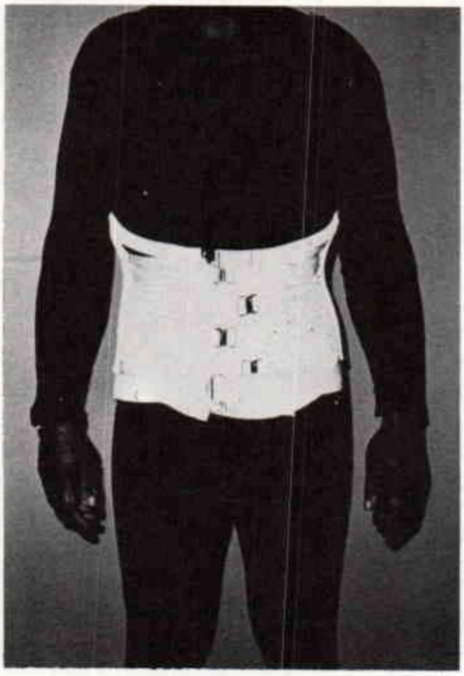

Fig. 8A: Knight Brace—front.

Fig. 8B: Knight Brace—side.

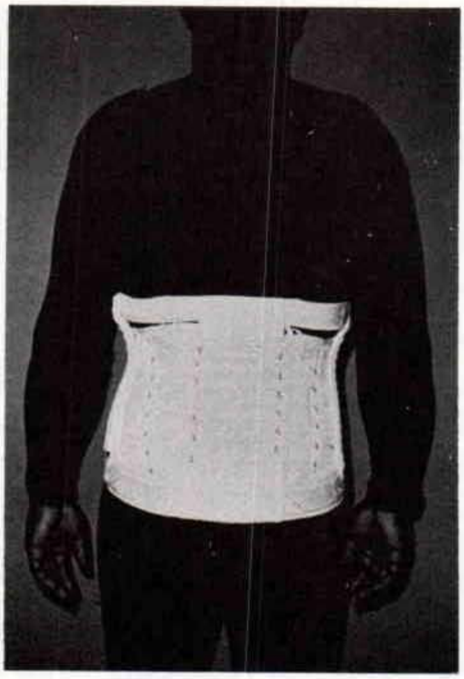

Fig. 8C: Knight Brace—rear.

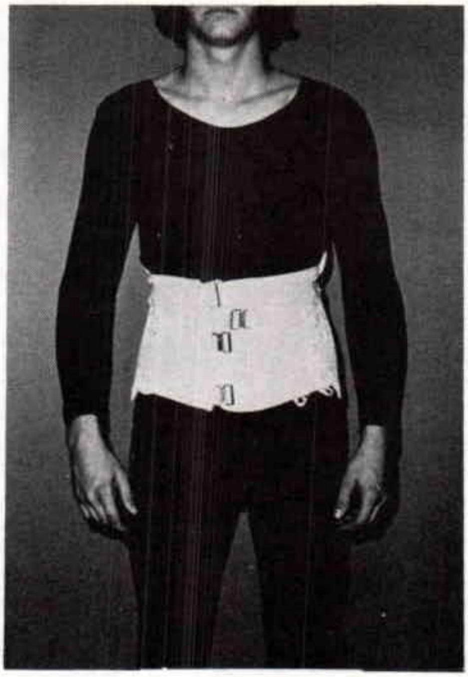

Fig. 9A: Williams Brace—front.

Fig. 9B: Williams Brace—side.

Fig. 9C: Williams Brace—rear.

limiting flexion and extension as well as lateral bending. The Williams (Figs. 9A-C) flexion brace limits extension and tends to maintain a posture of slight flexion. The rigid molded plastic orthoses (Figs. 10A-D), especially those with inflatable pads and those with a compressible lining probably are the most efficient toward a goal of immobilizing the lumbar and lumbosacral spine in all planes. Abdominal pressure tends to unload the spine and, apparently, is a significant part in the increased efficiency of this type of orthosis. Its chief drawback is that these rigid orthoses are frequently uncomfortable when fitted low enough around the pelvis and trochanters and high enough around the ribs. Many adults cannot tolerate this for a significant period of activity. For most efficient wearing, a custom-made appliance is probably necessary. There should be some debate on this point.

Future Needs in the Lumbosacral Area

As for the future, I'd like to have an orthosis to accomplish the efficient immobilization of the rigid jacket with the abdominal pressure to unload the spine and produce minimal discomfort so that the orthosis can be worn during the entire working period.

ORTHOSES FOR SPECIAL GOALS

We now move on to orthoses for these special goals: treatment of scoliosis, kyphosis and spinal cord injury.

ORTHOSES FOR SCOLIOSIS

The orthoses now available for scoliosis include the standard Milwaukee brace and a number of "underarm" orthoses and rigid jackets for the trunk. These underarm jackets and braces include the rigid Lexan jacket from Pasadena, the orthoplast jacket from the du Pont Institute in Wilmington and the Boston prefabricated system. All are designed to treat a lateral deformity of the spine in growing children.

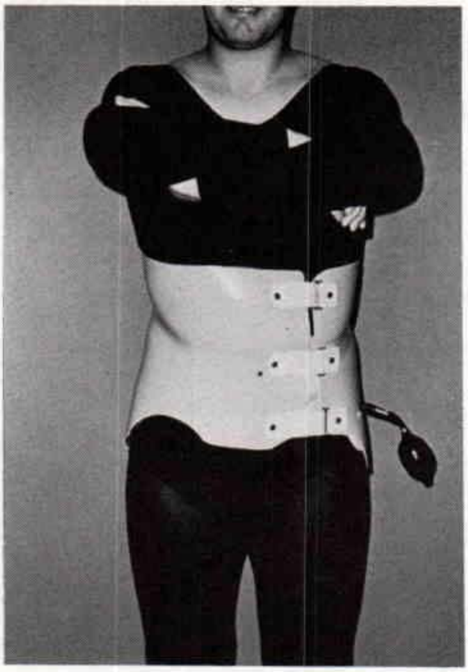

Fig. 10A: Rigid molded plastic orthosis with inflatable pads—front.

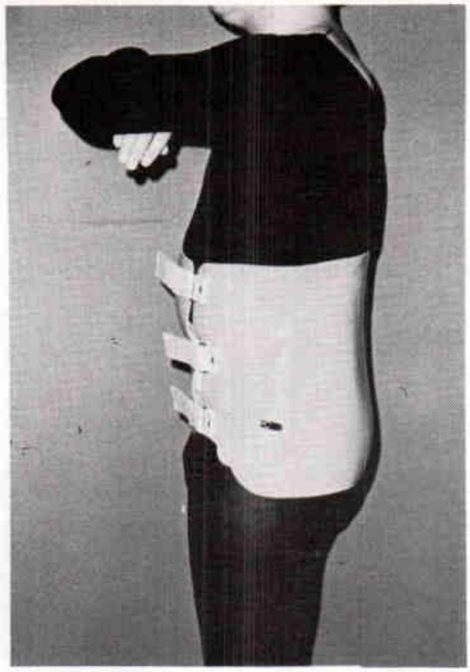

Fig. 10B: Rigid molded plastic orthosis with inflatable pads—side.

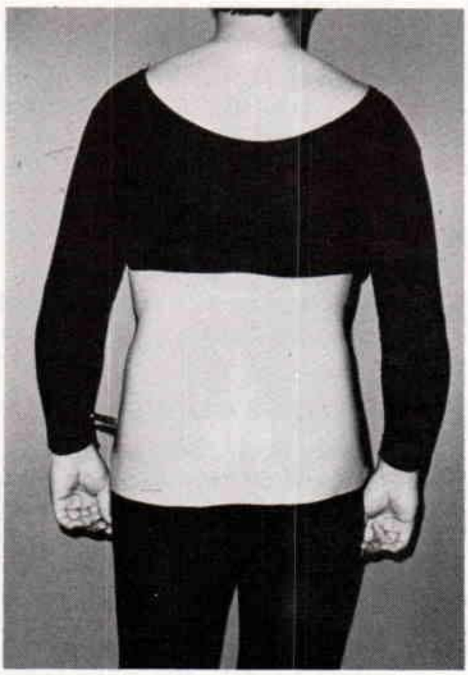

Fig. 10C: Rigid molded plastic orthosis with inflatable pads—rear.

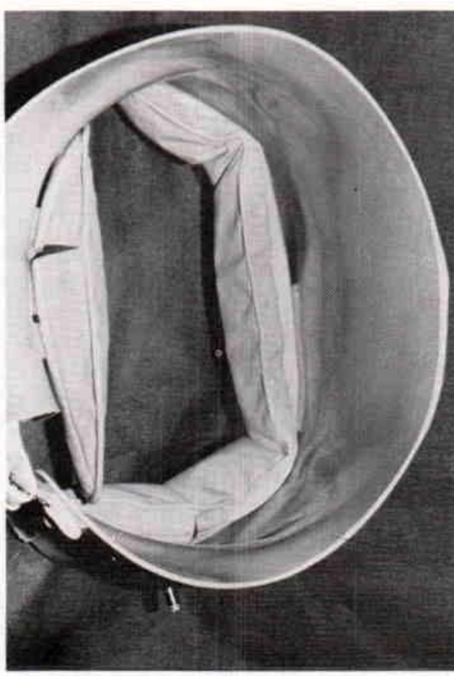

Fig. 10D: Interior view showing inflatable pads.

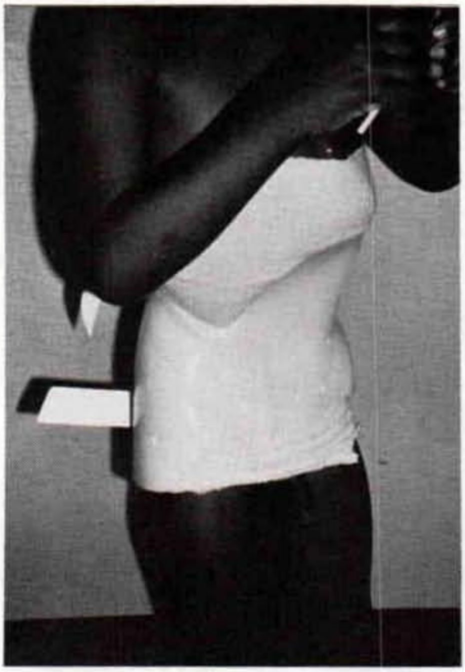

Fig. 11A: Underarm prefabricated orthoses for scoliosis. Lumbar lordosis is also controlled—front.

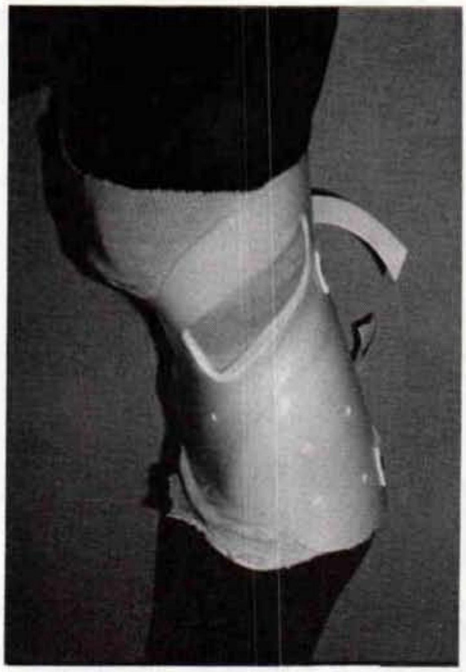

Fig. 11B: Underarm prefabricated orthoses for scoliosis. Lumbar lordosis is also controlled—side.

The Milwaukee brace, which produced improvement believed to be permanent in the lumbar, thoracolumbar and thoracic curves but not in upper thoracic curves, is now being seen in a little different light. Series of parents from both Minneapolis and from Milwaukee indicate that most of the "permanent" correction is eventually lost even though there are obvious spectacular exceptions. The Lexan jacket from Pasadena and the orthoplast jacket from Wilmington also seem to be "holding devices" for stopping progression of scoliotic curves in growing children and seem to offer little hope for actual improvement of the scoliosis.

The verdict is not yet in on the Boston orthosis (Figs. 11A-B and 12A-C) as for as"permanent improvement" is concerned. After only a few years of usage, it seems to be very efficient in treating lumbar and thoracolumbar curves and may prove satisfactory in thoracic curves although this is still not yet determined. This orthosis provides very rigid immobilization of the lumbar and thoracolumbar spine, but as I see it, does not al-

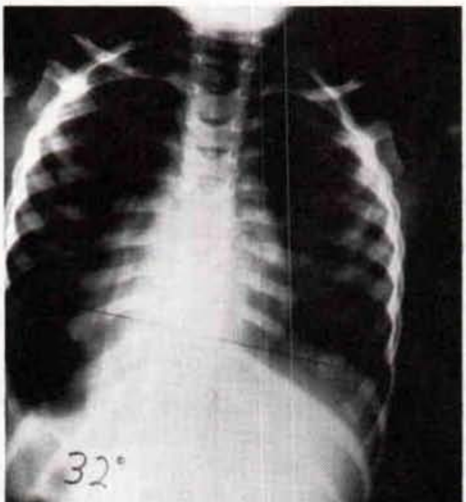

Fig. 12A: Nine-year-old male with left lumbar curve of 32 degrees.

Fig. 12B: With plastic orthosis applied, curve measures 7 degrees.

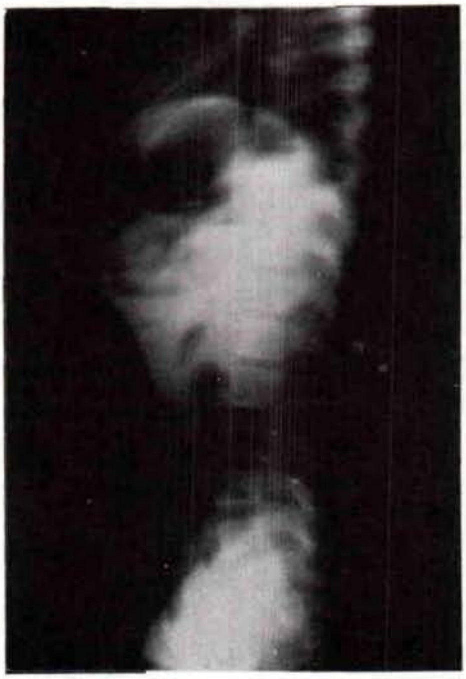

Fig. 12C: Lateral view shows almost complete flattening of the lumbar lordosis.

low the same freedom of activity of the trunk as the standard Milwaukee. Whether or not this will make a difference in the long-term results will not be determined for another 10 to 15 years. Prefabricated plastic girdles (Fig. 13A) of several types are available. In the Boston system (Figs. 14A-C), the blank for the girdle is constructed so that the major portion of the underarm orthosis is also prefabricated.

As for the future needs for orthoses for scoliosis, we are still looking for production of permanent improvement in the scoliosis and permanent improvement with the least restriction of trunk and total body activity. Removal for trunk exercises seems to be important. The patient again is looking for cosmetic acceptance, good hygiene and minimal restriction in activity. The cosmetic advantages of the underarm brace are obvious to everyone. If they live up to their promise, they may well be a great step forward in orthoses for scoliosis. Wally Blount has pointed out repeatedly for many years that underarm braces were not effective in controlling or improving scoliosis.

Fig. 13A: Milwaukee brace with prefabricated plastic girdle.

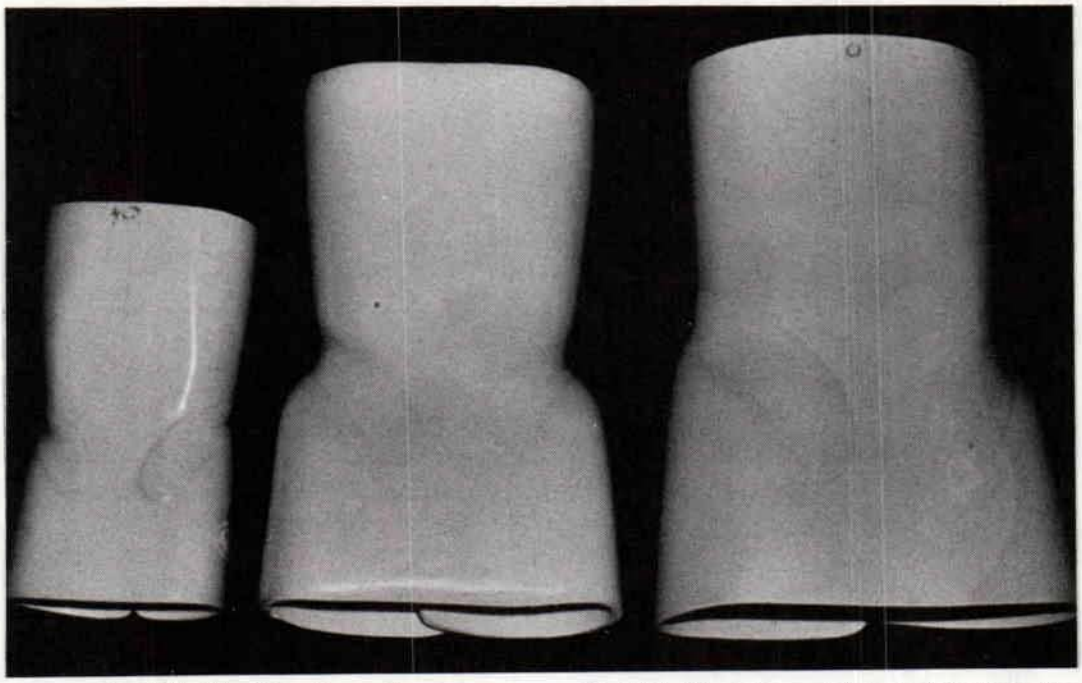

Fig. *13B:* "Fixed" lumbar pad.

Fig. 14A: Blanks for prefabricated plastic girdles.

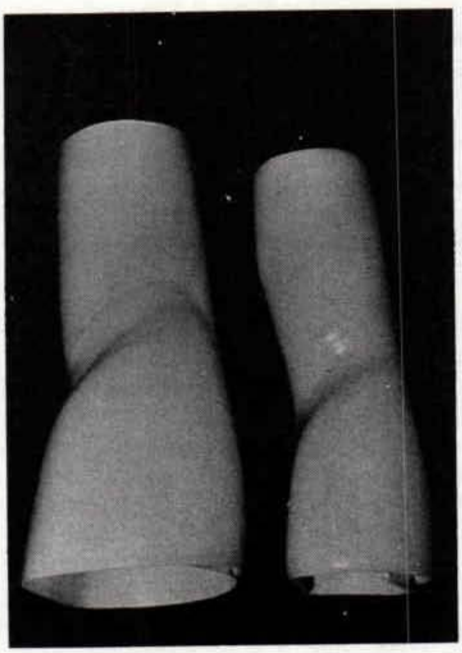

Fig. 14B: Blanks for prefabricated plastic girdles.

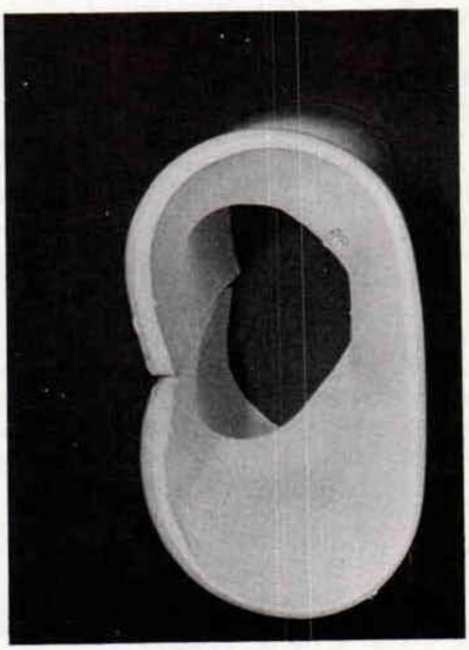

Fig. 14C: Another blank for a prefabricated plastic girdle.

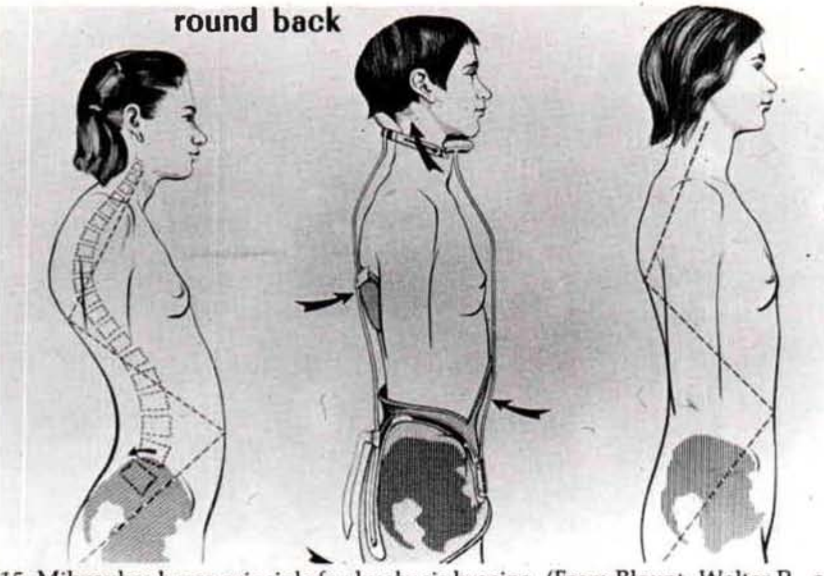

Fig. 15: Milwaukee brace principle for kyphosis bracing. (From Blount, Walter P., and Moe, John H.: *The Milwaukee Brace*. Baltimore: The Williams and Wilkins Co., 1973, p. 74.)

ORTHOSES FOR KYPHOSIS

Moving on to kyphosis braces, the ones now availavle are two types: 1) the standard Milwaukee brace and 2) the underarm braces employing the flexion or antigravity principle. There is no question but that the full Milwaukee brace (Fig. 15) with control of the head and neck and the upper portion of the thoracic spine is far more efficient than any of the underarm or antigravity type braces. The molded prefabricated pelvic girdle which is very efficient in flattening the lumbar lordosis, added to the regular Milwaukee superstructure becomes the most efficient orthosis for kyphosis to my knowledge. Again, as for scoliosis, for the future we need an orthosis to produce permanent improvement and restrict the activity of the trunk and the patient as little as possible. In addition, we must have cosmetic appearance. Again also, the greater cosmetic acceptance of the underarm braces is obvious and would seem to be the direction for future development.

ORTHOSES FOR SPINAL CORD INJURY

The last area to be covered is that of orthoses for adults with spinal cord injury. I know of no suitable orthosis for the quadriplegic which can be used for other than very short periods of time. This includes orthoses similar to long Taylors, molded plastic jackets and so on. The combination of a collapsing paralytic spine and insensitive skin is formidable. For a paraplegic with low level and protective sensation over the lower abdomen, and in the fortunate patient with sensation around the iliac crest, most of the thoracolumbar or lumbosacral orthoses can be used. Probably the most frequently used is the Jewett type of extension orthosis which does not depend on pressure around the crest of the ilium or over the sacrum.

While it is certainly true that a long spine fusion with internal fixation will provide the best permanent stability for the spine of a spinal cord injury patient, a dream for the future in orthotics is a spinal orthosis with a pressure fit around the pelvis and the thorax sufficient to support the spine without producing skin necrosis. Included in this must be a fit around the abdomen which does not inhibit or restrict respiration to any significant degree. For patients with high level spinal cord injury, a shell type modification of the seating device may be the only reasonable answer.

These comments should serve as an introduction and without question are not all inclusive. The "big picture" as I have presented it will undoubtedly look different to many of you. Perhaps, the workshop will get us into the planning or possibly sketching stage of a new big picture.

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DELIVERY OF PROSTHETICS AND ORTHOTICS SERVICES CURRENT STATUS AND FUTURE NEEDS

Ted Thranhardt, C.P.O.

The finest research and development program in any field of medicine is of little value unless the results are made available to the patients that it was intended to help.

Considerable success has been achieved in this country and in Canada in making the results of research and development in prosthetics and orthotics available to appropriate patients by providing educational opportunities to prosthetists, orthotists, physicians, and therapists. Yet, we all know that the delivery of prosthetics and orthotics services are not as efficient as they might be.

Before making recommendations for improvement let us look at some of the questions and facts facing practicing prosthetists and orthotists.

To whom are the services rendered?

• Physicians? No, that is to whom we are responsible for failure since the physician expects us to perform our duties successfully.

• The patient? Yes, but where are these patients? What are their disabilities? How many are there to be treated?

Where are these patients?

• The patients being currently treated by our existing delivery system are basically in the populated areas.

• "There is a universally accepted thesis that orthotic/prosthetic services are used in direct relationship to their availability and quality."[1]

• But, the patients available or in need of treatment are in every county, parish, and province in the world.

What are their disabilities?

• Amputation
• Paralysis
• Birth Defects
• Deformities
• Disease

How many of these patients are there?

• According to the figures compiled in 1971 and 1973 by the National Academy of Sciences there are:

Disability			Population
Amputation			300,000
Paralysis:			
Hemiplegia		340,000	
Paraplegia		200,000	
Quadriplegia		38,000	
Misc. (upper limbs only or one lower limb)		502,000	
	SUB TOTAL		1,080,000
Birth Defects:			
Cerebral Palsy		750,000	
Spina Bifida		27,500	
Osteogenesis Imperfecta		30,000	
	SUB TOTAL		807,500
Deformities:			
Upper Limb		819,000	
Lower Limb		2,916,000	
Spinal		1,135,000	
	SUB TOTAL		4,870,000
Disease:			
Muscular Dystrophy		200,000	
Multiple Sclerosis		500,000	
Parkinson's		1,000,000	
Disabling Arthritis		2,201,000	
	SUB TOTAL		3,901,000
		TOTAL	10,958,500

• These figures amount to about 7 percent of the population. This 7 percent figure closely agrees with the 7½percent figure quoted from the United Kingdom.

• 7 percent—that is what the unemployment rate is in the United States. Should equal emphasis be placed on caring for the disabled as the unemployed?

How many are being cared for?

• This a very difficult question to answer accurately. In communities where service is available and of high quality, the per capita expenditure is about one dollar and twenty five cents ($1.25) per year. This could conceivably be greater if even higher quality services were readily available.

• The expenditure per capita is about seventy cents (70¢) annually.

• If these figures are accurate, only 56 percent of the needed services are being performed by the current system.

By whom are these services being performed?

• The only accurate numbers concerning practitioners we have are concerned with those involved in the program of the American Board for Certification; and unfortunately there are many people delivering services who are not involved with the certification program.

• There are currently about 1,600 practitioners certified by A.B.C.

CP — 36 percent
CO — 41 percent
CPO — 23 percent

• Of these 1,600—12.5 percent have baccalaureate level education.

• 50 percent of these have high school education or less — NO short courses, NO college level training at all.

• 22.5 percent of these certifees will retire in the next ten years (or are retired).

• 50 percent have been in the field more than 20 years.

How are these services being delivered?

• They are for the most part delivered by a part-time, semi-professional.

• They are delivered by a part-time mechanic, carpenter, craftsman.

• They are ordered by an independent, better educated, oft-times autonomous, but not so knowledgable, physician, through a shy, inferiority complex ridden, under-educated (formerly) prosthetist or orthotist who in addition to patient care responsibilities, must fabricate the devices in his "shop."

• Not every practitioner fits the above description just as every clinic and physician certainly does not, but the numbers of prosthetists, orthotists, physicians and clinics that do certainly generate the predominate colors of the current picture of service delivery in prosthetics and orthotics.

• Still 56 percent of the needed services are being provided.

Future Needs

If that is the current state of delivery, what *can* the future hold? What must the future have to provide a more complete, more modern, more realistic, more economical, more efficient, more beneficial delivery of services?

To whom?

• We cannot make our plans based on someone curing paraplegia or quadriplegia, but must anticipate there will be at least as many, if not more, as medical science preserves these lives. The same can be said of the other categories outlined. We must assume we will continue to be needed by 7 percent of the total population.

Who will deliver these services?

• The A.B.C. has taken the first major step in defining who will provide patient care service in orthotics and prosthetics with the upgrading of requirements for certification examination. The requirement for a baccalaureate degree will provide the patient, physician and clinic with not only a better educated, but more self-confident, knowledgable, full-time practitioner of patient management.

• This practitioner will not have the manual trade skills so evident in current practice, and should not need them.

• Rather than trade skills the practitioner of tomorrow will have a more thorough knowledge of the body sciences, including a finer understanding of what is truly involved rather than a superficial overview of the problem. He will, of necessity, have mechanical and electrical concepts included in his education.

• He will, in short, need to have a "professional's" education, responsibility, and attitude. That education will have to be available in many colleges and universities, not just one or two.

How will these services be delivered?

• We now get into the real charge to this workshop.

• What can research do to facilitate delivery of services to the full 7 percent of the population; to the spina bifida in Pineville, Virginia, to the paraplegic in Plains, Georgia, to the cerebral palsy victim in Belmont, Nevada?

• Research must first develop a system (or systems) of measurement and design that can be transmitted to a fabrication center or laboratory so rapidly and so accurately that the laboratory can produce devices that fit, function, and facilitate habilitation or rehabilitation.

The prosthetics and orthotics practice of tomorrow will not have a "shop" anymore than the dentist's treatment room or the cast room is a "shop."

The dentist and the orthopedist use modular components and we are fast approaching that in prosthetics; but there remains the fabrication of the interface—the socket.

Orthotics has not yet developed a modular system in lower limbs and has touched only the surface in upper-limb and spinal problems.

Recommendations

For each area of treatment—lower-limb orthotics, spinal orthotics, below-knee prosthetics, etc.—a system should be developed for measuring, correcting or modifying those measurements, and transmitting the corrected measurements to a fabrication center rapidly, whether the center is 4 miles, 40 miles or 400 miles away.

Each new device, component, technique, or design must be compatible with a central fabrication system or provide for such use.

The achievement of the central production system must not compromise patient care effectiveness but must enhance it.

As all legal contracts say "time is of the essence," this system must facilitate rapid delivery rather than impede it.

In the future we must deliver our services to all who need them. We must provide these services to every locality in a timely and quality fashion. Only by allowing the practitioner to practice his profession more and trade less, can he reach out ot offer his services to more people in less densely populated areas.

At least 44 percent of the population that need help is not being helped. Only *we* have the skill, education, and responsibility to care for them.

Service? Delivery? Research? Yes, they go hand-in-hand! Each is dependent upon the other.

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Orthotics and Prosthetics, Vol. 31, No. 4, pp. 47—53, December 1977

REPORT
PANEL ON UPPER-LIMB PROSTHETICS

Membership:
Chairman: Dudley Childress
Recorder: Maurice LeBlanc
Members: John Billock, Jack Hendrickson, Alfred Kritter, John Lyman, Carl Mason, Ray Mendrola, Raymond Pellicore, Wesley Prout, William Sauter, Carl Sumida, Bert Titus

It is estimated there are 100,000 upper-limb amputees in the United States of whom about half actually wear prostheses. Lack of acceptance of prostheses is a complex, multifaceted subject, but it is known that prostheses are accepted for about four reasons:

(a) good appearance (cosmetic)
(b) useful function
(c) reliability
(d) comfort

Body-powered, cable-driven upper-limb prostheses have gone through a 25-30 year evolutionary process and, within their limitations, have functioned well. They will be important in upper-limb prosthetics for many years to come, but improvements in their function and appearance are needed. However, dramatic breakthroughs in this area seem to be unlikely.

Amputees today have high expectations for their prostheses and the goal of research and development should be to create improved prostheses which are functional and cosmetic while also being reliable (repair free for one-year intervals) and comfortable. Powered limbs offer potential for improved prostheses, but it is estimated that only one percent of the upper-limb amputees in the United States currently use powered prostheses of any form. Expanded growth in this area is expected.

State-of-the-Art

Current state-of-the-art in upper-limb prosthetics practice is defined to include devices (or systems) and techniques which are available today (1977) to the general amputee population. State-of-the-art is summarized in Tables 1, 2, and 3 which relate amputation levels with standard practice.

TABLE 1

Unilateral Upper-limb porstheses	STATE OF THE ART				Needs
	Socket	Components	Control	Other/ Comments	
Partial Hand	Plastic Laminated, Flexible or Rigid Socket	Robin-Aids Handy-Hook Passive	Cable Operated		
Wrist Disarticulation	Plastic Laminated Atmospheric Pressure Suspension (APS) Elastic Liner Suprastyloid Suspension	Standard Mechanical Hand or Hook Powered Electric Hands Passive Hand	Cable Operated Switch Control Myoelectric	Difficulty in Donning Length Problems	
Below-Elbow	Supracondylar Plastic Standard Flexible Sockets APS	Standard Mechanical Hand and Hook Powered Electric Hand Mechanical Wrist Rotator Powered Electric Wrist Rotator	Cable Operated Switch Control Myoelectric	Self-Suspended, Self-Contained, Myoelectric is the Most Desirable	More Efficient Mechanical Hand Inter-changeability of Powered Hook and Powered Hand

TABLE 2

Level of Upper-Limb Prostheses (Unilaterals)	STATE OF THE ART				
	Socket	Components	Control	Other/ Comments	Needs
Elbow Disarticulation	Elastic liner Screwdriver shape for rotation control Plastic Laminate	Powered Electric Hands Outside Locking Joint Powered Electric Wrist-Standard Mechanical Components	Cable Operated Elbow Only	Marquardt Angular Osteotomy	Improved Elbow Joint
Above-Elbow	Plastic Laminate - standard - over shoulder - open shoulder APS	Powered Electric Wrist Powered Electric Hands Endoskeletal System Powered Electric Elbow Cable Recovery Unit Standard Mechanical Components	Cable Operated Switch/Myoelectric Hybrid-External/ Body Power	Self-Suspended, Self-contained Most Desirable	Endoskeletal - Active Elbow Multifunction Control
Shoulder Disarticulation including Inter-scapulo-thoracic	"Frame" Socket Plastic Laminate	Shoulder Caps Passive Components Cable Recovery Unit Endoskeletal System Standard Mechanical Components	Cable Operated Switch Control	Success With Cable driven Components Is Low	Multifunction Switch Control Powered shoulder Improved socket Interface Multifunction Control

TABLE 3

High-Bilateral Upper-Limb Prostheses	STATE OF THE ART				
	Socket	Components	Control	Other/ Comments	Needs
	Laminated Rigid Frame	TD's Wrist Elbow	Cable Driven Switch (Elec.) Hybrid	Simpson (CO_2) Provided by contract?	System Approach Better Special Center Multifunction Control System
	Plastic Laminate				
		Conventional Mechanical Joints		Wrist Rotation & Flexion	
		Coordinated Arms (Feeders)		Humeral Rotation	
		Simpson Arm System		Hand vs. Hook	
				FOOTNOTES:	FOOTNOTES:
				Lack of sensory feedback	Improved Sensory Feedback Improved Prosthetic Skin Improved Cosmesis Reduced Weight

Improvements have been made in upper-limb prosthetics during the last ten years although none of these have been significant enough to revolutionize the field. A partial list of improvements is as follows:

(1) Improved supracondylar below-elbow sockets.
(2) Improved above-elbow socket systems.
(3) Self-contained and self-suspended powered prostheses.
(4) Development of externally powered hands and other components.
(5) Myoelectric control systems.

Myoelectrically controlled hands for the below-elbow amputee are available through regular channels. Powered limbs for the above-elbow amputee and the higher level amputee are available in special centers. Electrically powered hooks, to provide hook-hand interchangeability are ready for clinical evaluation.

Improved prosthetics practice is not limited to technology. The technology is here, the biggest problem concerns the transfer of the technology to the field (clinical practice). This does not mean that technical improvements are not necessary with existing devices. It means that technology can out-race our ability to implement it in the field.

Recommendations

There are many recommendations which could be made in the field of upper-limb prosthetics. Only a few are listed here in order to emphasize their particular importance. They are listed in order of perceived importance.

1. It is strongly recommended that the delivery of available technology and techniques (e.g., below-elbow myoelectric prostheses) be promoted actively.
   (a) A TEST (Technology-Extension-Service-Testing) program should be instituted to implement the new developments. The TEST program could operate somewhat as an Extension service (e.g., The Agriculture Experiment Station System). This organization would transfer technology to the "grass roots" level through extension education programs and be involved with overseeing service problems and evaluation (testing). A catalog of available components and systems, as well as up-dated information on new developments, could be provided by this group to local prosthetists, therapists, and physicians.
   (b) New prosthetics techniques and systems that have been shown to be worthy should be taught in the basic and continuing prosthetics education programs of the U.S. These programs should be directed toward the clinic team, primarily the prosthetist, the physician, and the therapist.
   (c) The American Academy of Orthotists and Prosthetists should play an active role in this delivery program.
   (d) Third party payers (e.g., insurance companies, agencies, etc.) should be kept informed of the benefits and cost of new prosthetics practice.

2. It is recommended that a mechanism for the clinical evaluation of new and existing research developments be established. Provision should be made for a coordinated effort in this field to insure effective and efficient use of resources.
   (a) It is especially important for the school faculties and manufacturers as well as the developers to be involved in the evaluation cycle.
   (b) The functions of the former Committee on Prosthetics Research and Development (CPRD) should be reinstituted for this purpose.
   (c) The AAOP should be involved in evaluation of upper-limb prostheses.
   (d) Clinical evaluations should be performed by objective evaluators and not by the developers.

3. It is recommended that specialized centers be developed to provide service and to undertake research concerning the special problems of the high-bilateral amputee and other difficult cases.
   (a) Such centers should serve children and adults.
   (b) These centers should be few in number and capable of handling multimembral amputees.
   (c) The centers would provide information and consultation to the upper-limb prosthetics field.
   (d) These centers would focus on available technology, whatever its source. An immediate goal should be to obtain for evaluation the system developed for amelic children by Simpson in Scotland.

4. It is recommended that the achievement of self-suspended and self-contained prostheses be promoted strongly for the amputee population.
   (a) Emphasis initially should be directed toward above-elbow level prostheses.
   (b) The use of externally powered elbows should be studied and development expedited.
   (c) Dr. Marquardt's surgical technique of angular osteotomy, to increase suspension and rotational stability for above-elbow limbs, should be studied and recommendations made for clinical practice.

5. The development of improved prosthetic skin and soft tissue for arm prostheses is recommended.
   (a) Reference should be made to previous specifications prepared by CPRD for prosthetic skin and soft tissue.
   (b) Commercial enterprise should be funded to develop an improved prosthetic skin material.
   (c) Other efforts should be recognized and studied for possible interim or long range benefit for certain situations. These include efforts of Otto Bock (new glove), and of Dr. Leonard (acrylic coatings), Mr. Sauter (silastic), and Mr. Billock (latex).

6. It is recommended that the improvement of body-powered upper-limb prostheses not be neglected in a trend toward powered prostheses.
   (a) Improved harness techniques which optimize the effectiveness of body motions are needed.
   (b) Self-suspension techniques should be examined for use in many body-powered prostheses. Sockets, in general, have not been given adequate attention in development laboratories and in practice not enough concern is shown for intimacy of fit.
   (c) Creative experimentation with combinations of body power and external power (hybrid systems) is strongly encouraged.

Standards

Non-invasive, upper-limb prostheses are not life threatening and pose no more hazard than the non-amputee's normal physiological limb. Mechanical or electric failure of upper-limb prostheses normally pose no hazard to the user. Consequently, these devices should be exempt from regulations.

Future prostheses which might contain implantable or transcutaneous components (electrical or mechanical) would need to be considered separately.

Long-Range Considerations

1. The development of subconscious control of prostheses having multiple func-

tions is desirable. Such a system would relieve the amputee, as much as possible, of continuous monitoring of the prosthesis and permits the prosthesis to serve the amputee instead of the amputee serving the prosthesis. A number of technical systems are being developed for this purpose. These include:

(a) Extended physiological proprioception (e.p.p.).
(b) Trajectory control which directs the endpoint (hand) and automatically adjusts for changing torques and loads.
(c) Multiple and single myoelectric channel signal processing for control of multiple outputs.
(d) Neuroelectric control (multiple-channel) from nervous tissue.

Some of these techniques require complex electronics technology. However, recent advances in microelectronics make these systems potentially practical, from a technical standpoint.

2. The development of articulated and multifunctional hands appears promising.
3. Direct skeletal attachment is a laudable long-range goal in upper-limb prosthetics.
4. Improved battery design would be helpful in upper-limb prosthetics. High energy and power densities are desirable to reduce weight and size. Increased ruggedness and greater reliability are also needed.
5. The development of electric hands that are smaller than and larger than those currently available is desirable.
6. New prehension systems such as the hook proposed by Bottomley in 1966 should be investigated.

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REPORT
PANEL ON LOWER-LIMB PROSTHETICS

Membership:
Chairman: Robert G. Thompson, M.D.
Recorder: Michael Quigley
Members: James Foort, Bert Goralnik, John Leimkeuler, Fred Leonard, Eric Lyquist, Hans Mauch, Alvin Muilenburg, Charles Pritham, Charles Radcliffe, William Wagner, M.D.

The panel was convened after the presentation of the position papers, and we considered the problems in light of the charges given; that is, to consider those devices currently available on the market, and those perhaps in need of clinical evaluation. We attempted to set some sort of priority in reference to the devices and techniques that are needed. We also made recommendations for research, development, educational efforts, materials development, fabrication and fitting techniques, and evaluation programs.

Surgical Phase

For the lower-limb amputee, it was the opinion of the group that there was a great need to improve the surgical technique or the performance of the amputations that are subsequently fitted and treated by the prosthetist and therapist. Ideas were expressed that for some patients the prosthetist should be involved in the decision as to the level of amputation prior to the actual procedure. Because a great number of lower-limb amputations are performed by general surgeons and vascular surgeons it was the consensus that a protocol should be established for amputations to yield the best possible results for subsequent rehabilitation. Since the Veterans Administration has been a leader in the field of prosthetics, it was suggested that such a protocol be established for the performance of amputations in VA Hospitals (with involvement of amputee clinic teams) and this technique could then move into the non-VA sector.

The question of selection of amputation level for the vascular amputee was also discussed. At present there are several ways of determining a satisfactory level of amputation that would be reasonably successful, such as the Xenon 133 technique, the thermograph, the angiograph, the oscilloscope, the Doppler technique with its variations; and as a clinical appreciation of satisfactory level, the bleeding at 3 minutes post-tourniquet time. This subject was of such importance in the performance of the amputation that a strong recommendation was made that a workshop be convened, consisting of surgeons knowledgeable in the field, who could then also establish a protocol for the various problems associated with surgery. These would include level determination in the vascular case, the place of disarticulation procedures, amputations in children, and amputations secondary to tumors. It is recommended that this same surgical workshop provide guidance in the post-surgical treatment of amputations prior to the fitting of a prosthesis.

Again recognizing the fact that the majority of the amputations are done by surgeons unfamiliar with rehabilitation techniques, but rather in most instances by general surgeons and others, and that these individuals generally do not, as a rule, read the texts or books specifically related to amputation surgery, that an effort be made to reach the publishers of general surgical textbooks such as Christopher, implying in these notifications that there is a great deal of new information available in the area of amputations, and that when these books are revised that an update section on amputation surgery be included. This would then reach the medical students and those who are doing or will be doing the amputations, aside from the very small group that has adequate knowledge of the problems at the present time.

It was also brought to the attention of the group that although there are good methods of treating amputees prior to the fitting of definitive prostheses, and although there exists a period of time in the post-surgical phase where a temporary prosthesis is of great value, it has been the experience of the surgeons present that third party payers, including Medicaid and Medicare, will not reimburse the patient for the cost of such prostheses. These temporary prostheses are provided in large part by prosthetists, and as the costs involved can be considerable, there should be some communication with the third party payers that indicates that temporary prostheses are a part of continuing medical treatment of the amputee, and is needed as well as a definitive prostheses.

Prescription of Lower-Limb Prostheses

Prescription of lower-limb prostheses is probably best provided in the environs of an amputee clinic, or in a physician's office. There is a considerable number of new components and new techniques available to the lower-limb amputee during the past ten or fifteen years, and it was the opinion of the group that a workshop of those involved in teaching and determining prescription principles be held in order to standardize modern prescription criteria. In addition, particularly in the atmosphere of the amputee clinic, the prosthetist should be invited to designate a prescription recommendation for the particular patient prior to the involvement of the physician. This technique may accommodate the natural reticence of the prosthetist, who, as of now, ends up second-guessing the physician in the prescription of the prosthesis.

Levels of Amputation

Partial Foot and Syme's Levels of Amputation

The State of the Art at this level of amputation is anything from stuffing material into the toe of a shoe to providing molded plastic devices, indicating a rather wide divergence of prosthetic practice in amputations through the foot. It was recommended that the AAOP Newsletter include a questionnaire to explore the various solutions already in use for this problem, and that following this a small meeting of prosthetists who are involved in this area be held at the time of an AAOP meeting in order to establish a more workable solution to this problem. It was recognized that the Syme's amputation and prosthesis present no serious problems at the present time but this area might be involved in the same discussion.

The Below-Knee Level of Amputation

Considerable discussion was held on the state of the art. Discussion concerning the foot revealed that the SACH, the single axis, and the multi-axis (Greissenger) feet are in use at present. A hydraulic foot by Mauch is apparently nearing completion. This foot design incorporates a hydraulic joint which may improve many of the problems associated with artificial feet. It was further recommended that the designs of the foot be modified for the geriatric amputee and that part of this recommendation include the weight of such a foot. It was recommended that a mechanical foot be designed that allows dorsi- and plantarflexion, inversion and eversion, and transverse rotation. The existing multi-axis foot does not allow an effective range of transverse rotation. This foot should also include heel-height adjustment in order to enable patients to wear shoes with different heel-heights and to modify their alignment.

The subject of below-knee sockets invoked considerable discussion, revealing among other things, that the present state of the art did not allow for a definitive clinical decision as to when the residual limb is mature, and that perhaps a device to size or sense the limb is needed. Foort and Duncan in Canada and Herron in Houston are studying the problem using photographic techniques. This would also allow a more appropriate size of the cosmetic cover to approximate the size and shape of the opposite leg. The problem of socket adjustability was also discussed. Amputees who are children, are on chemotherapy, are alcoholics, or are geriatrics with weight fluctuation problems usually have frequent volume changes in their residual limbs, necessitating major socket modifications, new prostheses, or rejection of the prosthesis. The use of temporary prostheses is usually not economically feasible, and not practical for a chronic problem. Therefore, it is recommended that a method for easily adjusting definitive socket fit, particularly volume, be developed. The final technique should be able to make use of the already fabricated plastic socket-shank and foot of the prosthesis. A further problem noted, in addition to size and shape changes, was that in going from standing to sitting posture the below-knee amputation stump tends to ride out of the socket. This may be due to either inadequate fitting or perhaps the posterior trim lines of the socket are not adequate for change in position. A study of socket shape and fit to control this problem was also suggested.

Suspension of below-knee sockets was felt to be handled at this point rather well, utilizing the various methods of providing suspension such as the supracondylar strap with pelvic belt, removable wedge, or a supracondylar suprapatellar modification. Most below-knee amputees could be handled by one of these suspension techniques. For the few amputees who require hinges and thigh corset, there was also discussion suggesting use of plastic joints rather than metal, and it is probably in order to consider a clinical evaluation of such joints. Cosmetic covers for below-knee prostheses was also discussed with the trend toward modular prostheses, indicating that at present there was some difficulty in contouring the inside of the cover to accommodate the socket, although the outside contouring could be well handled by most tools in the limb facilities. However, the cover or cosmetic skin for cosmetic covers apparently is well on the way to solution under the direction of Dr. Fred Leonard at George Washington University with VA funding. Further, with the use of modular components a lightweight, good socket-to-pylon coupling device that is easily adjustable and inexpensive is required.

It is also suggested that weight of prostheses be considered a problem for geriatrics and active amputees and it is noteworthy that the polypropylene prostheses are a step in that direction. It is recommended that development of these lightweight prostheses be further encouraged for application of such problems. An evaluation of lightweight prostheses should be conducted, including possible suspension and energy consumption benefits.

The Above-Knee Level of Amputation

The quadrilateral-shape (Berkeley) above-knee socket has been in use for many years, but from the discussion in the group it is evident that there is a need for re-design of this type of socket in view of problems encountered concerning the difference between geriatric and young adult amputees. Patients who have large muscle masses may need better accommodation for the glutei, the rectus, and the adductor muscles. The height of the anterior and lateral wall is also a subject recommended for review. Since the majority of above-knee sockets are now plastic, there is also a need for a thorough review of the methods of obtaining the model used for the definitive socket cast.

Knee Joints

In the area of constant friction joints it was pointed out that the Northwestern "Varigait" knee has been improved with the use of better materials, and at present this is a very definite addition to the lower-limb armamentarium. There is a need for braking, or yielding, knees, and although the present designs are reasonably good, those that are more efficient such as the Kolman knee, have a noise problem as well as function problems. However, it was brought to the attention of the panel that there is a group at Berkeley who are working on this problem and may come to a solution rapidly. Those in manufacturing at present have available materials that could solve the problem of maintenance at a quicker pace and with less effort than people who are primarily doing research in the field. It is recommended that funding of these manufacturers be considered in order to provide them with the stimulus to do this particular job.

Discussion concerning fluid control units revealed that the hydraulic units are at acceptable levels of development, the major drawback to hydraulic units at present being maintenance problems. Mr. Mauch indicated that this has been a continuing problem and may take a further period of time to solve.

Discussion also provided the information that eventually there well may be myoelectric control of knee units to provide locking in the stance phase and/or increase stance phase stability. There is some low priority research going on in this area at the present time, and it is recommended that this be continued on that priority level. This technique would have to have considerable safety features built in to it to prevent injuries that might provoke product liability suits.

Further discussion of the myoelectric situation revealed that an electronically controlled adjustable leg for the below-knee amputee as well as the above-knee amputee might be a significant advance in improving alignment procedures. This could provide dynamic alignment, so that minor changes could be accomplished by the patient or prosthetist while the patient is walking, rather than having the patient stop to change the alignment or rotation. This again is a low priority item. There are several centers working on this problem (University of Tennessee and Moss Rehabilitation) and it was recommended that this work be encouraged.

Knee Disarticulation

There are several systems now available to handle the knee disarticulation level with hydraulic yokes, outside knee hinges, and four bar-linkage mechanisms. Discussion revealed that eventually the four bar-linkage mechanism should be perfected to the point where it would probably replace most of the other mechanisms. Discussion as to surgical tailoring of the stump to provide better sockets revealed that this perhaps should be discouraged because one of the values of the knee disarticulation is the large bulbous distal portion providing end-bearing potential as well as rotatory stability. Any surgical technique that might eliminate these features, in our opinion, should be discouraged.

Hip Disarticulation

Discussion at this point indicated that the previous rigid plastic sockets have been modified by most prosthetists to provide more flexibility, particularly on the unaffected side and it is suggested that perhaps this information should be disseminated more widely than it is apparently known at present. Techniques for providing socket flexibility should also be included. Discussion about the hip-disarticulation hip joint revealed that they were probably too weak in as much as break-down is a significant problem. There is not enough control of hip motion, particularly during swing phase, and a device that will provide some cadence control to the hip motion needs to be developed. Furthermore, the size and shape of the hip joint should be modified to allow easier sitting.

Discussion also revealed that most of the hip-disarticulation prostheses today are being made with modular components, and this, in many cases, solves the problem of excess weight. Further discussion revealed that there was a tendency for instability of the plastic cover on the prostheses and this needs to be improved. Secondly, the question of "creep" of the flexed knee into extension because of the stretching of the anterior cosmetic cover and the compression of the posterior cover, is a problem that is not readily solved. A further look at this area seems to be indicated.

Hemipelvectomy

Socket designs again have been modified slightly from the original concepts, and perhaps information about these modifications need dissemination. Additional suspension techniques for some of the hemipelvectomy sockets are also needed. This might be a shoulder strap. It is recommended that this area be investigated, perhaps through the questionnaire technique provided by the NEWSLETTER—Prosthetics and Orthotics Clinic recently inaugurated by the American Academy of Orthotists and Prosthetists.

Training

It was brought out that there were apparently many variations in the techniques of training lower-limb amputees and that perhaps a workshop composed of therapists, and those in the schools involved in training amputees, should be convened to restudy thoroughly the whole subject of training techniques. This workshop should include practicing prosthetists.

Children Problems

Some discussion was held on children's prosthetics. One of the problems noted is bony over-growth. This matter could be referred to the workshop on surgery to bring out the latest techniques for handling the over-growth problem in the growing child. Secondly, the question of growth and the required lengthening and increase in sizing of the prostheses were discussed briefly. The opinion was that modular components could probably solve the length problems significantly. The question arose of adaptation of sockets for change in shape and size. It was recommended that this be referred to a Rehabilitation Engineering Center that is working on children's problems, particularly in prosthetics. A further problem addressed is that of swing-phase control units for the children and adolescents. The Rehabilitation Engineering Center at the University of Tennessee at Memphis would be particularly suited to this task.

Recommendations

The following recommendations summarize the conclusions of the panel. They are classified by priority—high, medium, or low—and each class is then subdivided by priority, the highest being at the top of the list.

I. High Priority Recommendations
   - A. Workshop on Lower-Limb Amputation Surgery
     1. Recommendations for techniques for predicting successful amputation levels.
     2. Recommendations for disarticulation procedures.
     3. Relative value of muscle stabilization techniques.
     4. Amputation procedures for cancer patients.
     5. Amputation procedures in children.
     6. Post-surgical management.
   - B. Development of Adjustable Definitive Sockets to Accommodate Growth and Volume Fluctuations and Accurate Methods of Measuring Limb Volume
   - C. Development of a Multi-Axis Foot That Provides Lateral Motion, Transverse Rotation, and Heel-Height Adjustability.
   - D. Updating the Literature on Amputation Surgery
     1. Revising general surgery texts such as the Christopher text.
     2. Prepare a new text on amputation surgery.
     3. Determine authors of above publications.

E. Establishment of a Protocol for Amputations
   1. Establish optimum system for amputee rehabilitation.
   2. Stress clinic team approach.
   3. Recommend methods of determining amputation level.
   4. Recommend post-surgical procedures.
   5. Prosthetist consultation before surgery when possible.
   6. Prosthetist initiate prescription recommendations.

F. Development and Evaluation of Lightweight Prostheses
   1. Utilize new materials and fabrication techniques.
   2. Measure energy cost.
   3. Modify suspension techniques to take advantage of weight reduction.
   4. Evaluation training.

G. Development of a Hip Joint for Hip Disarticulation Prostheses
   1. More durable than existing models.
   2. Allow ease of sitting.
   3. Provide cadence control.

H. Workshop on Prescription Principles for Lower-Limb Prostheses
   1. To be attended by physicians, prosthetists, therapists, and representatives from teaching institutions.
   2. Review of existing prescription principles and teaching materials.
   3. Recommend new prescription principles based on updated surgical and prosthetic techniques and components.
   4. Prepare a brief manual to establish guidelines of prescription principles for the lower limb.

II. Medium Priority

A. Development of Improved Methods of Providing Cosmesis to Lower-Limb Prostheses
   1. Development of a prosthetic skin to coat foam cosmetic covers.
   2. Development of methods or materials to prevent rotation of foam covers and creep of these covers, particularly for above-knee and hip-disarticulation prostheses.
   3. Development of methods such as photogrammetry for accurate shaping of the cover of the prosthesis.

B. Improvement of Braking Knee Mechanisms
   1. Reduction of noise and maintenance problems.
   2. Manufacturers best qualified for this and should be encouraged through funding.

C. Development of Remote Control Dynamic Alignment Device
   1. Allow alignment changes while the patient is walking.
   2. Allow the patient to make his own alignment changes.
   3. Allow more variations of alignment to be tried during fitting procedure.

D. Working on AK Casting and Socket Fitting and Alignment Techniques
   1. Recommendations for improvement of existing casting fixtures.
   2. Recommendations for new cast modification techniques.
   3. Recommendations for new socket materials and designs.
   4. Recommendations for alignment.

E. Workshop on Physical and Functional Training of Lower-Limb Amputees
   1. Attended by therapists, prosthetists, and representatives from the educational institutions.
   2. Review existing texts and teaching materials.
   3. Recommend protocol for training.
   4. Prepare a manual providing guidelines for training of lower-limb amputees.

III. Low Priority
   A. Development of Electronic Knee Units
      1. Myoelectric controls.
      2. Switch controls.
      3. Electronic control of hydraulic knee units.
      4. Electromagnetic braking knee unit.
   B. Treatment of Partial Feet and Syme's Amputations
      1. Survey of present fitting techniques through the AAOP NEWSLETTER.
      2. Meeting of experienced practitioners at a national AAOP meeting.
      3. Publication of the results of such a meeting including recommendations for treatment.
   C. PTB Socket Modifications to Correct Sitting Discomfort
      1. Disseminate existing information concerning the solutions to this problem.
      2. Survey of the field to determine other solutions to this problem.
   D. Socket Designs for Hip Disarticulation and Hemipelvectomy Prostheses
      1. Survey of physicians, therapists, and prosthetists through the AAOP NEWSLETTER.
      2. Meeting of experienced practitioners at a national AAOP meeting.
      3. Publication of the results of the survey and meeting in a professional journal.

Orthotics and Prosthetics, Vol. 31, No. 4, pp. 61—64, December 1977

REPORT
PANEL ON UPPER-LIMB ORTHOTICS

Membership:
Chairman for the first day: H. Richard Lehneis
Chairman for the second day: Maude Malick
Recorder: Gary Fields
Members: Thorkild Engen
Steve Reger
Terry Supan

Currently upper-limb orthotics requirements have included a broad spectrum of upper-limb disability areas. The orthotist has been called upon to supply orthotic devices in two primary areas—temporary orthoses (as required in acute care) and permanent long term orthoses.

The upper-limb orthoses required for temporary or short term use are most frequently needed in traumatic arm and hand injuries (involving skeletal, soft tissue, and nerve damage) pediatric splinting when growth spurts require frequent splint changes, and progressive splinting such as needed for the burn patient. The majority of splinting for this group individuals is done with low to moderate temperature thermoplastics. They are predominantly used because of ease of fabrication directly on the patient. Orthoplast, Polyform, and Aquaplast are most frequently used for low temperature requirements. Because these materials do not require either a positive or negative mold, orthoses can be made and fitted within minutes instead of hours. Progressive serial plaster splinting has also been used for temporary and short-term applications.

The majority of these orthotic requirements are static in nature, while dynamic splinting is used primarily for support while allowing joint excursion. Often occupational therapists have supplied these orthotic needs. The orthotist fabricates similar orthoses with moderate to high temperature thermoplastics for heavy use requirements.

Numerous assistive self help devices for activities of daily living (ADL) are available commercially which fulfill the short term orthotic need. Fred Sammons, Inc., Cleo, Zimmer, and OEC are a few of the specialty companies who supply the majority of these items. Permanent long term orthoses of a sophisticated nature are required for the spinal cord injured patients. These patients pose a challenge to all orthotists and occupational therapists who must train the patient to use the orthoses. Between 8 and 10,000 new spinal cord traumatically injured patients occur each year. Of these 5,500 are quadriplegics, all of whom require orthotic devices to regain some degree of independence. According to Dr. John Young of the National Spinal Cord Injury Data Research Center in Phoeniz, Arizona, only 10 percent of the quadriplegics are treated in regional spinal cord centers. The remaining 90 percent are treated in acute care hospitals, rehabilitation centers, and U.S. Military facilities.

Currently five basic orthotic systems are available for use by quadriplegic patients: The Engen (Houston), IRM/NYU (Institute of Rehabilitation Medicine—New York University), Rancho (California), Engel (University of Wisconsin) and RIC (Rehabilitation Institute of Chicago) models. The IRM/NYU, Rancho, and Engel models are now currently available in kit form and must be constructed basically from flat stock which involves a maximum amount of professional labor until all the splint adjustments are completed.

The RIC model can be constructed more quickly of either low or moderate temperature plastics. The RIC system is used in the early evaluation and training stages. It has limitations however, as special modifications and external power cannot be added easily and thus economically.

The modular system offered by Engen is the only readily assembled orthosis with a wide range of application.

The IRM/NYU orthosis now uses Nyloplex (high temperature thermoplastic) as the splint material which is a great improvement in appearance and allows interesting design solutions. Thus the availability of new thermoplastics as well as anatomical and biomechanical considerations have reflected some advances in design and fit.

Upper-limb orthotics for the arthritic has not shown any new advances though many orthoses are being constructed daily. One reason could be the lack of agreement by the medical profession in the efficacy of orthotics in relation to medical and surgical management of the arthritic patient. Little definitive research work has been done and certainly should be pursued. The work at the University of Michigan and that by Dr. Robert Bennett is a start. Investigation in the use of orthoses in rheumatoid arthritis requires active and comphrehensive action. In spite of the recommendations of the workshop sponsored by the Committe on Prosthetics Research and Development in 1973 at Hot Springs, Arkansas, no significant research has been done. A comprehensive research and development program for functional orthotic devices was recommended by the Workshop Panel especially because of the large number of arthritic patients that need help.

The following nine areas are listed in an approximate order of priority as needing further research and development:

1. *Review prehension patterns for quadriplegics.* Traditionally, the three-point prehension pattern has been stressed for quadriplegics. It is believed however, that this prehension pattern may not be best suited for this type of patient in view of the lack of sensory feedback and an interruption of the normal pattern of the kinetic chain. For example, a lateral pinch prehension pattern would permit the patient to use visual cues better in grasping objects. At the same time, this might prove useful in transfer activites and in propelling a wheelchair as it would leave the thumb "out of the way" for these activities. It is believed that this could be investigated by identifying certain necessary activities of daily living expected of a quadriplegic patient, and testing his ability in these tasks with various prehension patterns. The results could then serve as an aid to the design of the orthoses which provide a prehension pattern best suited for the quadriplegic patient.

2. *Control systems for the high quadriplegic.* At present, most externally energized systems are controlled by electromechanical transducers. It is recognized that the use of electromechanical transducers is limited by the availability of an adequate number of control sites. It is therefore recommended that other means of controlling a multiple-degree-of-freedom system be explored, e.g., myoelectric control which requires a better understanding of the EMG potentials available in the facial and cervical areas. This should be based on a mapping of these areas as well as exploration of EEG control or a hybrid system involving various control systems.

3. *Body powered/hybrid systems for quadriplegics.* It is believed that there is not only a need for more sophistication in providing function for quadriplegics but simplifications as well. As such, the work being done by Guilford which uses the effects of gravity beneficially

and thereby enhances the use of residual body power to provide hand and arm function is recognized. Other related systems provide manual control or locking of a prehension orthosis. Such body powered systems may also be incorporated, in part, in externally energized multiple-degrees-of freedom systems.

4. *Hand manipulators.* This is conceived to be an externally energized system for high level quadriplegics. These systems need not be based on an anatomic analog of the arm, but rather would bypass his shoulder, elbow, and wrist joints to simply guide the patient's hand along an XYZ axis. This is not to be confused with manipulators presently under investigation at the University of California, Los Angeles, by Lyman, which are systems that do not incorporate any part of the patient's body.

5. *Improved man-machine interface materials.* Generally, it is found that upper-limb orthoses tend to migrate distally on the patient's hand or forearm. Thus, it is recommended that better stabilization by improved attachments and materials with necessary friction characteristics be investigated.

6. *New materials.* It is felt that there is a need to investigate and develop materials that are both transparent as well as low temperature forming in order to observe injured areas in acute splinting.

7. *Improved functional orthoses for the C-6 quadriplegic.* Although wrist-driven prehension orthoses are available for this type of patient it was believed that such orthoses kinematically inhibit not only wrist movement but induce compensatory movement at the other major more proximal joints. It is recommended that the fitting of a hand orthosis distal to the wrist that may be energized either by external power or by body power be investigated. Such an orthosis would allow the patient to move his major joints, including the wrist, without inhibition by the orthosis.

8. *Improved arm sling designs.* An evalution of the designs of arm slings is believed to be in order to identify the relative value of each. It is recommended also that the vertical arm support sling be made available to a larger patient population in order to enhance the cosmesis and permit better positioning of the arm.

9. *Elbow flexion assist for ambulatory patients.* A need exists for an elbow flexion assist, which may use either external power or stored energy from the body, to aid patients with total paralysis of the upper limb, particularly those with brachial plexus lesions.

There are two remaining areas of top priority that were not mentioned in the preceding listing due to their specialized needs.

The first, and perhaps most urgent, concerns arthrists. It is recognized that very little has been done for arthritic patients. Other than the work being done by Dr. Robert Bennett and by the group at the University of Michigan referred to earlier, no real active and comprehensive action has been taken to investigate the entire problem of the rheumatoid arthritic patient. Specific reference is made to the recommendations noted at the CPRD-sponsored Workshop Panel held in May, 1973 in Hot Springs, Arkansas. In spite of these recommendations from the Workshop Panel, we are not aware of any significant research being done in this area since that time. In view of the large number of arthritics, this is deemed a major priority item. It is generally agreed that Early Fitting Procedures must be accomplished in order to provide good professional service. Contractures and deformities can be prevented if the patient was fitted promptly and accurately. There is a definite need for more qualified personnel both in orthotics and occupational therapy to handle this problem. In addition, we feel that our educational institutions should place a much greater emphasis on current methods available.

In the area of service delivery, it was recognized that problems exist due to the unavailability of competent orthotic service. The most advanced orthotics management is presently practiced at a few select major rehabilitation centers. However, the needs of may patients requiring orthotic services are not met optimally in may areas of the country. It is therefore recommended that central fabrication facilities be encouraged to provide upper-limb orthotic services. Further, it is believed that improved prefabrication systems might aid the orthotist who treats only a limited number of patients in the course of the year. For example, a basic wrist-hand orthosis may be stocked by the orthotist and trimmed to specific needs, e.g., basic opponents orthosis, wrist support, etc.

In conclusion, it should be recognized that the development of newer devices and techniques as recommended above in itself will not result in optimum patient care. Rather, such developments should be viewed as important tools in the overall management by the rehabilitation team in which the orthotist must play an integral role. With the advent of the more sophisticated technology that is available today including environmental control systems for the quadriplegic patient, it becomes important to provide advanced training for orthotists or rehabilitation engineers to be able to provide these services.

Orthotics and Prosthetics, Vol. 31, No. 4, pp. 65—66, December 1977

REPORT
PANEL ON LOWER-LIMB ORTHOTICS

Membership:
Chairman: Charles M. Fryer
Recorder: Bradd L. Rosenquist
Members: Dwight Driver, Robert Nitschke, Gustav Rubin, Melvin Stills, Ted Thranhardt

The first task considered was the definition of the "Current State of the Art" in Lower Limb Orthotics. It was felt that the "Position" paper presented by Melvin Stills serves this purpose accurately.

Major Advances

Mr. Stills cited the following items as significant developments occurring within the last five to ten years:

1. The development of current nomenclature.
2. Applications of plastics and vacuum forming.
3. The availability of prefabricated components.
4. Fracture orthoses.
5. The stress on patient evaluation.
6. Educational requirements for certification.
7. Continuing education as implemented by the American Academy of Orthotists and Prosthetists.
8. The multidisciplinary clinic approach to children's orthotics for certain classes of patients such as those with spina bifida.

"FUNCTIONAL ELECTRICAL STIMULATION" is the only item defined by the panel as being available only through special centers or circumstances.

Items Being Evaluated

Those orthotic devices and/or techniques currently in clinical evaluation are as follows:

1. Biofeedback devices for training.
2. Function Electrical Stimulation Systems.
3. Adjustable AFO foot positioning orthosis (Rancho).
4. Shoe rotator (Glancy).
5. Infant hip joint for treatment of hip dislocation and/or subluxation (Nitschke).

Items Needed

Devices and techniques which are most urgently needed are as follows:

1. Improved materials technology and applied design as they affect function, cosmesis, and cost.
   a. Improved joint mechanisms to aid sitting and standing (Example: Bilateral HKAO'S).
   b. Sensory feedback mechanisms.
   c. Dampening of motion (Example: CP).
2. To develop better utilization of the established channels of communications between all disciplines involved in patient services.
3. A method of bracing to maintain joint integrity under pathological and normal (Example: sports) conditions.

Inherent Problems in Delivery

Three areas, either singularly or in combination, are cited as presenting problems in the delivery of new devices and services.

1. Evaluation of new devices.
2. Financing.
3. Education.

Recommendations

It is the panel's intent to recommend only those items felt to be of major significance. The order in which they are listed does not indicate perceived importance.

1. "Standards" should be developed by the Orthotics Profession as is currently taking place through the ASTM and the FDA for prostheses.
2. A workshop be convened to determine responsibility for the dissemination of information to the following groups:
   a. Physicians.
   b. Third party payers.
   c. Allied Health Professions.
   d. The General Public.

   The panel specified those groups responsible for the dissemination of information to be:
   a. American Academy of Orthotists and Prosthetists.
   b. "The Universities."
   c. American Academy of Orthopaedic Surgeons.
   d. The Congress of Physical Medicine and Rehabilitation.
   e. Orthotists.
   f. Federal Agencies (V.A., R.S.A.).
3. Mandatory continuing educational requirements should be established, and an organization *be specified* to have this as their responsibility.
4. A system of measurement, modification, and communication needs to be developed to facilitate central fabrication in lower-limb orthotics. The purpose is to place the responsibility of decision making as concerns patient management, orthotic design and fit on the orthosis. The function of the central fabrication laboratory will be limited to fabrication only.
5. A more comprehensive training program is needed for orthotists in the area of shoe and foot orthotic problems. The *shoe* is recognized as an integral part of a lower-limb orthotic system.
6. A program of national scope should be established for the collection of, evaluation of, and dissemination of information on new devices and techniques.

Orthotics and Prosthetics, Vol. 31, No. 4, pp. 67—71, December 1977

REPORT
PANEL ON SPINAL ORTHOTICS

Chairman: Allen S. Edmonson
Recorder: Charles Dankmeyer, Jr.
Members: Martin Buckner, Frank Coombs, John Glancy, Marion Miller, James Morris, Don Vargo, Hugh Watts

Since the area for discussion was quite large, we chose to eliminate from consideration "total-body" orthoses or those which incorporated limb orthoses with trunk orthoses. Spinal orthoses were then considered from two aspects, purpose and anatomical area of application. Purpose was subdivided into general immobilization and special purpose. Orthoses for special purpose were corrective, preventive, and assistive and included devices for patients with scoliosis, kyphosis, and neuromuscular disorders with and without sensory deficit. Because orthoses for myelomeningocele frequently encompass both the torso and the lower limbs, this category was discussed only briefly.

The classification system used along with some comments is shown in Tables 1 and 2.

TABLE 1

SPINAL ORTHOSES FOR GENERAL IMMOBILIZATION

CERVICAL	DEVICE	FUNCTION	COMMENTS	NEED
Minimum Immobilization	Soft sponge collar Plastic adjustable collar	Limits flexion, extension or both	Generally comfortable	
Moderate Immobilization	Four-poster SOMI Molded collar (Philadelphia) Halo-Jacket	Limits flexion, extension and rotation	Some discomfort Halo-Jacket here because it can be removed by patient.	Design to free mandible
Maximum Immobilization	Halo-Cast	Approaches immobilization in all planes including distraction	Requires skull pins	Fixation to head without skull pins

CERVICAL	DEVICE	FUNCTION	COMMENTS	NEED
UPPER THORACIC				
T-1 — T-7				
Minimum	None		Difficult area	
Moderate	Occiput and mandibular attachment to lower spine orthosis	Fixes head to torso	Not comfortable Can be removed	Better head fixation
Maximum	Halo-Cast	Fixes head to torso	Comfortable and can't be removed. Can distract	Head fixation without skull penetration
LOWER THORACIC				
(T-8 — 12) and Thoraco-Lumbar				
Minimum	Thoraco-Lumbar Corset	General immobilization	Shoulder straps or anterior pads are not comfortable	Improved design and fabrics
Moderate	Jewett	Limits flexion	Sternal & lower abdominal pressure	Design to unload or distract
	Long Taylor	Limits flexion and extension	Shoulder straps	
Maximum	Halo-Cast	Near "immobilization"	Pins in skull not removable	Distraction without halo pins
LUMBAR AND LUMBO-SACRAL				
Minimum	Lumbar corsets	Limits all planes of motion	Reasonably comfortable	Better design and fabric
Moderate	Williams type	Holds lumbar spine flexed	Adequate	
	Knight or Chair-back type	Limits all range of motion	Adequate	
	Custom molded rigid plastic jacket (UCB type)	Limits all range of motion	Most efficient and utilizes abdominal pressure	Designed to wear at work
	VAPC Orthosis	Limits all range of motion and attempts distraction	Comfort is problem	Better patient tolerance

TABLE 2

SPINAL ORTHOSES FOR SPECIAL PURPOSES

DEVICE	FUNCTION	COMMENTS	NEED
SCOLIOSIS			
Milwaukee Brace (CTLSO)	Halt progression of curves in all anatomical areas	Permanent correction not routine	(1) Permanent correction device
Underarm Brace (TLSO) Boston, Pasadena, Wilmington & Italy	Treatment curves thoraco-lumbar and lumbar	Long term results not established	(2) Improve rib hump and lordosis
Kalabus-Harness	Control infantile curves	Efficiency questionable	
KYPHOSIS ADOLESCENT			
Milwaukee Brace (CTLSO)	Can produce efficient corrective tone	Treatment for structural and flexible curves Believed to produce permanent correction	Design to eliminate neck ring
Anti-gravity type (TLSO) (Pelvic flexion girdle +/— anterior outrigger)	Suggested for flexible curves Flattens lumbar lordosis Thoracic kyphosis expected to follow	"Postural correction"	More comfort
KYPHOSIS ADULT			
Jewett Long Taylor Molded Body Jacket Thoracolumbar corset	Support and resist flexion	Most are poorly tolerated by elderly Don't unload spine	Design and materials improved for comfort
NEUROMUSCULAR DISORDER WITHOUT SENSORY DEFICIT			
CTLSO with molded plastic girdle	Support and prevent collapse	Milwaukee type neck ring is problem	Design to minimize abdominal restriction
TLSO Molded plastic body jacket	Support and prevent collapse	Moderately efficient	Design to minimize abdominal restriction
Corsets	Support and prevent collapse	Less efficient Restricts abdomen	Design to minimize abdominal restriction
Custom molded chair inserts	Support and prevent collapse	Used for most-severely involved patients	Improved design
NEUROMUSCULAR DISORDER WITH SENSORY DEFICIT			
All above can be used for short periods of time only	Support and prevent collapse	Practical application very limited	New designs & materials to allow pressure and support without skin damage

RECOMMENDATIONS
(IN ORDER OF PRIORITY WITHIN EACH SECTION)

A. GENERAL

1. Evaluation and analysis of basic spinal orthoses both those presently used and those in experimental study are needed so that prescription and application can be done more nationally. A method of evaluation using objective engineering principles should be developed first, however.
2. Summary and review articles compiled from orthopaedic journals and texts in orthotic and prosthetic publications should be carried in the journals as appropriate to allow each half of the team to read more efficiently in the other's area of expertise.
3. Promotion of the "image" of the orthotist and the patient wearing an orthosis should be supported.

B. ORTHOSES FOR GENERAL IMMOBILIZATION

1. A method to "unload" or distract the spine and immobilize the head without skull pins should be developed. Mandible and anterior neck should be free.
2. A new orthosis for immobilization of the upper thoracic spine, (T-1 — T-8) should be developed.
3. Development of a semi-flexible lumbar support probably of molded plastic is needed.
4. A better method of orthotic fixation of the pelvis should be developed for lumbo-sacral orthoses.
5. Corset supports should be redesigned to be more comfortable, more stable, more easily applied, more easily adjusted, and constructed of better fabrics.

C. ORTHOSES: SCOLIOSIS AND KYPHOSIS

1. Development of an orthosis to *correct* preferably without a neck ring.
2. An organization of orthotists interested in scoliosis should be formed to work with the Scoliosis Research Society.
3. Design improvement is needed for upper thoracic and cervical curves in scoliosis and improvement in treatment of rib deformity and rotation.
4. A better orthosis for the elderly kyphotic with pain is needed.
5. The education of orthotists should include x-ray evaluation of spinal deformities using standardized positioning of the patient.
6. Improved cosmesis is needed in orthotics for adolescents for treatment of scoliosis and kyphosis.
7. An improved orthosis for scoliosis in infants should be developed.
8. Specialized local treatment center for scoliosis and kyphosis should be established.
9. Designs in orthoses for scoliosis and kyphosis should be more adjustable in the clinic to provide a wider range of fitting possibilities.

D. ORTHOSES FOR NEURO-MUSCULAR DISORDERS

1. Improved materials and design for orthoses that allow use on patients with sensory deficit are needed.
2. Development of a "dynamic" orthosis which utilizes external forces to provide both support and assistance should be initiated.
3. There should be a coordination of educational efforts in the field of genitourinary surgery and general surgery with orthotic advances to accomplish more optimal placement of urinary "ostomies."

E. DELIVERY OF NEW DEVICES AND SERVICES

With the demise of the Committee on Prosthetics Research and Development, there is at present no organization to coordinate, evaluate and disseminate information on new devices and services. An organization to meet this need is imperative. It is needed to work with the educational system so that prosthetists, orthotists, physicians, therapists and other interested persons can become familiar with worthy devices and services in order that they be delivered properly to the public. Unrealistic regulations and inadequate fee schedules are a barrier to delivery of new devices and services. Education of governmental agencies and other "third-party" organizations should be the best means to achieve modification.

F. WHO SHOULD PROVIDE SPINAL CORSETS?

This special charge was considered at length. It was pointed out that some corsets are custom fitted and others are not. Presumably one important factor involved in provision of "unfitted" or "off-the-shelf" corsets is economy of time and /or money. There was unanimous agreement that all "fitted" corsets should be provided by an orthotic facility. If no fitting was desired by the purchaser, agreement was not unanimous but strongly in favor of supply by an orthotic facility. Most agreed that fitting a corset was "best patient care."

AGENDA

"THE CURRENT STATUS OF PROSTHETICS AND ORTHOTICS AND TRENDS FOR FUTURE RESEARCH AND DEVELOPMENT"

APRIL 1, 2, 3, 1977—AMERICANA HOTEL BAL HARBOUR, FLORIDA

Friday, April 1, 1977

7:30 a.m.	REGISTRATION
8:00	WELCOME AND INTRODUCTORY REMARKS Newton C. McCollough, III, M.D. Mr. Anthony Staros Mr. Joseph Traub
8:30	UPPER LIMB PROSTHETICS —Current Status and Future Needs Mr. Maurice LeBlanc, C.P.O.
9:00	DISCUSSION
9:10	LOWER LIMB PROSTHETICS—Current Status and Future Needs Mr. Alvin Muilenberg, C.P.O.
9:40	DISCUSSION
9:50	UPPER LIMB ORTHOTICS—Current Status and Future Needs Mr. H. R. Lehneis, Ph.D.
10:20	DISCUSSION
10:30	COFFEE BREAK
10:50	LOWER LIMB ORTHOTICS —Current Status and Future Needs Mr. Melvin Stills, C.O.
11:20	DISCUSSION
11:30	SPINAL ORTHOTICS—Current Status and Future Needs Allen S. Edmonson, M.D.
12:00	DISCUSSION
12:10	DELIVERY OF PROSTHETIC-ORTHOTIC SERVICES—Current Status and Future Needs Mr. Ted Thranhardt, C.P.O.
12:30	DISCUSSION
2:00 - 5:00 p.m.	Panel Working Sessions
5:00	Steering Committee and Panel Chairman Meeting
6:30	Reception - Eastward Room

Saturday, April 2, 1977

8:30 a.m.	PLENARY SESSION—Brief Reports by Panel Chairmen and General Discussion
9:30	Resume Panel Discussions
4:00 p.m.	Deadline for submission of Panel reports to secretarial pool.
5:00	Steering Committee and Panel Chairmen Meeting

Sunday, April 3, 1977

8:30 a.m.	PLENARY SESSION—Final Reports of Panels Upper Limb Prosthetics—Mr. Maurice LeBlanc, C.P.O. Discussion Lower Limb Prosthetics—Mr. Alvin Muilenberg, C.P.O. Discussion Upper Limb Orthotics—H. R. Lehneis, Ph.D. Discussion Lower Limb Orthotics—Mr. Melvin Stills, C.O. Discussion Spinal Orthotics—Allen S. Edmonson, M.D. Discussion
12:00	Summation of Workshop Recommendations—Mr. Ronald Snell, C.P.O.

ROSTER

THE CURRENT STATUS OF PROSTHETICS & ORTHOTICS AND TRENDS FOR FUTURE RESEARCH & DEVELOPMENT

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Memphis, Tennessee 38103

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San Francisco, California

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P.O. Box 3885
Durham, North Carolina 27710

Joseph Traub
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Don Vargo
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Washington, D.C. 20546

Hugh Watts, M.D.
300 Longwood Avenue
Boston, Massachusetts 02115

A. Bennett Wilson, Jr.
12th Street and Tabor Road
Philadelphia, Pennsylvania 19141

LETTERS TO THE EDITOR

Editor 5 *July 1977*
Orthotics and Prosthetics
1444 N Street, N.W.
Washington, D.C. 20005

Gentlemen:

Since the publication of "Polypropylene Spiral Ankle-Foot Orthoses" in Orthotics and Prosthetics, Vol. 29, No. 2, pp33-35, June 1975, an improved technique for vacuum forming polypropylene has been worked out.

The talcum powder mentioned previously was found to be especially troublesome from the safety standpoint—breathing of airborne material, and also a great deal of time was wasted removing the powder from *everywhere*. We even received complaints from other departments. The oven was the prime culprit here, causing the dust-filled air to circulate.

Aside from esthetics, the procedure was also made more functionally stable. We found a steady state temperature that allows the polypropylene material to remain in the oven beyond the time it is actually soft enough to be moulded. We found this most useful from the practical standpoint since the staff could attend other matters and not have to be concerned about overheating the material.

In conjunction with this critical temperature, good heat distribution and better support of the material is had if the polypropylene blank is placed on a bare aluminum sheet. This prevents the edges from being too soft and the center, especially of the footplate, from being too hard. At the critical temperature sticking of the material to the aluminum is not much of a problem, but to be certain no sticking occurs, silicone is sprayed lightly on the aluminum sheet or the plastic blank.

In our oven, Grieve, Model HB-500, the critical temperature was found to be 162° ± 2°C; and the time interval for heating the blanks, 20 minutes or longer. It is important that the oven door remains closed throughout the heating cycle.

It is expected that different ovens will have different critical temperatures because of discrepancies in thermostat calibration and other reasons. Your readers might try a few small samples first, starting with the suggested temperature. The way to be sure the critical temperature for a particular oven has been reached is to watch for these characteristics:

- the polypropylene does *not* turn clear
- it can be formed to complex surfaces without exerting much pressure
- it does not stretch and thin out like chewing gum due to its own weight
- it does not readily stick to various materials

One more change can be made in the procedure for the sake of simplification. The placement of felt between the hot blank and the PVA bag can be eliminated. However, the bags would have to be replaced more often.

We hope these suggestions will make this vacuum forming procedure more useful to your readers.

Sincerely,

Samuel M. Cohen, C.O.
Warren Frisina
Orthotics & Prosthetics
Institute of Rehabilitation Medicine
New York University Medical Center
400 East 34th St., New York, N.Y. 10016

The Editor

June 20, 1977

Orthotics and Prosthetics
1444 N Street N.W.
Washington, D.C. 20005

Dear Sir:

I would like to up-date your editorial entitled "Present Use of Orthoses for Persons with Paraplegia" in volume 31, number 1, March 1977, page 31.

You quote me as stating in 1948 that one hour of standing each day will prevent osteoporosis in the lower limbs (1). That article was significant in that it stimulated a spate of studies which demonstrated that the effect of weight bearing was minimal as compared to the effects of muscle contraction which stressed the skeleton to a far greater degree. These studies were summarized in a paper by myself and Delagi (2).

In addition, the use of the 10th thoracic vertebra as a landmark when describing orthoses and the lack of need for using pelvic band and Knight spinal attachments were analyzed by myself in papers (3,4).

Sincerely yours,

Arthur S. Abramson, M.D.
Professor and Chairman
Rehabilitation Medicine
Albert Einstein College of Medicine
Yeshiva University
1300 Morris Avenue
Bronx, N.Y. 10461

1) Abramson, A.S.: Bone disturbances in injuries to the spinal cord and cauda equina: Their prevention by ambulation. J. Bone Jt. Surg. 30-A: 982, 1948
2) Abramson, A.S., Delagi, E.F.: The Influence of Weight-bearing and Muscle Contraction on Disuse Osteoporosis. Arch. Phys. Med. 42: 147, 1961
3) Abramson, A.S., Principles of Bracing in the Rehabilitation of The Paraplegic. Bull. Hosp. Jt. Dis. 10:175, 1949
4) Abramson, A.S., Principles of Bracing the Paraplegic. Orth. Pros. Appl. J. 28:35, 1955

NEW PUBLICATIONS

The Advance in Orthotics, edited by George Murdoch, Edward Arnold (Publisher) Ltd., London, 602 pp. Now available in the United States through the Williams and Wilkins Company at $67.50

The review of this book which was included in the March 1977 issue of "Orthotics and Prosthetics" is repeated here:

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 Limgs)
- 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 $67.50

Total Hip Prosthesis, edited by N. Gschwend and H. V. Debrunner, Williams and Wilkins, Baltimore, 1976; 328 pp., profusely illustrated; $28.95.

The preface to this beautifully printed report of a retrospective study of 2500 patients with total hip prostheses is reproduced here in full:

The victory of the total hip-prosthesis over the painful ankylosed degenerative arthritis is world-wide. Since Charnley reported his first results more than fifteen years have passed. In the meanwhile one single factory in this country has produced more than 100,000 total hips and these have probably been inserted in an equal number of joints with the expectation of both the surgeon and the patient to reduce suffering and give back physical activity to the invalid.

But how much additional distress has been produced by iatrogen induction? How much avoidable insufficiency has influenced the results and where are the main risks?

Since 1968 this operation is done routinely in an increasing number of much too many hospitals. Therefore a halt is necessary. Many complications appear only after a prolonged period of observations and these should be carefully analized. The Swiss Society of Orthopaedics has charged Professor Gschwend with a polyvalent and poly-clinical study of the most important orthopaedic clincis in order to review all material available. The results have been reported at the annual meeting of the Swiss Society of Orthopaedics and the Netherland Orthopaedic Association in Lausanne 1974. The study was endangered by a lack of cooperation to engage in an anonimous computer-study. Thus the primarily expected number of cases was reduced to half. However the actual figure 2500 cases seems representative to get the necessary information in order to improve the results in the future. Selfcriticism is essential and it is easier to obtain through neutral channels than by revewing the own results.

In the name of the Swiss Society of Orthopaedics all contributers are to be congratulated and cordially thanked for the essential research.

Swiss Society of Orthopaedics
The President 1974
Hermann Fredenhagen, MD
Basle, October 1975

Children's Orthopaedics-Practical Problems, N. J. Blockey, M. Ch. Orth., F.R.C.S. (Eng. and Glas.), Butterworths, London, Boston, Sydney, Wellington, Durban, Toronto, 1976; 141 pp., 92 illus.

The foreword by Sir Harry Platt is reproduced here in full:

"Mr. Noel Blockey has always had the courage to expound his views on many of the debatable problems in the field of orthopaedics. During his formative years in the University Department of Orthopaedic Surgery in the Manchester Royal Infirmary, this quality, both to me as his Chief and to his contemporaries and juniors, was most stimulating. Now with the ripeness of years of experience in Glasgow at the Royal Hospital for Sick Children, Mr. Blockey has selected a number of topics in which, with some justification, he feels that he has something of practical importance to convey to the postgraduate student of orthopaedics. As I read this collection of essays I recapture the essence of his critical mind, and I welcome the privilege of writing this foreword."

H. P.

"Prosthetics and Orthotics International", The International Society for Prosthetics and Orthotics announces the publication of an official professional journal entitled "Prosthetics and Orthotics International."

The core of each issue of the Journal will be scientific, clinical and practical papers on all aspects of prosthetics, orthotics, rehabilitation engineering and related orthopaedic surgery. Although no firm decisions have been made as to the balance of the articles which will appear in each issue regarding disciplines or specialty, they hope to ensure that each individual member will find a large proportion of the material of interest. The first two issues are being devoted to the presentation of up-dated versions of papers originally presented at the World Congress in Montreux in 1974. Future issues will be a blend of papers based on ISPO congresses, invited papers and, in particular, papers submitted by the ISPO membership.

Prosthetics and Orthotics International is published three times yearly by the International Society for Prosthetics and Orthotics (ISPO), PO Box 42, DK-2900, Hellerup, Denmark. Subscription rate is $14 (U.S.) per annum, single numbers $5 (U.S.). The journal is provided free to Members of ISPO. The subscription rate for Associate Members is $7 (U.S.) per annum. Remittances should be made payable to ISPO.

Editorial correspondence, advertisement bookings and enquiries should be directed to Prosthetic and Orthotics International, National Centre for Training and Education in Prosthetics and Orthotics, University of Strathclyde, 73 Rottenrow, Glasgow G4 ONG (Tel.: 041-552-4049).

We are currently conducting a follow-up survey in regards to employment in the Prosthetic/Orthotic profession following graduation or attendance in the Cerritos College Program. If you are a former student we would appreciate your cooperation in this matter by sending your current mailing address to:

Robert W. Hinchberger, Instructor
Prosthetic/Orthotic Department
CERRITOS COLLEGE
11110 E. Alondra Boulevard
Norwalk, California 90650

ANNOUNCEMENT

The abstracts of all papers presented at the 1977 ISPO-AOPA World Congress along with the names and addresses of all authors are now available from the National Office of AOPA-ABC-AAOP for $7.00. Both of the documents were contained in the package distributed to registrants at the Congress, but there has been a demand for copies for individuals who could not attend and by libraries.

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T5G 0B7

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	To	Multiply by
pounds (avdp.)	**kilograms**	**0.45359**
slugs‡	kilograms	14.594

FORCE

To convert from	To	Multiply by
ounces-force (ozf)	newtons	0.27802
ounces-force (ozf)	kilogram-force	0.028350
pounds-force (lbf)	newtons	4.4732
pounds-force (lbf)	kilogram-force	0.45359

*This double-prefix usage is not desirable. This unit is actually a nanometer (10^{-9} meter = 10^{-7} centimeter).

† For practical purposes all subsequent digits are zeros.

STRESS (OR PRESSURE)

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

TORQUE (OR MOMENT)

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

ENERGY (OR WORK)

Definition

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

1 cal (gm) = 4.1840 joules

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

TEMPERATURE CONVERSION TABLE

To convert °F to °C $°C = \dfrac{°F - 32}{1.8}$

°F	°C
98.6	37
99	37.2
99.5	37.5
100	37.8
100.5	38.1
101	38.3
101.5	38.6
102	38.9
102.5	39.2
103	39.4
103.5	39.7
104	40.0

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

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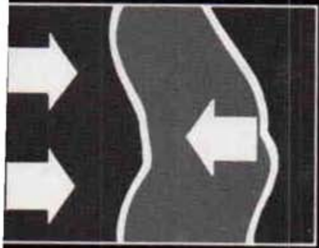

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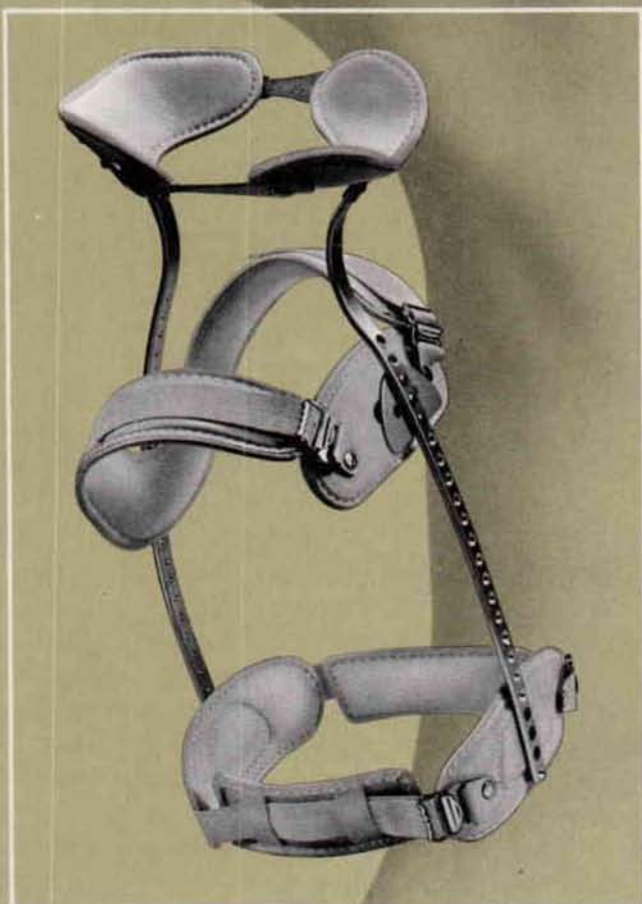

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