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Artificial Limbs

*A Review of
Current Developments*

COMMITTEE ON PROSTHETICS
RESEARCH AND DEVELOPMENT

COMMITTEE ON PROSTHETIC-
ORTHOTIC EDUCATION

**National Academy of Sciences
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ISPO, An International Prosthetics-Orthotics Program

Anthony Staros¹

IT IS appropriate that the editorial board of *Artificial Limbs* should invite us to tell its readers about a new professional association. This outstanding journal has given form and clinical meaning to the products of a research and education program, which in turn demonstrates the effectiveness of interdisciplinary cooperation between physicians and surgeons, engineers, therapists, prosthetists, orthotists, physiologists, psychologists, educators, and other specialists who help to solve the problems of patients with neuromuscular and skeletal disorders.

The correlation of the research, development, evaluation, and education and training efforts of many individuals, laboratories, and centers throughout North America has indeed been a great achievement. Many people have often cited the Committee on Prosthetics Research and Development and the Committee on Prosthetic-Orthotic Education for their contributions to the government sponsors of such programs. The management product is a temperate, yet definitive and noninhibitive, merging of the interests of a variety of professions and projects into an entity with minimal overlapping of effort. This program not only has been productive but also has yielded demonstrable economies, and it now can serve as a sound foundation for an overdue expansion based on an integrated system of personal relationships and lines of mutual assistance among projects in Canada and the United States.

Such correlative and management tasks unfortunately have not been performed effectively on a broader international basis. Although, from time to time, a number of individuals and groups here and abroad have assisted programs in other countries, that assistance was given with little or no cohesiveness. Indeed, one gained the impression that some help was given more in a spirit of publicity-seeking than with the aim of benefiting patients on a worldwide basis. In recent years, the United Nations has made some progress in correlating the many worldwide activities; however, its efforts have been limited primarily to informing interested parties about the various technical-assistance projects. This has served a useful purpose, but it attacks only part of the problem.

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The Committee on Prosthetics Research and Development and the Committee on Prosthetic-Orthotic Education provide professional advisory functions in the management of the prosthetics and orthotics programs in the United States and Canada. The same certainly should be provided on an international level. For this reason, the International Committee on Prosthetics and Orthotics of the International Society for Rehabilitation of the Disabled was reconstituted as a separate society, comprising a group of professionals who represent the members of prosthetics-orthotics clinical and research teams throughout the world.

The International Society for Prosthetics and Orthotics (ISPO) is now an established organization. Its membership consists of national member societies, which are formed in each country when the number of members of ISPO has reached the ISPO constitutional requirement. At that time, the national member society elects its own executive board, which in turn selects officers, including representatives to sit on the International Committee, which is the governing body of the International Society itself.

The International Committee elects the officers of the International Society in compliance with the constitutional requirement for balance among the various professions. At present, formation of a national member society called the U.S. National Committee of ISPO is underway. Membership drives have been conducted sporadically, but these are now being reorganized.

The International Society will, under its constitution:

serve as an international, impartial and non-political coordinating, correlating and advisory body on prosthetics and orthotics and other matters related to the neuromuscular and skeletal system in close collaboration with the national and international bodies involved in international prosthetics-orthotics programmes, offering appropriate guidance and advice to these bodies to avoid unwitting duplication of effort and to encourage maximum use of resources. In particular, it is intended that ISPO will be affiliated to the International Society for Rehabilitation of the Disabled (ISRD) as an associate member and as such, will collaborate in all ISRD functions and missions relevant to the field of prosthetics and orthotics;

effect a scientific exchange among its members and others by collecting and disseminating information through publications, correspondence, exhibits, regional or international courses, seminars, symposia, conferences, staff efforts, or otherwise;

encourage, promote and when requested, assist in efforts to co-ordinate or guide research, development, and evaluation activities related to prosthetics and orthotics throughout the world;

encourage, guide, and support the efforts of all those responsible for care of patients involving these important fields and when requested, correlate these activities throughout the world;

undertake, when requested, appropriate projects to encourage and facilitate high-level uniform practice by development of standards for

nomenclature; curricula, design of devices, techniques, and processes; testing; and by involvement in all appropriate aspects of patient care, research and development, evaluations and education and training; [and]

conduct research and surveys when appropriate.

Membership in ISPO is open. Special classes of membership are available for professional persons who are actively engaged in prosthetics and orthotics rehabilitation, including research, education, clinical practice, and other significant categories. Nonprofessional individuals who are interested in supporting the Society can elect to be Associate Members. Other individuals or organizations, e.g., suppliers or manufacturers, can apply as Sponsoring Members.

Standing committees of the Society already have started to work, covering critical areas of the Society's interest such as Research, Evaluation, Education, and Publications. Already the standing committees have been called on by international organizations, such as the United Nations, to provide services on very specific projects, particularly in education and training and in dissemination of information. The Society will soon begin publishing a bulletin to inform its members not only about Society business but about matters of technical importance as well.

We trust that this newly formed association will receive the support of professional people around the world. The field of prosthetics and orthotics is a highly specialized area of technology, and the longer-established international engineering, medical, and other scientific professional societies touch prosthetics and orthotics only peripherally; broader scopes dilute their interest in this field. There is a distinct need for this newly organized grouping of professional individuals who are directly involved or concerned with the care of patients who have neuromuscular and skeletal disabilities. Eventually, an integrated, professionally run, international program concerned with all aspects of prosthetics and orthotics will result, with benefits accruing to the disabled all over the world.

A Method of Early Prosthetics Training for Upper-Extremity Amputees¹

TIMOTHY V. REYBURN, MAJ., AMSC²

OVER the past ten years, there have been gradual changes in the treatment and training of patients who have had upper-limb amputations (1,2,3). This paper discusses early training techniques used over a two-year period at Valley Forge General Hospital on 67 (32 above-elbow and 35 below-elbow) amputees. Thirty-four of the amputees were treated from July 1968 to February 1969, and 33 from February 1969 to July 1970.

Prior to February 1969, there was no separate ward for amputees, and each patient was placed on a ward appropriate to his overall disability, rather than according to his amputation. The upper-extremity amputees were pretrained in the leather-laced practice prosthesis with plaster-shell insert. However, this type of practice prosthesis was not fitted to the patient's stump until all wounds had healed and drainage had ceased. Consequently, preprosthetic training was delayed, and unilateral patterns could develop in the interim. When the patient did receive his practice prosthesis, training was initiated, with limited practice periods in occupational therapy for one hour a day. At first, the amputee wore the practice prosthesis only in the clinic. After he had mastered its operation and could tolerate the socket for longer periods, he was allowed to wear it the entire day. The patient was instructed to remove the prosthesis at night and to use the

standard stump-wrapping procedure to control edema. A major problem during the training period was the constant separation of the plaster socket from the leather-laced cuff. Also, the functional alignment and the appearance were anything but desirable (fig. 1). The therapist noted that the patients did not voluntarily wear their practice prostheses outside the supervised clinic environment. It was apparent that a more functional and streamlined type of practice prosthesis was urgently needed.

In February 1969, the chief of orthopedics organized a separate amputee service, and a new training plan was initiated. The successful treatment of lower-extremity amputees by a technique in which a rigid dressing and plaster pylons were applied immediately after surgery lead to the hypothesis that a similar procedure might be beneficial for upper-extremity amputees. A practice prosthesis that consisted of a plaster socket with the terminal device

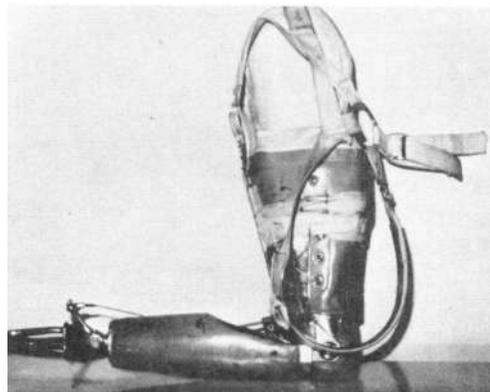


Fig. 1. A leather-laced practice prosthesis with plaster-shell insert.

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Fig. 2. Adapted above- and below-elbow practice prostheses.

and cable attachments embedded within the outer shell was fabricated (fig. 2). From February 1969 to July 1970, 30 patients were fitted with the device (three amputees could not be fitted, because of transfer, infection, etc.). Their ages were between 19 and 39; the average age was 22 years.

The key to a successful practice prosthesis is a firm, nonconstrictive, well-made socket. Both the above- and below-elbow sockets must be formed firmly and evenly to control swelling and to forestall blisters from developing by movement of the stump within a poorly fitting socket. Fabrication of the plaster-of-paris socket and prosthesis is relatively easy, and the procedure is basically the same for both above- and below-elbow prostheses.

For the below-elbow socket, a layer of stockinet is pulled over the stump (fig. 3) and extended two or three inches above the elbow, which allows for a fold and a trim on the proximal end. The distal end of the stockinet is cut and folded smoothly over the stump. Double thicknesses of three-inch plaster roll are thoroughly soaked and placed lengthwise on the stump. An area is left open ventrally to allow room for maximum flexion of the forearm. Circular, non-



Fig. 3. The first layer of stockinet applied to a below-elbow stump.



Fig. 4. Application of plaster to the below-elbow stump.

constricting, single-thickness wraps are then applied (fig. 4).

For an above-elbow socket, the stump is completely covered with stockinet. The distal end of the stockinet is cut and folded smoothly over the stump. Double thicknesses of three-inch plaster roll are thoroughly soaked and placed lengthwise on the stump (fig. 5). Each strip is ended three or four inches distal to the axilla to facilitate removal of the plaster socket. Circular, nonconstricting, single-thickness wraps are then applied. The lateral proximal apex is reinforced in order to provide a firm base for attachment of the lateral harness buckle.

Aluminum struts are attached to the prosthetic appliance and plastered into the socket (fig. 6). When the socket is finished, a figure-eight harness with a Northwestern ring is fitted to the patient, and a terminal device is attached to the practice prosthesis. All of the cable, base-plate, and harness connections are adjusted for each patient. Once the connections are attached and in proper alignment, the patient is trained to operate the practice prosthesis (fig. 7). Additional sockets are fabricated if stump shrinkage exceeds the thickness of two

single-ply stump socks. This basic prosthesis is used by the patient until he receives his final prosthesis.

Because these prostheses have proved so acceptable to the amputees, a plaster socket is fitted immediately upon the patient's admission. A below-elbow amputee can be fitted and can start to use his prosthesis all in the same day. An above-elbow amputee, if not ready for a practice prosthesis, is

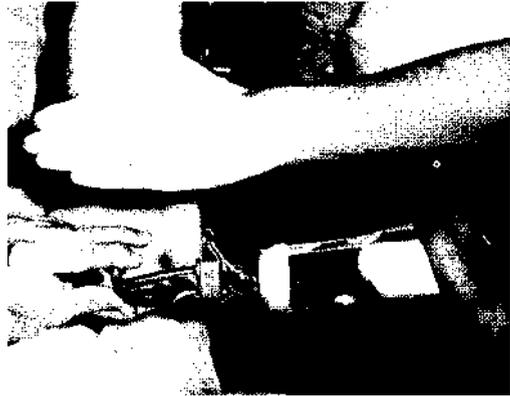


Fig. 6. Affixing aluminum struts and a terminal device to the plaster socket.



Fig. 5. Plaster being applied over the stockinet.



Fig. 7. A below-elbow amputee learns to operate the terminal device on a practice prosthesis.

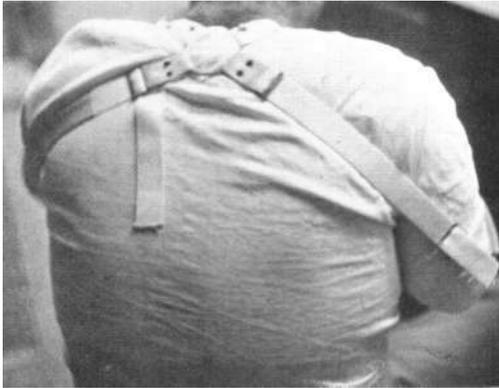


Fig. 8. An above-elbow amputee fitted with a plaster shell with figure-eight harness and North-western ring.

fitted with a plaster-shell socket and figure-eight harness (fig. 8). Anterior and posterior elastic straps are attached to the plaster shell to provide an even upward pressure.

The plaster shell replaces the standard elastic wrap and provides an exercise modality for the patient. The protection provided by the hard plaster shell and the non-constricting but firm pressure against the patient's stump are superior to that provided by an elastic-bandage wrap. An elastic bandage, when wrapped properly, is firm distally and becomes less and less firm proximally. The wrap is thus very unstable, and it readily falls off. The plaster shell provides a more constant pressure, and the elastic straps can be adjusted easily.

Once the patient masters his practice prosthesis, he is assigned to a work-therapy job, which usually is related to his future vocational interest. The ability to use his prosthesis on the job convinces the patient that he can function normally, which is another step in preparing the man for his permanent prosthesis and eventual discharge. If the patient cannot perform a certain function with his prosthesis, a therapist shows him how to solve the problem. The ability to hold grain sacks, handle meat knives, and lift pails are just a few of the everyday tasks that can be taught in work-therapy assignments.

At this point in his rehabilitation, the patient receives a thirty-day leave. It is during

this period that the amputee can really give his prosthesis a workout, by wearing it around the house and using it while doing repair work or mechanical tasks. Completely relying on his prosthesis is the best way for him to work out any problems in its operation. He learns what works best for him, and this knowledge is of great value when he is sent to the prosthetist for the fitting of the permanent prosthesis. After the patient receives his permanent prosthesis, he needs no further training; he can operate it with maximum efficiency, and all that is needed is a final check-out. After minor pressure points and alignment problems are adjusted, the patient is ready for discharge.

If necessary, amputees can be fitted while their stumps were still open and in traction. The importance of skin traction cannot be overemphasized; 75 percent of the amputees received for treatment needed some type of skin traction before being fitted.

The skin-traction weight is removed, and the traction ties are folded back over the stump end. Another stockinet is then pulled over the skin traction, and a plaster socket is fabricated over both.

Although at first only the less open stumps were fitted in this manner, the method was so successful that we used it on grossly open stumps, and the fittings were accomplished without difficulty (fig. 9).



Fig. 9. Stump ready for fitting with practice prosthesis and traction still maintained.

Training sessions in occupational therapy with the practice prosthesis are a tremendous boost to the patient's well-being. After the training session, he removes the prosthesis, reties the traction, and attaches the traction weights. As skin coverage and healing improve, skin-traction time becomes less, and practice-prosthesis-wearing time increases.

DISCUSSION

Acceptance of the permanent prosthesis by the 30 patients fitted after February 1969, and their functional use of it, was evaluated. The degree of acceptance and functional use decreased as the level of amputation increased, with positive acceptance of the long below-elbow prosthesis and a gradual rejection of the shoulder-disarticulation prosthesis. Every patient was given and trained with an APRL (Army Prosthetic Research Laboratory) hand. Two of the 30 patients preferred the APRL hand to the hook; both of these had shoulder disarticulations.

The post-February 1969 patients were fitted three to four weeks earlier than the pre-February 1969 patients. Duration of hospitalization remained about the same, but the post-February 1969 patients were on work therapy and were productive three to four weeks earlier.

Ease of fabrication and patients' acceptance of the streamlined practice prosthesis were noted. The patients' stumps tolerated the hard-shell sockets without difficulty.

Early fitting over open stumps and over skin traction is possible. Edema is reduced and the stump is desensitized while the patient uses his prosthesis.

Rehabilitating the upper-extremity amputee to normal activities as soon as possible requires a total team approach. Close coordination among the physicians, nurses, physical therapists, occupational therapists, and prosthetists is necessary. If everyone on the team understands the problems of the upper-extremity amputee, then all can work together in directing and guiding his treatment.

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The Children's Prosthetics and Orthotics Program¹

HECTOR W. KAY²

DURING the early 1950s, pioneering clinicians in the management of the child amputee repeatedly insisted that children were not miniature adults, to whom modes of fitting developed for adults could be applied indiscriminately. The physicians argued that these children had characteristics and problems that required special study and treatment. Primarily because of the missionary efforts of these men, the Committee on Prosthetics Research and Development in February 1956 moved from an indirect role in the area of children's prosthetics to an active and dynamic one by the establishment of a standing Subcommittee on Child Prosthetics Problems (SCPP). The first chairman, Charles H. Frantz, M.D., guided the activities of the subcommittee until 1965, when he was succeeded by George T. Aitken, M.D. The current membership of the subcommittee appears at the end of this article.

Concurrently with the establishment of the SCPP, the Child Prosthetics Studies program at New York University was created under the direction of Sidney Fishman, Ph.D. From its inception, the New York University program has been closely related to the activities of the Subcommittee on Child Prosthetics Problems. In essence, New York University has acted as an executive arm of the subcommittee in

implementing many of its recommendations. This relationship led to the initiation and completion of numerous significant studies, some of which were: (1) extensive laboratory and field evaluations of various models of the APRL-Sierra no. 1 hand; (2) tests of the Dorrance juvenile hand, size no. 2; (3) studies of the application of the quadrilateral suction socket to the juvenile above-knee amputee, and of the patellar-tendon-bearing prosthesis to the skeletally immature below-knee amputee; (4) a field evaluation, preceded by the development of a fabrication manual and an instructional course, on the Minister-type fitting for the below-elbow amputation stump; and (5) laboratory and field studies of the CAPP electric cart.

Significant nonevaluation activities included studies of the prosthetic fitting of children amputated for malignancy, numerous surveys and census-type studies of children under treatment, and follow-up studies related to the early work of Frantz and O'Rahilly in the classification of congenital limb deficiencies, with efforts to achieve an internationally acceptable system.

As a result of the activities of the subcommittee and of the studies conducted at its instigation by New York University, a number of important by-products have emerged:

1. The treatment of the limb-deficient child has become a recognizable subspecialty in medicine that has attracted many competent physicians.

2. The principle of fitting the child with congenital limb deficits at a very early age has been well established.

3. The early fitting of the juvenile who loses a limb because of malignancy, other

¹This article was adapted from a report prepared for the Maternal and Child Health Service, Health Services and Mental Health Administration, Dept. of Health, Education, and Welfare. This agency has for many years supported the activities described in this report.

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diseases, or trauma has also become generally accepted.

4. Developers and manufacturers have been encouraged to produce prosthetic components for all age levels of the child-amputee population.

COOPERATIVE CLINIC PROGRAM

A significant early action of SCPP was to bring together in August 1958 a group of persons with a known interest in the treatment of the child amputee. Included were the chiefs of 11 existing child-amputee clinics who agreed to cooperate in studies seeking improved treatment for the limb-deficient child. The participants in this historic meeting were:

Gen. F. S. Strong, Jr., Washington, D.C.
Tonnes Dennison, Beverly Hills, Calif.
George T. Aitken, M.D., Grand Rapids, Mich.
Carleton Fillauer, Chattanooga, Tenn.
Charles H. Frantz, M.D., Grand Rapids, Mich.
Colin A. McLaurin, Chicago, Ill.
Charles Radcliffe, Ph.D., Berkeley, Calif.

Harry Campbell, Los Angeles, Calif.
Leon DeVel, M.D., Grand Rapids, Mich.
Edward Hitchcock, New York, N.Y.
Bertram Litt, New York, N.Y.
Edward Peizer, Ph.D., New York, N.Y.

Anna M. Bahlke, Albany, N.Y.
Milo Brooks, M.D., Los Angeles, Calif.
Capt. Thomas Canty, Oakland, Calif.
Carleton Dean, M.D., Lansing, Mich.
George G. Deaver, M.D., New York, N.Y.
Sidney Fishman, Ph.D., New York, N.Y.
Col. Maurice Fletcher, Washington, D.C.
James Glessner, M.D., Newington, Conn.
J. Leonard Goldner, M.D., Durham, N.C.
Richard E. King, M.D., Atlanta, Ga.
Claude N. Lambert, M.D., Chicago, Ill.

Arthur J. Lesser, M.D., Washington, D.C.
Robert Mazet, Jr., M.D., Los Angeles, Calif.
John R. Moore, M.D., Philadelphia, Pa.
Frank Potts, M.D., Buffalo, N.Y.
Frederick Vultee, M.D., Richmond, Va.

Subsequently, other child-amputee clinics sought affiliation with the cooperative program, and, upon meeting the criteria or standards established by the subcommittee, additional clinics have been accepted into the cooperative research endeavor. Thirty clinics, broadly distributed, have now been accepted.

A large proportion of the studies authorized by the subcommittee have been carried out by the participating clinics under the guidance of New York University.

In addition to the 30 clinics currently enrolled in the cooperative program, contact is being maintained with 36 other child-amputee clinics.

PROJECTS

By the mid-1960s, it had become apparent that significant advances had been made in prosthetics generally. Many of the improved fitting techniques that had been developed were found to be applicable to children, and numerous components of advanced design had been made available for use by the child amputee. As a result, children with less severe or with uncomplicated limb deficits, of either congenital or acquired origins, could be treated, and reasonably satisfactory results could be expected. However, the management of the child with severe losses, particularly those affecting both upper limbs at high levels, left much to be desired. The solutions to these problems were considered to be in the successful application and control of externally powered devices. Although available components and systems of this type were (and are) relatively crude, they are regarded as the hope of the future, and a major evaluation and redevelopment effort is being mounted. Already in progress or about to be initiated as a result of prior action by the Subcommittee on Child Prosthetics Problems are a number of studies of great potential value in the evaluation of improved devices and treatment procedures.

Studies will be conducted by New York University, through the participating clinics, on the Ontario Crippled Children's Centre (OCCC) coordinated electric arm, an advanced model of the Michigan Crippled Children Commission feeder arm, the OCCC electric elbow, the Rancho Los Amigos Hospital electric elbows, the Otto Bock myoelectric hand, and the Viennatone myoelectric hand.

At the request of SCPP, New York University has conducted an annual census of

CHILD AMPUTEE CLINICS PARTICIPATING IN THE
COOPERATIVE RESEARCH PROGRAM



Fig. 1.

the child amputees who are being treated at the cooperating clinics. For 1969, the data indicated that the total population under treatment was 4,625—an increase of 236 over the prior year. An expanded census relative to the calendar year 1970 has been completed.

SPECIALIZED FITTING CENTERS

At its meeting on October 21, 1967, the Committee on Prosthetics Research and Development approved a proposal by the Subcommittee on Child Prosthetics Problems that an ad hoc committee be established to develop a detailed plan for the creation of specialized prosthetics fitting centers for severely handicapped children. At its meeting on June 12, 1968, CPRD received the report of the committee, which presented criteria for operation of the centers. This plan, which had been previously approved by the child-amputee clinics, was also approved by CPRD.

CHILDREN'S ORTHOTICS

At its meeting on November 4-5, 1969, the Committee on Prosthetics Research and Development charged the Subcommittee on Child Prosthetics Problems with the responsibility for enlarging its sphere of activities to include children's orthotics. An ad hoc committee of SCPP was appointed to investigate the implications of this new responsibility and to make recommendations for its implementation. It should be noted that the Subcommittee on Design and Development of CPRD had already conducted a number of meetings and workshops on orthotics topics, particularly in the area of lower-extremity bracing, which was the first segment of the orthotics field to be investigated, and many items with possible applications to orthopedically disabled children were beginning to emerge from this work.

Upon the recommendation of the ad hoc committee, a number of selected lower-extremity orthotics items that had emerged from the design and development effort and several bracing and ambulation aids that had been developed at the Ontario Crippled Children's Center were demon-

strated at a meeting of amputee-clinic chiefs on June 11, 1970, and the clinic chiefs were polled as to their interest in clinical applications of the items demonstrated. Their responses were tabulated by New York University and revealed considerable interest in virtually all items. The Subcommittee on Child Prosthetics Problems reviewed these findings at its October 16, 1970, meeting and recommended that NYU undertake the recruitment of a nucleus of clinics interested in a cooperative research program on treatment devices for cerebral palsy, Legg-Perthes disease, and myelomeningocele. It was further recommended that orthopedic surgeons currently participating in the program be surveyed to identify clinics they knew to be interested in these problems. Subsequently, NYU reported that three clinics in the New York City area had indicated an interest in participating, and that discussions were being held with these clinics to develop a format for the initiation of a mutually useful program.

EDUCATION

A major requirement for participation in the cooperative clinical program has been that clinic personnel attend the appropriate upper- and lower-extremity courses at one of the three universities offering such programs. Moreover, since December 1961 at Northwestern University, and since 1964 at the University of California at Los Angeles, 26 courses in the management of the child amputee have been offered to 864 students, including 450 physicians, 238 therapists, and 146 prosthetists. New York University has offered special lectures in the management of the child amputee in its regular prosthetics courses. In connection with the evaluation of specific items where special application skills are required, courses of instruction have been given to the participants.

All these educational activities have tended to provide an increasingly higher level of competence among physicians and others in the management of the child with limb deficiencies. Moreover, the Child Amputee Program has been a direct par-

ticipant in, and contributor to, the general transition procedures governing the overall prosthetics research and education program. These procedures have served to bring new research-derived information directly and expeditiously to the consumer through courses of instruction and published materials.

PUBLICATIONS

In May 1961, at a meeting of the 12 clinic chiefs then participating in the cooperative program, the chairman of the Subcommittee on Child Prosthetics Problems proposed the creation of a bulletin or newsletter that would serve as a medium for the exchange of information between the clinics. The idea was received enthusiastically by the clinic chiefs, who undertook to provide articles on a scheduled basis. The first issue of the *Inter-Clinic Information Bulletin* was published in October 1961. It was six pages long, and 100 copies were distributed. Now, 10 years later, the *Bulletin* is a 16-page printed booklet with circulation in excess of 2,700 copies per issue.

Initially, *ICIB* dealt solely with amputees and prosthetics management. In the past year, however, in line with the general trend, the scope of the *Bulletin* has been enlarged to include orthotics topics. Since 1967, *ICIB* has been catalogued in the Library of Congress (Catalogue Number 67-304).

At the last four annual meetings of the chiefs of the cooperating clinics, a feature of the program has been a symposium on a

selected area of child-amputee management. The proceedings of the symposia held in 1967 (*Normal and Abnormal Embryological Development*), 1968 (*Proximal Femoral Focal Deficiency*), and 1969 (*Surgical and Prosthetic Management of Lower-Extremity Anomalies*) have been published and distributed to clinicians, medical schools, and other interested groups. The proceedings of the 1970 meeting (*The Child with an Acquired Amputation*) are being prepared for printing.

Effective communication with and between the clinics has been maintained by means of the *Inter-Clinic Information Bulletin*, the annual meeting of clinic chiefs, and personal contacts through CPRD and NYU staff. These factors have been critical elements in the extremely successful operation of the cooperative child-amputee research program. As the scope of the endeavor now expands to include conditions requiring orthotic assistance, the same elements may be used to develop an equally successful program for children with orthopedic disabilities other than amputation.

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The CAPP Electric Cart: Recent Developments¹

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SINCE the development of the first Child Amputee Prosthetics Project (CAPP) electric cart (I-5), the device has been completely redesigned. A limited number were produced in 1968-69, and a field test was conducted by New York University. This article describes the mechanical changes that have been made in the cart. The report of the field test is presented elsewhere in this issue.

The changes in no way altered the basic concept of the cart, and the design is still consistent with the original criteria: (1) the cart should be a powered vehicle which provides mobility to severely limited, limb-deficient children; (2) the controls should be simple to operate; (3) the cart should be compact, highly maneuverable, yet very stable and transportable; and (4) it should require minimal maintenance, and be attractive in appearance without resembling a wheelchair.

Earlier models of the cart are shown in figures 1, 2, and 3. These prototypes were built between 1962 and 1966. The changes made since prototype III have made the production of the 14 carts needed for the field test less costly. Figures 4 and 5 show

the cart produced in 1968-69 for the field test. The differences between this model and the 1966 prototype are described below.

STRUCTURAL CHANGES

The chassis, redesigned to simplify construction, is built of 1-in.-square mechanical tubing. The seat frame is made of ³/₄-in.-square, chromed mechanical tubing. The front axle was redesigned to allow torsional or vertical movement by means of a central pivot stud that is located at the center of the

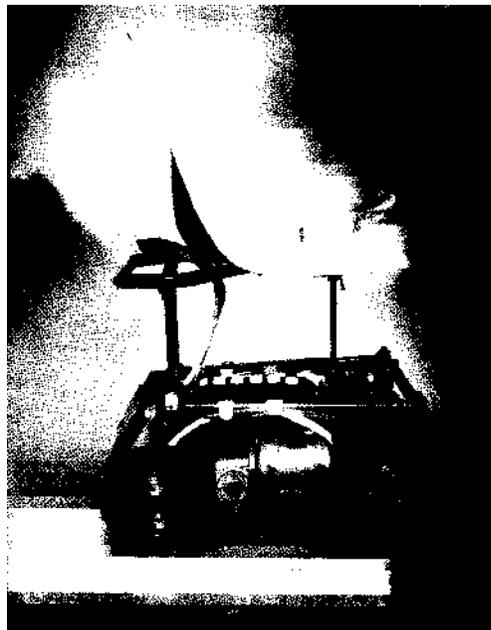


Fig. 1. Prototype I, CAPP electric cart.

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Fig. 2. Prototype II, CAPP electric cart.

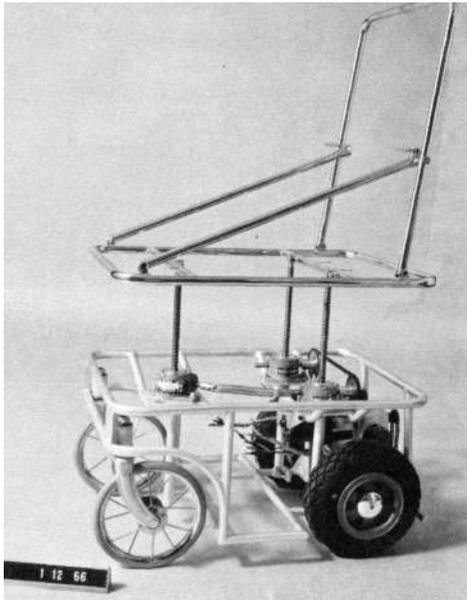


Fig. 3. Prototype III, CAPP electric cart.

axle, which allows the chassis to travel over an uneven surface and still maintain four-wheel contact and stability.

A new folding-seat arrangement makes the cart more compact for transport and adds lateral support from the side arms.

The arms are set back far enough to allow the cart to be placed close to a table, desk, or washbasin. The frame for the backrest can be folded flat by lifting it slightly out of its locking notch and allowing it to fold forward onto the seat cushion.

A shell made of metallic-green fiber glass covers the chassis and power equipment. The upholstery for the seat cushion and



Fig. 4. Field-test cart.



Fig. 5. Field-test cart folded.

backrest is black Leatherette (TM). The seat frame is slightly larger than the seat cushion, thus leaving a small space for storage behind the cushion. Eight-inch, spoked casters with one-inch, solid-rubber tires (wheelchair type) are used on all four wheels.

POWER-SYSTEM CHANGES

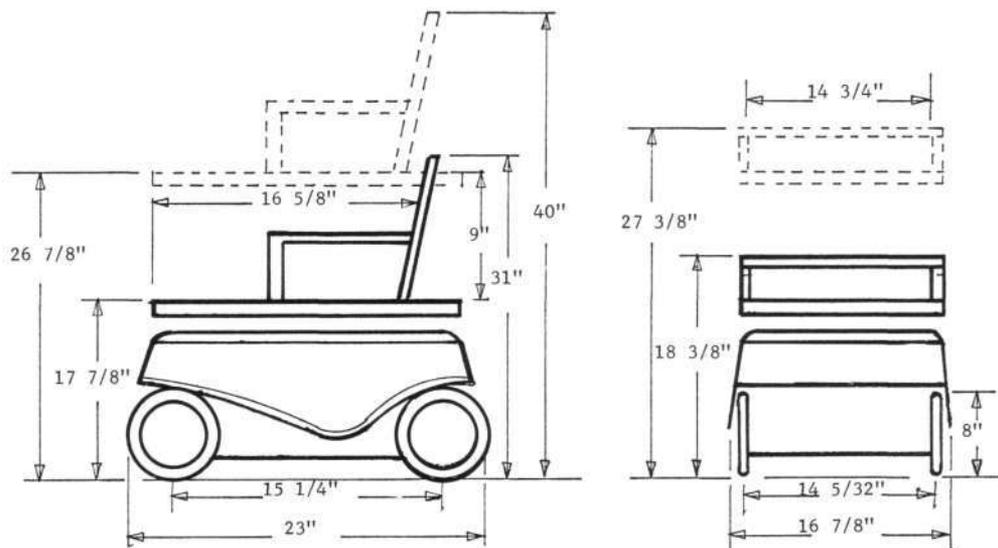
The two drive motors are positioned independently on each side of the chassis. Each motor drives a specially designed worm-gear reduction box. The rear wheels are mounted directly on the output shaft of the gearbox, which is bolted to the frame. Power is fed into the gearbox through a Browning gear belt.

A third motor powers seat raising and lowering. This motor is mounted adjacent

to the right drive motor and is connected to the two rear screw jacks by a Browning gear belt and to a single front screw jack by a flexible shaft. These screw jacks raise the seat platform nine inches.

The battery is positioned between the rear wheels and is easily accessible from the rear of the cart. This arrangement is more convenient than the side opening in the previous model, but it necessitated repositioning the motors and gear boxes, which had been a single package at the rear of the cart in prototype III.

The control box is a specially designed unit developed at CAPP. It has toggle switches for directional control and a separate switch to raise and lower the seat. A circuit breaker was added to prevent an overload of the drive system. The switch



Power Source

Drive motors	Redman, 12 v, dc, permanent magnet
Speed	1½ mph (approx.)
Range	One day use with overnight charging
Battery	Sears Roebuck, G8-2, 6 v, 135 amp for 20 hr, or equiv.
Control unit	Motorette solid-state, proportional control (Motorette Corp., 6000 Reseda Blvd., Tarzana, Calif.)

Chassis

Body	Fiber-glass shell
Ground clearance	1½ in.
Cart weight	Approx. 95 lb with battery
Turning radius	15¼ in.
Wheels (front)	8:00 x 1 in. spoked casters
Tires	Solid rubber, 8:00 x 1 in., wheelchair type

Fig. 6. Dimensions and specifications of CAPP electric cart.



Fig. 7. Cart with solid rear wheels and new control unit.

controls are housed in a compact cylindrical unit that is mounted at the end of a reshaped control arm, which is attached to the left side of the seat frame and extends to the child's chin. The control arm can be adjusted for height and distance from the seat back. The chin receptacle is positioned next to the seat-elevation-control lever and is foam-padded (see figures 4 and 5). The control arm is held in position in front of the child by a ramp lock. When lifted slightly, the control arm swings out for seat folding, the child's use of the table top, or transfer.

The specifications for the cart's power equipment, size, turning radius, etc., are shown in figure 6.

CHANGES SINCE FIELD TEST

In November 1970, two additional changes were made. (The modified cart, with the new wheels and control unit, is shown in figure 7.)

1. A new solid-state proportional control unit, now available commercially, was selected to replace the previous control unit. This new unit (manufactured by the Mo-

torette Corporation of Reseda, California) provides proportional (variable-speed) control and an on-off master switch. The manufacturer provided a control for raising and lowering the seat so that the unit could be used with the electric cart. The control box can be positioned for control by the chin or an extremity. The circuitry unit fits on the storage rack behind the seat.

2. The rear drive wheels were changed from spoke casters to specially designed cast-aluminum wheels to eliminate the possibility of breakage due to high torques, but they have the same solid-rubber tires as the front casters. Although the use of pneumatic tires is being considered, solid-rubber tires have been retained for the present because they provide less rolling resistance and thus prolong the life of the battery. Also, solid-rubber tires are more reliable for a testing program because no problems arise from variations in air pressure.

PRODUCTION

The gear box, control box, chassis, body, and seat-lifting mechanisms for the carts used in the field test were specially de-



Fig. 8. Assembly of field-test carts.

signed by Mr. Carl Sumida at the Child Amputee Prosthetics Project at UCLA. These items were manufactured by sub-contractors, and other components were purchased from commercial sources. The fourteen carts were assembled for the field test at the CAPP (fig. 8).

During the field test, all mechanical repairs were made at CAPP. At the end of the test, all the carts were rechecked, new control boxes were installed, and new wheels were applied. The carts have been returned to the children who participated in the field test, who will continue to use them as long as necessary.

Attempts are now being made to find a commercial manufacturer for the electric

cart because it has proven to be an extremely valuable aid to the mobility of the severely limb-deficient child.

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Evaluation of the CAPP Cart¹

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RECENT studies of juvenile amputees in the United States and Canada have revealed a sizable number of severely handicapped limb-deficient children. Fortunately, many of these amputees have been fitted with prostheses that enable them to perform skills necessary for daily activities. The quadrimembral amputee, however, presents particularly serious problems. While he may achieve considerable arm function with one or two upper-limb devices, the leg loss may not be adequately compensated for, especially in high-level amputees, and locomotion remains at best an exercise. In an effort to solve the problem of mobility for the most severely handicapped children, the Child Amputee Prosthetics Project at UCLA developed an electric cart. This article presents a study that was designed to determine the extent to which the CAPP cart assists children with quadrimembral deficiencies to achieve independent mobility.

The CAPP cart (fig. 1) is 17 in. wide and 23 in. long, and consists of a seat mounted on a chassis. In the driving position, the seat is 18 in. from the floor. The seat can be raised to 27 in. to enable the child to sit at a table or to transfer to a standard chair or bed. The cart, powered by a 12-volt battery, travels at a constant speed of 1 1/2 mph. It is guided by a lever that is

controlled by the chin, and which operates on a "joy-stick" principle. The control arm can be swung to the side to facilitate transfer or activities at a table or desk.

SAMPLE

Since the cart was designed for the child with quadrimembral deficiencies, priority consideration was given to such candidates. The children were selected on the basis of the number of limb deficiencies and the degree of limitation. Eleven children from ten clinics participated in the study (table 1). A twelfth child was provided with a cart (see Appendix) but not included in the sample, because this clinic already had two subjects represented in the study; additional data from the same reporters might have biased the study.

The sample included four boys and seven girls, six to fourteen years of age. Their weights ranged from 20 to 74 lb; the average weight was 30 lb. Trunk measurements were taken of each child from the bottom of the buttocks to the crown of the head. Sitting height averaged 25 in. and ranged from 20 to 32 in.

Table 2 shows the skeletal deficiencies and prosthetic fittings for the eleven children. Of the five children with bilateral proximal femoral focal deficiencies (PFFD), two had not been fitted with lower-limb prostheses. One child ambulated with a lateral-sway walker, one wore below-knee orthoses bilaterally, and one wore a "brace-prosthesis" on the left and a socket, pylon, and SACH-foot prosthesis on the right.

Four children had bilateral amelias. One wore hip-disarticulation prostheses with the knees locked, two used lateral-sway walkers, and the fourth child had not been fitted with any prostheses.

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One child had a very short below-knee stump on the right, and a knee disarticulation on the left; the last child had a fusion of the right knee and a left knee contracture. Neither had been fitted with prostheses.

Again referring to table 2, two children had bilateral upper-limb phocomelia, and neither had ever been fitted with arm prostheses.

Of the two children with bilateral amelia, one wore two conventional shoulder-disarticulation prostheses, and the

other had been fitted unilaterally, alternating between an experimental Michigan feeder arm and a conventional shoulder-disarticulation prosthesis.

Of the four children with bilateral hemimelia, three wore conventional above-elbow prostheses, and the fourth was fitted bilaterally with elbow-disarticulation prostheses.

Three children had a combination of right amelia and left hemimelia. One wore a Michigan feeder arm on the left only, another wore a conventional shoulder-



Fig. 1. The CAPP cart. Power is provided by a 12-v battery; direction is controlled by the chin-operated lever.

TABLE 1. CHARACTERISTICS OF CHILDREN IN CAPP CART EVALUATION STUDY

Child and Clinic	Sex	Age (yr)	Weight (lb)	Trunk Height (in)	Associated Abnormalities
P. V. G., Washington, D.C.	M	8	52	24	Hearing loss; malocclusion
V. R., Los Angeles, Calif.	M	7	27	26	Hypoplastic mandible; sacral agenesis
C. N., Atlanta, Ga.	F	12	74	32	—
T. C., Memphis, Tenn.	M	8	38	27 $\frac{3}{8}$	—
S. A. M., Birmingham, Ala.	F	14	37	24 $\frac{3}{4}$	Scoliosis
M. O., West Orange, N.J.	F	7	26	22	Dislocated hips; scoliosis
T. B., Springfield, Mass.	M	10	30	22	Neuromuscular disorder; scoliosis
L. A., New York, N.Y.	F	7	29	22	—
J. S., Chicago, Ill.	F	12	64	30 $\frac{1}{2}$	High palate
A. R., Grand Rapids, Mich.	F	6	20	20	—
M. E., Grand Rapids, Mich.	F	7	30	24	Double vision

TABLE 2. SKELETAL DEFICIENCIES AND PROSTHETIC FITTINGS

Child	Upper Extremities		Lower Extremities	
	Skeletal Deficiency	Prosthetic Fitting	Skeletal Deficiency	Prosthetic Fitting
P. V. G.	Bilateral phocomelia	None	Bilateral PFFD	R, pylon with SACH foot; L, brace-prosthesis
V. R.	R, hemimelia; L, elbow disart.	Bilateral elbow-disart.	R, hemimelia; L, knee disart.	None
C. N.	Bilateral phocomelia	None	R, knee fusion; L, knee-flex. contract.	None
T. C.	Bilateral hemimelia	Bilateral standard above-elbow	Bilateral amelia	Bilateral hip-disart. with knee locks
S. A. M.	R, amelia; L, hemimelia	None	Bilateral amelia	None
M. O.	R, amelia; L, hemimelia	R, shoulder-disart.; L, above-elbow	Bilateral PFFD	None
T. B.	Bilateral amelia	R, none; L, MFA ^a and shoulder-disart.	Bilateral PFFD	Bilateral short leg braces
L. A.	Bilateral amelia	Bilateral shoulder-disart.	Bilateral PFFD	None
J. S.	Bilateral hemimelia	Bilateral above-elbow	Bilateral amelia	Bilateral hip-disart. without knee joints
A. R.	R, amelia; L, hemimelia	R, none; L, MFA ^a	Bilateral amelia	Lateral-sway walker
M. E.	Bilateral hemimelia	Bilateral above-elbow	Bilateral PFFD	Lateral-sway walker

^a Michigan Feeder Arm.

disarticulation prosthesis on the amelic side and an above-elbow prosthesis contralateral[^], and the third had not been fitted with any prostheses.

Three of the children were scoliotic, and three had skeletal problems involving

the mouth. One child had bilateral hip dislocations; another had sacral agenesis, with associated loss of muscular mass in the lower extremities and bowel and bladder incontinence. Other abnormalities included hearing and visual deficiencies,

and one child had an unspecified neuromuscular disorder manifested by generalized weakness.

Five children alternated between the use of wheelchairs pushed by others or walked with their prostheses. Two children either were pushed in a wheelchair or carried by adults. Two were able to push themselves in regular wheelchairs, and one child used an electric wheelchair. One child used an adapted cart that had been constructed by his father.

Six children lived in homes with steps at the outside entrance. The families of five of the children had ramps built to accommodate the CAPP cart. The sixth child lived in a two-story house, but used the cart only at school. Five children lived in homes with no stairs either outside or inside the building.

All the children were of school age. Six attended special schools for the handicapped, and four attended regular classes in public schools. One child received private tutoring at home.

PROCEDURE

The study was conducted over a six-month period, with evaluations performed at the clinics on three occasions. The results were submitted to New York University. Each clinic was responsible for the routine maintenance of the cart, with major repairs or adjustment that required disassembly of the cart being referred to NYU.

The characteristics of each child, his physical and environmental conditions, and his prosthetic experience were recorded on the Selection Forms, which were returned to NYU.

A representative of the New York University research staff was present when each cart was delivered and described the study to the child, parents, and clinic team. The training instructions and evaluation forms were discussed with the clinic therapist, and the maintenance instructions with the parents and the prosthetist.

The child operated the cart under supervision until the clinic members felt that

the child could drive it independently with safety. At the end of the training period, the therapist completed the Training Evaluation Form.

The child returned to the clinic after he had used the cart for three months. The therapist, in consultation with the child's parents, evaluated the cart in terms of design, safety factors, and function, and recorded the information on the appropriate form. A maintenance check was made, and any necessary repairs and adjustments were also recorded.

The child returned again to the clinic with the cart after six months. The clinic personnel recorded suggestions for improvements in the cart, the child was questioned as to his overall reactions to the cart, and all maintenance problems were recorded. The child's parents and teachers completed forms in which they described their reactions to the cart in terms of suggestions for cart modifications.

RESULTS

Ten of the eleven children who participated in the study preferred the CAPP cart to other modes of transportation. Their parents were equally enthusiastic about the cart. The child who ultimately rejected the cart had a personality problem from the beginning; a strong mutual dependence between the child and her father was threatened by the increased independence offered her by the CAPP cart.

The features of the cart that were most appreciated by both the parents and the children were the increased independence and mobility it provided. The main objection voiced by the parents was the weight of the cart. Table 3 lists the features the children and parents liked best and least about the cart.

OPERATIONAL SKILLS

As seen in table 4, most of the children learned to control the cart with relative ease. The average training time was 5 1/2 hours. The oldest child (14 years) learned to operate the cart in 1/2 hour, while the

TABLE 3. FEATURES OF CAPP CART LIKED BEST AND LEAST BY CHILDREN AND PARENTS

Features	Number	
	Children	Parents
Liked Best		
Increased independence	6	10
Adjustable seat	3	6
Increased speed	3	—
Appearance	1	2
Ease of operation	1	—
Reduction of fatigue	1	—
Less lifting and pushing	—	1
Liked Least		
Weight	—	9
Lack of "on-off" control	2	3
Slow speed	3	1
Frequent mechanical breakdowns	2	2
Insufficient ground clearance	—	3
Difficulty driving over uneven terrain	2	—
Chin control not centered	2	—
Use of prosthesis impeded by control arm	1	—
Cart "drift" toward the left	—	1
Lack of sufficient wheel traction	—	1
Erratic turning	—	1
Noise during seat elevation	—	1

youngest (6 years) required 14 hours of instruction.

Training items were divided into "starting and stopping," "driving," and "turning". The children were asked to start and stop smoothly while driving forward and backward. Most of the children learned this with little difficulty; four learned with no formal training.

The driving test consisted of moving forward and backward in a straight line and on a diagonal, crossing doorsills, and changing direction on command. The children learned to ascend and descend inclines of 10 degrees, to avoid obstacles, and to drive through a "slalom" course.

Finally, the children were taught to turn the cart on its base, using a rear wheel as a pivot, 90 degrees forward and backward. Three children required no training to perform these tasks, and all of the children learned to perform all activities independently.

Two of the younger children began training programs using cars with six-volt batteries because the speed of the cart with the larger battery frightened them at first. After training, they found the cart too slow, and the original twelve-volt batteries were reinstalled.

Seven children considered driving backward the most difficult operation to learn. Other areas of difficulty mentioned by the subjects were the delicate control required in confined areas, and turning.

Three children lost their balance while learning to operate the cart. One child lost his balance while turning and driving backwards and two, when they changed directions rapidly on a level surface. However, none of them lost sufficient balance to fall from the cart during the training period.

Six children damaged property while learning to drive the cart: scraping walls, door frames, or furniture. One child scratched the family car; another, through continued reckless driving, endangered other persons who were in his way.

SAFETY

Five children wore safety belts while driving the cart.

One child fell from the cart while at school. She was not wearing a safety belt,

TABLE 4. MOST DIFFICULT MANEUVER AND TIME REQUIRED IN TRAINING

Child	Age (yr)	Training Time (hr)	Most Difficult Maneuver
P. V. G.	8	1	
V. R.	7	3½	Approaching object; driving through doorway
C. N.	12	6½	Driving on incline
T. C.	8	4	Backing
S. A. M.	14	½	Backing
M. O.	7	5	Approaching table; backing
T. B.	10	8	Turning
L. A.	7	5	Backing
J. S.	12	2	
A. R.	6	14	Backing
M. E.	7	3	Backing

TABLE 5. CAPP CART USAGE

Child	Age	Average School Day (%)	Average Nonschool Day (%)
P. V. G.	8	100	75
V. R.	7	0	10
C. N.	12	70	30
T. C.	8	100	100
S. A. M.	14	10	10
M. O.	7	50	0
T. B.	10	40	15
L. A.	7	2	2
J. S.	12	—	75
A. R.	6	80	—
M. E.	7	75	25

because it restricted her movements while in, and transferring in and out of, the cart. She had swung the control arm away while leaving the battery connected to the motor, and a classmate accidentally touched the drive control, which sent the cart forward and caused the child to fall from the cart. Although the child was not injured, the episode dramatized the need for additional safety features.

EXTENT OF USE

Table 5 shows the extent of cart usage. On the average school day, four children were in the cart at least 75% of their waking hours, three children utilized it between 40 and 70% of the day, and four children less than 10% of the time.

On weekends, two children used the cart more than 75% of the time; two children, 25 to 30%; and seven children, less than 25% of the day.

In considering where the cart was used primarily, we found that four children used it both at home and at school; five, only in the home; and two, only at school. The principle reason for using the cart in only one location was its excessive weight, which made transportation difficult. Nine people commented on this problem. Those who used the cart only at home considered the danger of driving a cart with such sensitive controls too great to permit unsupervised use. Two clinics stated they were unable to rely on school personnel to pro-

vide daily care for the cart, such as charging and filling the battery and reporting breakdowns.

As shown in table 6, most children were independent in such activities as driving through a 24-inch doorway, entering and leaving an elevator, approaching objects, and adjusting the seat height. The children with upper-extremity amelia and phocomelia continued to require assistance for activities involving reaching, such as pushing elevator buttons and opening and closing cupboards and drawers.

The majority of the children were independent in transfer activities (table 7),

TABLE 6. PERFORMANCE OF CHILDREN ($N = 11$)

	Independent without Cart	Need Less Help in Cart	Independent in Cart	Totally Dependent
Drive through 24-in. doorway	3	1	7	0
Push elevator call button	1	2	4	4
Enter, turn in, leave automatic elevator ^a	2	2	5	1
Push button in elevator ^a	1	1	4	4
Approach table; adjust seat ht.	0	2	9	0
Play, write, eat at table	3	1	4	3
Approach toilet, sink, bathtub	1	2	5	3
Open cupboard; obtain object	0	1	4	6
Close cupboard	0	2	4	5
Open and close drawer	1	2	4	4
Get item from drawer	1	1	4	5

^a One child not tested.

TABLE 7. EASE OF TRANSFER

	Children Independent with Cart	Easier for Assistant without Cart	Easier for Assistant with Cart	Not Tested
Cart to bed	6	0	4	1
To/from cart and toilet	4	3	3	1
Cart to car	3	4	3	1
Cart to schoolroom chair	4	2	4	1
Bed to cart	6	1	3	1
Car to cart	3	3	4	1
Schoolroom chair to cart	4	1	4	2

TABLE 8. ADVANTAGES AND DISADVANTAGES OF CAPP CART

Advantages	Clinics Reporting	Disadvantages	Clinics Reporting
Adjustable seat	7	Lack of "on-off" switch	5
Increased mobility	7	Insufficient ground clearance	4
Easy control	4	Nonmaneuverability in confined areas	2
Maneuverability	3	Inability to use prosthesis on same side as control arm	1
Movable control arm	2		
Stability	1		

e.g., cart to bed, toilet, or chair. The most troublesome transfer activities involved the toilet; presumably, these difficulties arose because of the narrowness of many bathroom doors and the lack of removable armrests on the cart.

After three months of use, most reporters noted a general improvement in driving and maneuvering skills.

ADVANTAGES AND DISADVANTAGES

Seven clinics reported that the greatest functional advantage of the cart was the adjustable seat (table 8). Other assets reported were the increased maneuverability, easy control, the movable control arm that facilitated transfers, and the stability of the cart. The greatest disadvantages were the lack of an "on-off" switch, and insufficient ground clearance.

Six children depended less on adult help while in the CAPP cart; four reported no change in the amount of adult help required; no information was available for the eleventh child. Nine parents reported that their children required less lifting; however, one child required more lifting. Before the arrival of the cart, this girl spent most of her time on the floor, where things had been built to accommodate her. Since she was unable to transfer in and out of the cart from the floor, she had to be lifted each time.

One child was unable to use his prosthesis while in the cart, because the control arm was on the same side and interfered with its use. Most of the children felt that the chin control was not the optimal control site, and they preferred to use their arm stumps. Two therapists suggested that, if the control arm were placed to

the side, a child could control the cart more efficiently with his stump. One therapist objected to the chin control because she feared damage to the child's lower jaw while driving the cart over rough terrain, although there was no report that this occurred. It was suggested that, if the control arm were relocated, a child could maintain a more normal sitting posture and turn his head for driving, and the control arm would not hinder activities at a desk.

CART MAINTENANCE

The twelve-volt battery required recharging every 24 hours. The batteries normally were charged overnight, and none needed replacement during the test period. Filling the battery with water was a considerable problem for parents because of the small storage space in the cart, which made battery-removal difficult.

Most maintenance problems concerned the rear wheels and switches; five carts required wheel replacements. The rear wheels attach to the gear box and receive the power to drive the cart. Since they do not swivel as the front wheels do when the cart turns, a torque is applied. These wheels, which were commercially available as wheelchair casters, were not designed for this amount of force and broke as a consequence of the torque overload.

All the carts required replacement of the switches in the control mechanism. The original switches were not the model ordered, but, for reasons of expediency (low cost and commercial availability), they were installed in the carts. When it became apparent that these were unsatisfactory, they were replaced with the model

originally ordered, and the problems were eliminated.

CONCLUSIONS

With one exception, all the children and their parents were very enthusiastic about the CAPP cart and preferred it to other modes of transportation. It provided increased independence to ten of eleven children with quadrimembral deficiencies.

Training did not present a problem, even for the youngest child; however, consideration should be given to introducing the very young or apprehensive child to the cart with a six-volt battery. Since the cart is very stable, most driving hazards arose because of recklessness or poor driving skills. Perhaps greater care should be directed toward predriving instructions, and the children should be given more opportunity to practice driving skills under supervision. It must be remembered, however, that children tend to be less responsible and less coordinated than adults, and more accidents are to be expected from them.

The CAPP cart afforded the children more independence in terms of mobility and endurance. Hemimelic children were able to perform many activities, such as opening and closing cupboards and drawers, as a result of the adjustable seat, which allowed them to approach objects more closely and normally.

DESIGN CONSIDERATIONS

Although a number of clinics suggested the inclusion of a seat belt, this would tend to restrict a child's independence if he were able to transfer in and out of the cart without assistance, since most arm amputees would be unable to manipulate the belt independently. Seat belts are readily available or easily devised, and the application of a belt might best be left to the discretion of the clinic or the child's parents. Another suggestion was the incorporation of an "on-off" switch that could be controlled by the child, or a switch that would automatically cut the power when the control arm is swung to the side.

Although the present velocity of the cart is satisfactory for forward maneuvers, it is clearly too fast for driving backwards or for delicate control. Consequently, consideration should be given to including a variable speed-control mechanism.

Although wheelchair casters are commercially available and relatively inexpensive, they are not designed to absorb the high torque forces that are applied to the rear wheels of the CAPP cart. Stronger drive wheels would probably have prevented many of the mechanical breakdowns that occurred. Consideration should also be given to including pneumatic tires, which provide greater traction and more comfort.

Since most of the children preferred to control the cart with their arm stumps, consideration should be given to placing the control arm to one side, close to the shoulder or stump. This would also avoid interference with use of an upper-limb prosthesis. A second possibility, particularly for the upper-limb amelic child, is to lower the control arm to the level of the chair seat, which would allow the child to control the cart with his foot or leg stump while enabling him to sit straight and to turn his head freely.

Note: As a result of the findings of the evaluation study, a new control box was developed that incorporates a variable-speed mechanism, and an "on-off" switch that can be controlled by the child. All carts have been recalled to UCLA, where a detailed analysis is also being conducted of the effect of use on the mechanical segments of the cart. The new control mechanism and a set of stronger wheels have been installed, and the carts were returned to the children for continued use. Each clinic will provide any further training required to operate the cart with the new control system. After six to eight weeks of additional use by the child, the clinic and the children will be asked to record their reactions to the modified cart.

RECOMMENDATION

On the basis of the results of the clinical evaluation of this item, and the design

modifications implemented by the developer, it is recommended that the C APP cart be made available to all limb-deficient children for whom conventional methods of transportation are unsatisfactory.

APPENDIX

J. T. was an eight-year-old girl with bilateral upper-limb amelia and lower-limb terminal-transverse hemimelia (A/K type). Initially, the control arm on the cart was lowered to the seat level to allow her to operate it with her leg stump. She did not wear lower-extremity prostheses while she was in the cart.

This child learned to operate the cart in approximately 2 1/2 hours; driving backwards and turning were the most difficult tasks for her to learn. As with the other

amelic children, she was able to move about independently, but she continued to be totally dependent in activities involving the arms.

She used the cart for the entire school day, but she did not use it at home because her parents found that its weight made transporting the cart very difficult.

Both the child and her parents found that the cart was too slow for her to keep up with the other children. The child's other reactions were similar to those of the other children; that is, she liked the adjustable seat and the increased independence, but disliked the lack of an "on-off" switch and of sufficient ground clearance. Her teacher reported that the cart often became stuck in the school yard because of insufficient clearance.

Ulnar Hemimelia

CHARLES H. FRANTZ, M.D.,¹ AND
RONAN O'RAHILLY, M.D.²

ISOLATED deficits of the long bones form a well-recognized group of anomalies. They may be described as *terminal*, in which there are no unaffected parts distal to and in line with the deficient portion (fig. 1); or *intercalary*, in which a middle part is deficient while those portions proximal and distal to it are present (fig. 2) (3).

Ulnar hemimelia is a postaxial longitudinal deficiency of the upper limb, wherein the ulna is completely or partially absent. Clinically, because of the multiplicity of forearm and hand deformities or contours, it may be very difficult to recognize precisely the deficiency without roentgen studies (figs. 3 and 4). The elbow joint may be in extension or in acute flexion. There may be fusion of the radiohumeral joint. The range of motion, if present, may be markedly limited. The proximal part of the radius may articulate with the underdeveloped capitulum, or it may be completely luxated. If the deficiency is incomplete, the ulnar remnant may vary in length and contour. The digits of the hand may vary greatly in number (figs. 5 and 6). At the shoulder girdle, one may observe considerable muscular atrophy, ligamentous relaxation, and a deep web in the axilla.

In 1932, Kanavel (6) reported 60 cases of ulnar deficiencies. Comparison of Kanavel's findings with those of the cases presented here reveals the digit deficits as shown in table 1.

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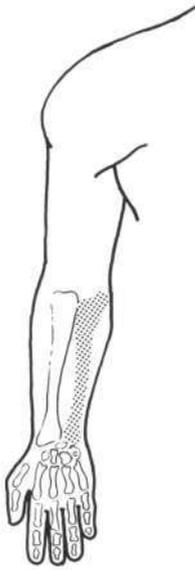
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O'Rahilly (17) presented a resume of 65 cases in the literature up to 1950. This deficit is seen much less frequently than is radial hemimelia, the literature indicating a ratio of 18:1. O'Rahilly's analysis revealed that 67% of the cases were unilateral, and 69% involved the right upper limb. The incidence in males was more common, with a ratio of 2:1. Radiohumeral fusion and/or digital syndactyly were not mentioned.



Fig. 1. Terminal longitudinal paraxial hemimelia, ulnar. There is absence of one or more digits (the absent parts have been ghosted in).

INTERCALARY-Longitudinal



PARAXIAL
HEMIMELIA
(Ulnar)
I/I:U

Fig. 2. Intercalary longitudinal paraxial hemimelia, ulnar. Note that all five fingers are present.

The absence of a radiohumeral joint (fusion) indicates the failure of cavitation of this structure. It is suggested that the lack of cavitation is an integral part of the total deficit seen in some cases of ulnar hemimelia (38.5% of Frantz's patients).

During the past 15 years, the staff at the Area Child Amputee Center has examined and managed 26 children with ulnar hemimelia. An analysis of these cases reveals a follow-up of from 1 to 15 years. There were 16 males and 10 females.

This deficit appears to be a sporadic lesion, in that there were 59 normal siblings of the 26 patients studied. One patient had a fraternal twin who had no skeletal deficits.

Ten of the patients (38.5%) had unilateral ulnar hemimelia with no other skeletal deficiencies. Three children (11.5%) had bilateral ulnar hemimelia; seven also had lower-limb deficits. Six patients with unilateral ulnar hemimelia had varying deficiencies in the contralateral upper limb. These included terminal transverse hemimelia, phocomelia, absent thumb, and absent fifth finger. Ten patients (38.5%) had radiohumeral fusion accompanying the ulnar hemimelia.

The involvement of carpals and metacarpals is complex. The triquetrum and capitate often are absent. There is an increasing frequency of metacarpal failure as one passes from the radial to the ulnar side of the hand.

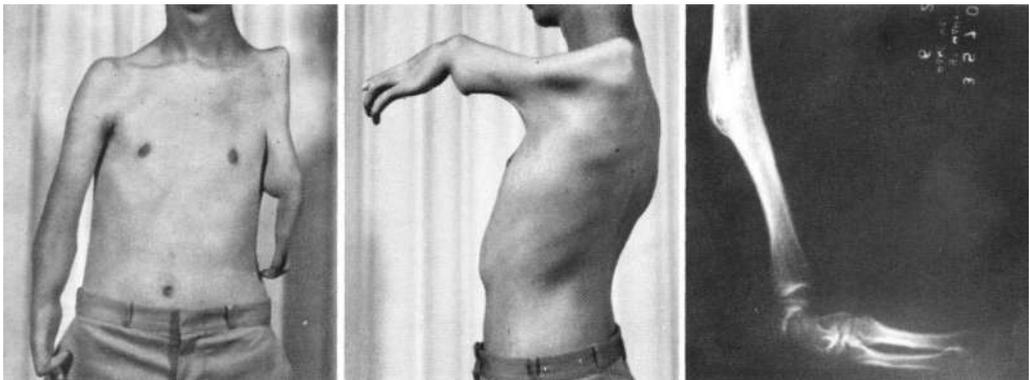


Fig. 3. *Left*, the short left upper limb is phocomelic. Note the severe atrophy of the left shoulder girdle. There are three digits in the hand. The right arm (ulnar hemimelia) demonstrates good shoulder musculature and motion. *Center*, abduction and forward flexion are limited by the axillary web. *Right*, X-rays reveal fused right radiohumeral joint (failure of cavitation).

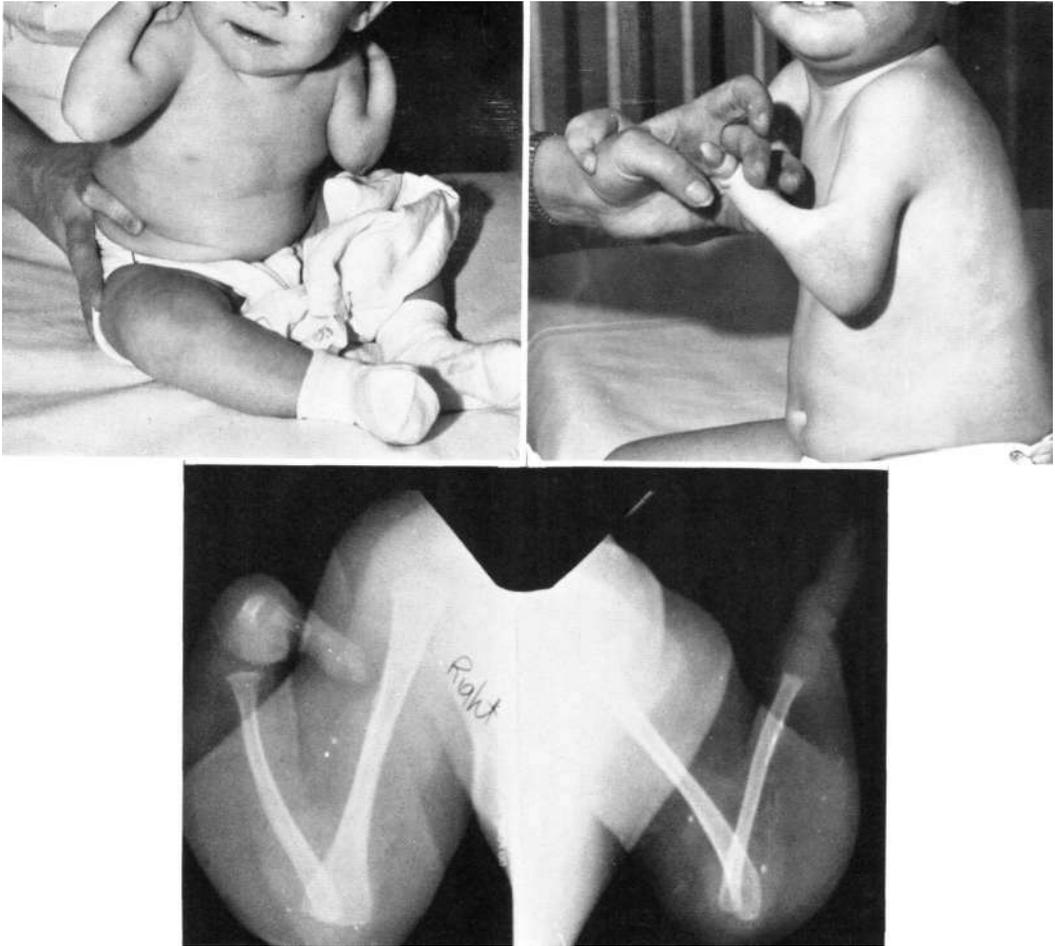


Fig. 4. *Left*, bilateral ulnar hemimelia, with monodigital hands. *Right*, note the deep web at the cubital fossa (pterygium). *Center*, X-rays reveal the radiohumeral relationship. There is no true elbow joint.

The frequency of digital absence is shown in table 2. It is of interest to note that the three-fingered hand is preponderant, followed closely in occurrence by the monodigital hand.

MANAGEMENT

In our experience, most of these children can be managed without surgical intervention. The goal, of course, is to improve function, with or without the use of a prosthesis. Whether surgery is indicated depends upon whether both arms are involved, and on the range of motion, the number of digits present, and the presence or absence of syndactyly (table 3).

NONSURGICAL

No Fitting

Some of these children had radiohumeral synostosis (figs. 3 and 7).

Opponens Post

Children with one digit (monodigital hand) possessing good flexion power and lateral stability of the metacarpophalangeal joint were fitted to advantage (fig. 8).

Below-elbow Prosthesis

Modified below-elbow sockets were sometimes prescribed (fig. 9). However, range of elbow motion is significantly lacking.

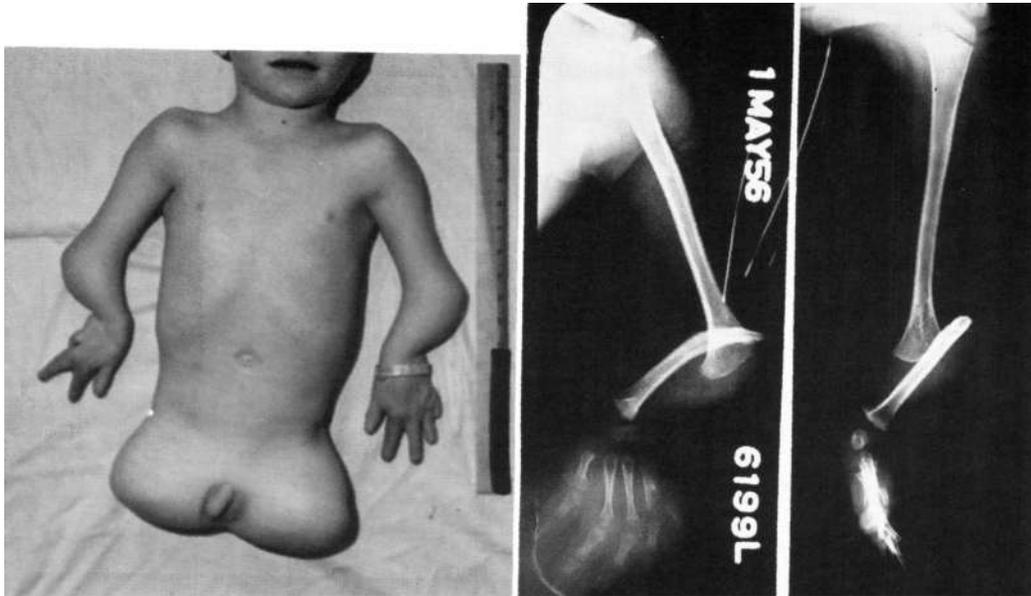


Fig. 5. *Left*, bilateral ulnar hemimelia. The left is intercalary, since there are five digits; the right is terminal because there are only four digits. Patient has complete anonychia with distinctive pulp prints on the dorsum of the fingers. *Right*, X-rays reveal complete dislocation of the radiohumeral joints.

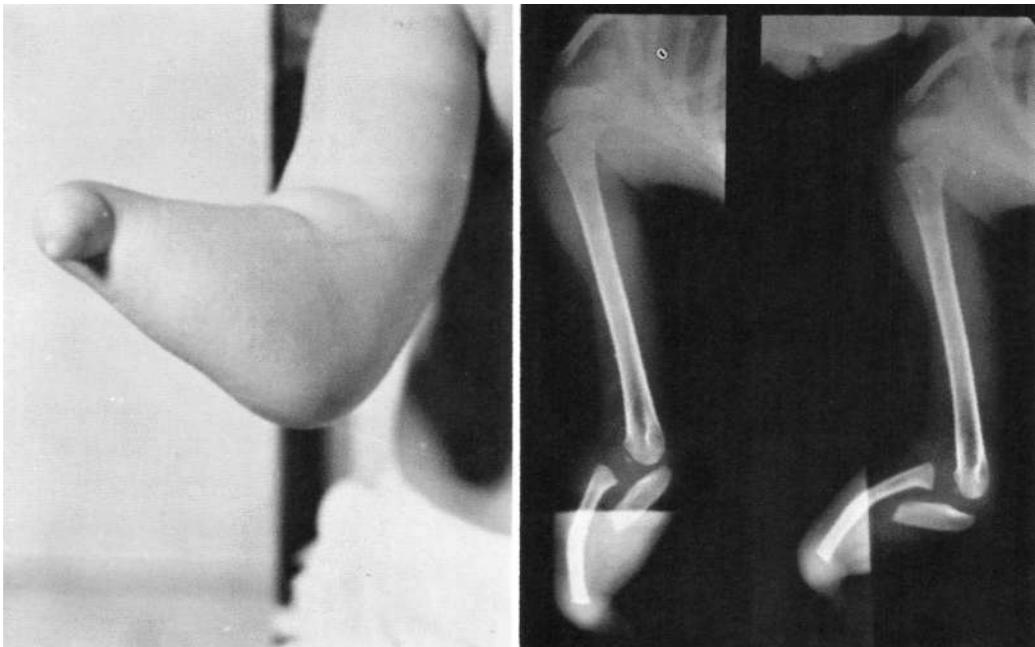


Fig. 6. *Left*, monodigital ulnar hemimelia, incomplete. *Right*, X-rays reveal proximal remnant of the ulna, with a bowed radius.



Fig. 7. *Left*, ulnar hemimelia with three-digit hand (left). The right upper limb is phocomelic. *Right*, X-rays show radiohumeral fusion (failure of cavitation).

Above-elbow Prosthesis

This is a highly satisfactory method of fitting patients with unilateral, monodigital, ulnar hemimelia. The forearm segment is acutely flexed against and parallel to the humeral shaft and then encased within the humeral socket. The elbow-locking mechanism has a lever with which the single digit controls the elbow lock and unlock mechanism (fig. 10).

SURGICAL

Elbow Z-plasty

Z-plasty in the cubital fossa was performed in two instances in an endeavor to decrease the cubital web and in the hope of allowing a greater range of elbow flexion and extension. This procedure is somewhat advantageous in that it allows a better fit of the forearm socket, but it fails to offer any

significant increased range of motion and therefore is not recommended (see fig. 9).

Elbow Disarticulation

This surgical procedure is followed by fitting the limb with an elbow-disarticulation type of prosthesis. The surgeon should be meticulous in his technique so as not to disturb the distal humeral epiphysis during the disarticulation procedure.

The application of the elbow-disarticulation type of prosthesis with an outside locking elbow offers 11 different positions of the elbow joint.

Humeral Derotation Osteotomy

Two children received a humeral derotation osteotomy of at least 90 degrees (fig. 11). One was lost to follow-up after early union.

DISCUSSION

From this brief outline of management, it is obvious that the treatment of these children is highly individualized. The timing and procedure may be dictated by the age of the patient, the question of bilaterality, and the scope of the handicap. The decision as to whether or not to prescribe a prosthesis may be a difficult one. The approach to handling these children with ulnar

hemimelia has been developed over the years by trial and error and by functional analysis.

In figure 3, severe as the deformities may appear to be, the right shoulder functions normally, and the boy is able to abduct and forward-flex the shoulder, which allows him to prehend with his right hand. The left upper limb is phocomelic; however, he has a functional "pinch force" with the digits for close-in functioning. In the occupational therapy department, he demonstrated a very acceptable level of accomplishment in the activities of daily living and therefore was not fitted with prostheses.

This logic is in accord with the problem faced by the boy shown in figure 7. The efficiency of this four-year-old's performance in dressing, undressing, and toilet care is such that he needs no prosthetic aids. Utilizing the ulnar hemimelic limb, this boy is able to feed himself and care for most of his daily living demands.

Bilateral ulnar hemimelia with monodigital hands is a severe handicap (see fig. 4). One male in this group had the Cornelia de Lange syndrome. If a child is seen at an early age (i.e., before two years), one may be tempted to procrastinate. How long? The major question is whether one should fit one or both sides with a passive type of prosthesis (terminal devices with no cables, but with small rubber bands on the hooks) or whether to interfere surgically.



Fig. 8. This boy was born with bilateral ulnar hemimelia with monodigital hands (see fig. 4). At 4 years of age the right upper limb was fitted with an opponens post. The left limb was managed by elbow disarticulation and prosthetic replacement. The elbow unit has 11 positions, allowing from 45° flexion to 180° extension.



Fig. 9. *Left*, monodigital ulnar hemimelia, with extension limited to 70°. Web release in the cubital fossa offered little additional motion. Initially the child was fitted with a below-elbow type of prosthesis (*center*). After a 2-year trial, the family expressed dissatisfaction with the limited motion and function of the arm. At 4 years of age an elbow disarticulation was performed and prosthetically fitted (*right*).

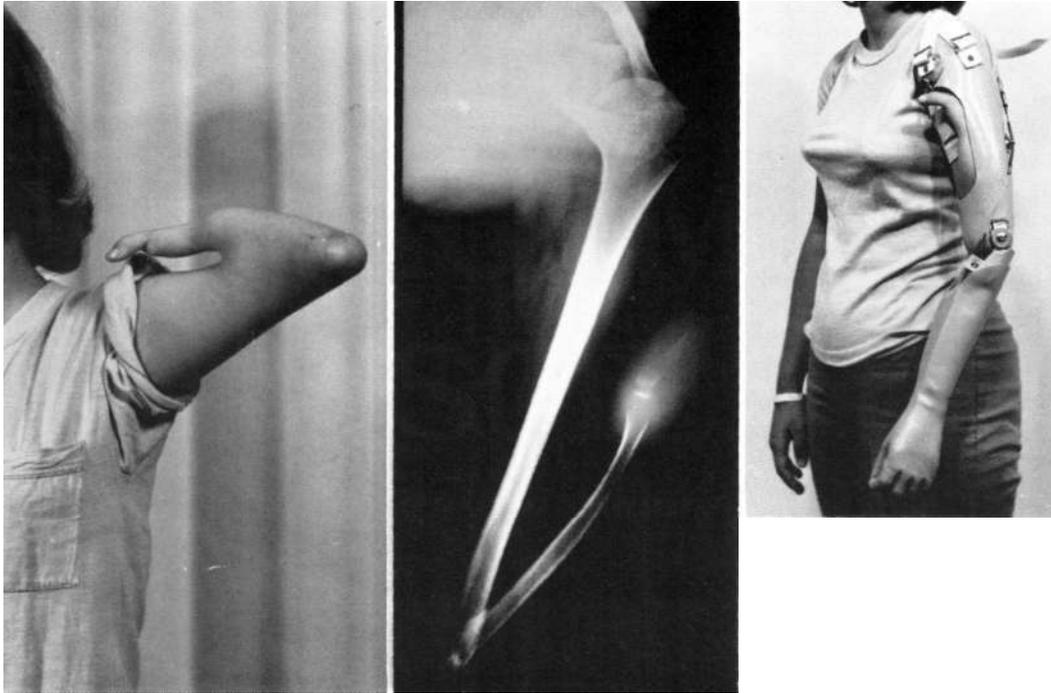


Fig. 10. *Left*, ulnar hemimelia with a monodigital hand. Note the acute flexion and the deep cubital web. *Center*, the radiohumeral angle is 20° . *Right*, the monodigital segment is encased in a fenestrated humeral socket in an elbow-disarticulation type of prosthesis. The digit operates the elbow lock.

It has been stated that a Z-plasty at the cubital fossa offers little improvement of the radiohumeral arc of motion.

One approach may be to fit one side with an opponens post and the opposite side with a modified below-elbow prosthesis. Should the prosthetic side prove to be inadequate with a below-elbow type of prosthesis, one may then elect to perform an elbow disarticulation one year before kindergarten, allowing a year of prosthetic wearing before formal schooling. This was done in the patient shown in figure 8. At this writing, the boy is 14 years old. He is in junior high school and is the manager of the football team. Also, he is a fair bowler, for which he utilizes a special attachment to his prosthesis.

Unilateral, monodigital, ulnar hemimelia with a normal contralateral upper limb is not as serious a handicap. The patient shown in figure 9 was fitted at two years of age with a modified standard below-elbow pros-

thesis. At the age of four years, the patient and her mother were dissatisfied with the function afforded, because of limited elbow motion. (The Z-plasty at the cubital fossa offered little additional motion.) The child received an elbow disarticulation and was subsequently fitted with a standard elbow-disarticulation prosthesis with a medially placed outside-locking elbow. At the time of writing, she is 18 years of age, ready to enter college, and is considered a very good prosthesis-wearer.

The patient in figure 10 was seen in 1964 at 15 years of age; she has a monodigital, left-sided, ulnar hemimelia. Her degree of radiohumeral flexion was more severe than that of the girl in figure 9. This patient was not particularly concerned with the cosmetic effect (and still is not). She was fitted with a prosthesis that encased the acutely flexed forearm within the humeral socket. The anterior, or ventral, wall of the socket was then fenestrated and a lever was attached



Fig. 11. *Left*, ulnar hemimelia, left; there is radiohumeral fusion (failure of cavitation) with 90° rotation. *Center*, derotation osteotomy of the humerus at 4 years of age. *Right*, arm position following derotation osteotomy. Note the three-fingered hand; the parents refused to have a syndactyly-release performed.

to the elbow-locking cable, which permitted her to use the single digit to operate the elbow locking/unlocking mechanism. At this writing, she is in her second year in college and now wears a mechanical hand with a cosmetic glove. The upper arm is usually covered by a fluffy-sleeved blouse.

To summarize, there are four approaches to treatment of the monodigital hand: opponens post; below-elbow prosthetic fitting; elbow-disarticulation prosthetic fitting, encasing the forearm in the humeral socket;

or no fitting, which is the least recommended procedure.

Rotational deformities occasionally are seen in which there may be up to 180 degrees of medial rotation of the forearm on the humerus. The hand rests at the side of the thorax, pointing dorsally. One patient was seen at eight months of age (see fig. 11). There were three digits in the left hand with soft-tissue syndactyly. She received a derotation osteotomy of the humerus at the age of four years, and a fair result was ob-

TABLE 1. FREQUENCY OF ABSENCE OF DIGITS IN ULNAR DEFICIENCIES

	Digit				
	1	2	3	4	5
Kanavel (60 cases)	4	8	18	29	32
Frantz/O'Rahilly (26 cases)	0	10	14	29	20

TABLE 2. DIGITAL ABSENCE IN ULNAR HEMIMELIA, 26 CASES

Digit	Unilateral	Bilateral	
		Right	Left
1	8	2	0
2	3	2	2
3	9	0	0
4	1	1	3
5	0	0	1
	21	5	5

TABLE 3. SURGICAL AND NONSURGICAL MANAGEMENT OF ULNAR HEMIMELIA, 26 CASES

Nonsurgical	Cases	Surgical	Cases
No fitting	5	Syndactyly release	2
Opponens post	1	Elbow Z-plasty	2
Below-elbow fitting	7	Elbow disarticulation	2
Above-elbow fitting	5	Humeral derotation osteotomy	2
	18		8

tained. Unfortunately, she was lost to clinic follow-up shortly after surgery.

Dislocation of the radiohumeral joint is rare. One such patient was first seen at four years of age. He has five digits on the left hand and four on the right. There were no fingernails. It is of interest to note that this boy has distinctive prints on both the palmar and dorsal surfaces of his fingers. His radiohumeral joint anatomically is non-existent (see fig. 5). The intrinsic muscles of the hands are weakened, and the wrists are unstable. The forearms and hands have been encased in a half-sleeve of plastic attached to crutches (he also has bilateral amelia of the legs). He is now 18 years old and attends a trade school.

Incomplete ulnar hemimelia occurred twice in this series. The proximal portion of the ulna is present, thus affording a normal-appearing elbow joint with an excellent range of motion (see fig. 6). That child was seen at four years of age and fitted with a standard below-elbow prosthesis, which she is currently wearing.

Syndactyly was encountered four times in 26 cases. Two cases have been corrected surgically.—*Charles H. Frantz, M.D.*

PATHOGENESIS

The term "hemimelia" (*hemimelie*) was introduced in 1836-37 by Isidore Geoffroy Saint-Hilaire (19), who also introduced the term "teratology". In 1877, Verneuil proposed subdivision (of "ectromelia") into longitudinal and transverse varieties (21). In addition to absence of the distal half (two of the four segments) of a limb, it became clear that, in some cases, only one side of the distal half was affected, and such instances were named (after the defective portion) "radial," "ulnar," "tibial," and "fibular" hemimelia. By 1903, a further distinction, that between terminal and intercalary varieties of hemimelia, had been made (7). Finally, in 1951, O'Rahilly suggested the term "paraxial hemimelia" for the longitudinal variety, because either the preaxial or postaxial side of the limb is involved in such cases.

It is not proposed to discuss here either the terminological basis (19) or the terato-

genesis (11) of limb malformations in general, as these aspects have been considered recently elsewhere.

Ulnar hemimelia was first reported in 1683 by Goller (14) and hence is probably the first of the paraxial hemimelias to be identified as such, there being some doubt about the true identity of the case of hemimelia described by Pare in 1573 (13).

Although chronological tables of all the early cases of radial, tibial, and fibular hemimelia are available in the literature, no such list other than the bibliography provided by Rabaud and Hovelacque (21) seems to have been prepared for ulnar hemimelia.

Among the hemimelias involving one of the four bones of the third limb segment, or "zygopodium" (forearm and leg), the ulnar type occurs the least. It differs from the others also in that a partial deficiency is more commonly found than complete absence. However, it resembles radial, tibial, and fibular hemimelia in that it is more frequently unilateral, more commonly seen on the right side, and more often observed in the male (17). Of particular interest are those cases in which thorough dissection has been possible (23).

Several additional cases of ulnar hemimelia have been reported in the literature during the past two decades. The higher incidence of unilaterality and of right-sided involvement has been confirmed (9).

It is important to appreciate that the hemimelias may occur as isolated anomalies, or they may, as shown in this paper, be associated with other malformations. Ulnar hemimelia, for example, is sometimes a component of a sporadic syndrome that includes femoral and fibular defects (8). The cause of the "FFU" (femur, fibula, ulna) syndrome is unknown; such factors as parental age and thalidomide have been ruled out, and familial occurrence has not been observed.

A striking example of familial occurrence in several generations was recounted to Roberts (22) by a patient with ulnar hemimelia. Partial ulnar hemimelia of the intercalary type, together with hypoplasia of the thumbs and fibular hemimelia, has more

recently been described and illustrated in two brothers (25). A different condition, ulnofibular dysplasia, characterized by shortening of the ulna and fibula, was found to be inherited as an autosomal dominant (20).

Ulnar hemimelia accompanied by Polydactyly is not unknown (25), and the coexistence of Polydactyly and a long-bone deficiency in the same limb has been noted previously (e.g., heptadactyly and tibial hemimelia) (18). In such cases, it has been suggested that this seeming paradox of excess associated with deficiency may perhaps result from an excessive outgrowth, which occurs relatively late in the early embryonic period, "involved only the digital area, and attracts some of the tissue immediately proximal to the area of excess outgrowth" (26). In the human, the hand appears in mesenchyme at about 41 postovulatory days (stage 17), so that it may be expected that Polydactyly would be observable by about six weeks after fertilization. Indeed, an example of this as an isolated anomaly has been described (16).

What are generally termed "fusions" of skeletal elements—that is, the occurrence as a single structure of something that is usually composed of two or more elements—may be found either as an isolated anomaly or in association with other disturbances. Carpal and tarsal fusions, for example, are not infrequent in the paraxial hemimelias, and, as emphasized in this paper, ulnar hemimelia may include humeroradial fusion. Normally, of course, certain bony fusions, such as those between the epiphyses and their diaphyses and between the neural arches and their centra, are of constant occurrence. Even in areas where synovial cavities might be expected, however, fusions are not infrequent, such as symphalangia between the middle and distal phalanges of the little toe. The histological development of phalangeal fusion has been studied in detail (2,4), and it is of interest to note that carpal and tarsal fusions have been observed in both the embryonic and the fetal period (4). That such fusions arise early during embryonic development as an absence of joint cavitation (17) is also suggested by studies of

experimentally paralyzed chick embryos, in which articular cavities do not form (1,15). The cartilaginous skeletal elements, which are at first united by mesenchyme, become, under these conditions, joined together by fibrous tissue or by cartilage. In other words, fusion takes place across the presumptive joint regions.

That hemimelia occurs at a very early stage of embryonic life is indicated by the important, but neglected, observations of Hovelacque and Noel (5) on a strain of mice presenting tibial hemimelia. It was found that "the first manifestations of the anomaly are disclosed at a very early stage of development. They can be detected in embryos when the undifferentiated blastema begins to undergo change." In the tibial zone of the blastema, a "fibrous tract" appeared, and was connected to the fibula by the interosseous membrane. In some of these embryos, cartilaginous nodules developed in the area (especially proximally) where the tibia would normally form. Such nodules were in direct continuity with the fibrous tract; both constituted a unit that represented the tibia. The vascularization of the limbs was entirely normal. It was concluded (21) that "the tibia is never completely absent despite appearances; one can always find a trace of the element although it may be represented by only a nodule of pinhead size." There is no reason to believe that the above statements would not apply equally to the other types of paraxial hemimelia.

To return to the human—the mesenchymal femur, tibia, and fibula appear at about 41 postovulatory days (stage 17), and the humerus, radius, and ulna appear at about 37 postovulatory days (stage 16). In other words, it may be expected that, in the light of the French workers' observations, paraxial hemimelia could be detected in the human before six weeks after fertilization.

Prior to the first appearance of these specific skeletal elements, a sensitive period for teratogenic agents exists, as have been shown by correlations between the time of ingestion of thalidomide during pregnancy and the types of resultant anomalies (12). Thus, tibial defects occurred

mostly when ingestion began before the 46th menstrual day (perhaps about 32 post-ovulatory days). In one illustrated case, ingestion that commenced at 46 menstrual days resulted in bilateral radial hemimelia and malformations of the femur and tibia.

Finally, it may be mentioned that ulnar hemimelia has been found sporadically in various animals, such as the pig (23, 24). It also has been produced experimentally by the inclusion of large doses of acetazolamide (a carbonic anhydrase inhibitor) in the diet of rats during pregnancy (10). Of particular interest in these experiments is the circumstance that the ulnar hemimelia was practically restricted to the right side of the body.—Ronan O'Rahilly, M.D.

SUMMARY

The management of 26 cases of ulnar hemimelia has been discussed. This deficit is seen 18:1 less frequently than radial hemimelia. Bilaterality was present in 23% of the cases. Prior to determining the plan of treatment, a complete functional analysis should be carried out. Most of these children do not need surgery and may be treated by prosthetic fitting only. The pathogenesis of paraxial hemimelia and the embryogenesis of associated conditions, such as Polydactyly and joint fusions, are discussed.

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The Parapodium: An Orthotic Device for Neuromuscular Disorders

WALLACE MOTLOCH, CO.¹

Some of the serious shortcomings of the standard brace for young patients with paralysis of the lower extremities are the lack of adjustability to accommodate growth and contractures, excessive weight, instability, difficulty in locking and unlocking, and the time required for donning and removal. The Parapodium (3) was designed in the effort to introduce a modular system that offers alternatives and resolves some of those difficulties.

The Parapodium facilitates standing without crutches, thus freeing the patient's hands for a wider range of activities. The difference between tripod standing and crutchless standing is a major distinction between our approach to brace design and that of conventional braces.

This orthosis is best suited for patients with severe spina bifida or traumatic paraplegia; however, it also may be prescribed for other neuromuscular disorders in which stability of the brace (permitting standing or swivelling without crutches), lightness of the device, and an upright position are important.

Because of the modular design, growth in a child is easily accommodated. The footplate will accept several sizes of regular boots; there are four sizes of footplates for boots from 5 1/2 in. to 9 1/2 in. long. The height of the Parapodium can be adjusted by replacing the tubular sidebars with a longer piece of tubing, which is cut from

standard 1/2-in. or 5/8-in. aluminum tubing, and the back panel is made in two pieces to provide for width adjustment.

The Parapodium is constructed of light-weight, high-strength aluminum (2024T6) throughout. The average weight is between 8% and 14% of the body weight. The weight of a standard brace may be as much as 15% to 22%.

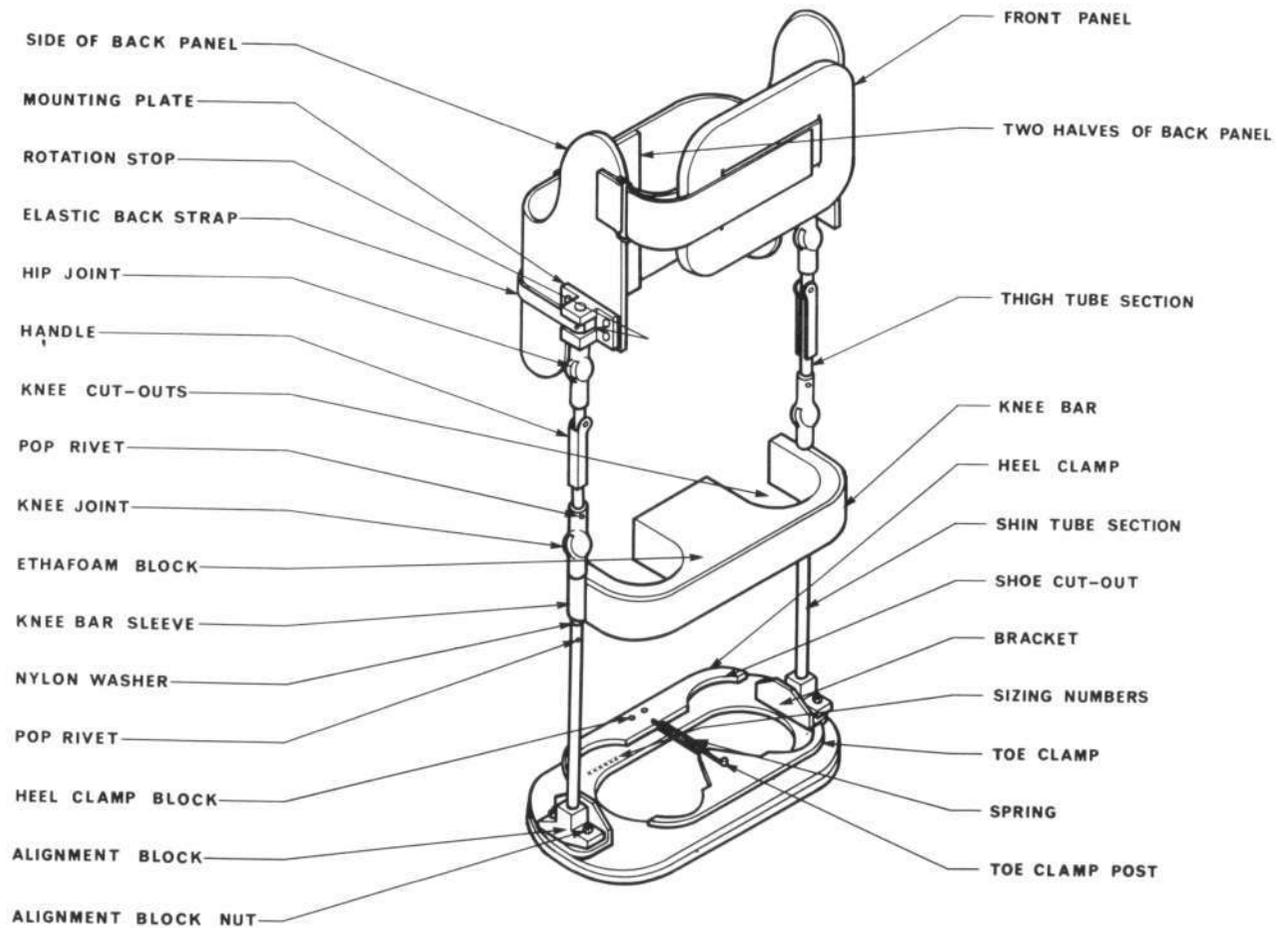
For stability, the footplate, sidebars, and back panel form a continuous rigid loop, cross-braced by a bar at the level of the knee. The shape of the bar virtually eliminates side-to-side movement, thus improving the anterior-posterior and medial-lateral stability of the unit.

The knee pads are shaped from 2-in. Ethafoam (TM) blocks. If contractures occur, they can be accommodated by deepening the knee cutouts in the foam block.

One of the unique features of this orthosis is the means used to lock and unlock the hip and knee joints. A set of folding handles is used to rotate the upright bars and thus rotate the hip and knee joints. For standing, the joint axes are aligned in the A-P direction; when rotated 90 degrees to the M-L position, the joints are free to flex. Also, it should be noted that one of the more difficult tasks a paraplegic has is to, extend his extremities fully so that he can lock his braces; the rotating sidebars not only lock the brace, but also extend it the last few degrees.

Since the patient's shoes are not permanently attached to the brace, he is able to put on and remove the brace without wasting time lacing and unlacing the boot. Also, the boot remains on the patient's foot to

¹ Orthotic Research and Development Spina Bifida Unit, Ontario Crippled Children's Centre, Toronto, Canada. This article was extracted from the report "Parapodium" prepared in collaboration with Sunnybrook Hospital, Toronto, February 1971.



PARAPODIUM

Fig. 1.

protect it from scratches and bruises. In addition, the time for donning and removing the brace has been greatly reduced because of the simplicity of the locking method. Our older patients can remove this brace in 15 to 20 seconds, whereas it could take from 5 to 20 minutes to remove a standard brace. Donning the Parapodium takes 45 to 90 seconds; donning a standard brace takes 10 to 20 minutes.

A minimum of maintenance is required. Because of the use of aluminum, the parts do not need to be plated to prevent corrosion, there are no delays for plating, and nylon does not need lubrication. No screws are used in the sidebars, nor leather for straps.

Because of the modular kit, the device can be assembled speedily. If no special modifications of the kit are needed, the fitting can be completed in two hours. Also, repairs or growth adjustments can be made while the patient waits.

Simple, clean lines, with no buckles, straps, or corsets, have superseded the cluttered look of the standard braces. The aluminum is easily cleaned or buffed, and it may be anodized when the brace is finished.

The Parapodium is easily aligned. An alignment block at the bottom of each upright enables the orthotist to align the brace while it is being worn. The brace can be aligned for maximum comfort while standing or for maximum stability.

CLINICAL CONSIDERATIONS

When the child indicates the desire to stand up by pulling up on furniture and other objects, or when he has developed sufficiently to stand, a bracing program may commence. (For a presentation on the orthotics aspects of treating children with spina bifida, the reader is referred to "Therapy Treatment Suggestions" by Elizabeth L. Hamilton, P.T., in 3.)

In some cases, a prebracing device, the "caster cart" (2,3), or a preliminary brace, the "standing brace" (2,3), may be used. At this center, the criteria for considering the use of the Parapodium are:

1. The patient does not have sufficient

muscle power in his lower extremities and trunk to ambulate and stand without crutches.

2. The patient has either gone through the standing-brace stage or is physically and mentally ready to go directly into the Parapodium.

3. The patient is of such size that comfortable sitting can only be accomplished by flexing the knees and hips.

In addition, the following points should be checked before a Parapodium is considered:

1. Upper-extremity coordination and strength. Can this person use crutches or walkers effectively for ambulation? If only standing is required, this point might not be important.

2. Condition of the feet. Can shoes be worn? Can the skin, bones, and joints withstand weight-bearing? Custom shoes, special padding, and plantar-flexion wedges could be used. A physiotherapy program can prepare the patient for weight-bearing.

3. Deformities and contractures. Check the legs, pelvis, and spine for severe deformities. Orthopedic surgery and physiotherapy can be of great value. Minor deformities can be accommodated without special modifications.

4. Skin condition. Check for sores and for hypersensitive areas over the chest (front panel area), sacrum (buttocks support), and patellar tendon and knees (knee pads).

5. Protruding myelomeningocele and spinal deformities. Can a body jacket support the trunk? Is there enough clear area

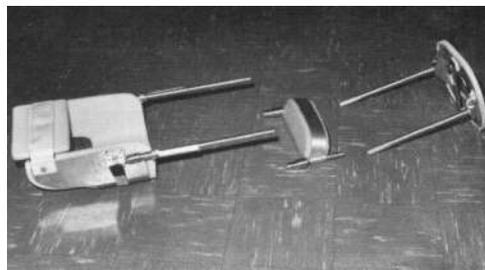


Fig. 2. The semi-assembled Parapodium kit as it is supplied by the manufacturer.

over the sacrum for a good buttocks-support panel?

ASSEMBLY AND FITTING

The parts of the Parapodium and the "kit" supplied by the manufacturer are shown in figures 1 and 2.

The tools required to assemble the kit are: a tape measure, knife, hacksaw, file, portable drill with 1/8-in. drill bit, pop-riveter, and a 1/2-in. reamer.

Step 1. Obtain a pair of lace-to-toe boots. Check their fit on the patient carefully; it is better that they tend to be loose rather than tight.

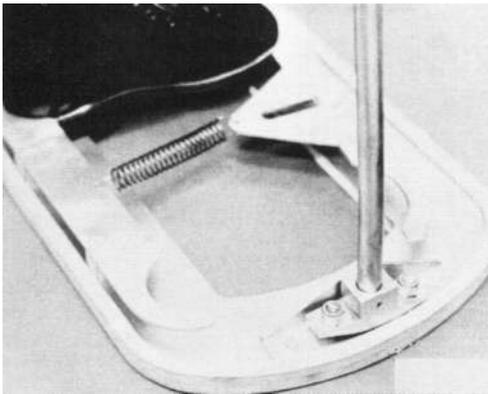


Fig. 3.

Step 2 (fig. 3). Fit the shoes into the footplate. Make sure that the clamps (toe and heel) hook securely over the welt of the shoe and that the spring is taut enough to hold the shoes in place. Sometimes it may be necessary to change the height of the heel-clamp block, toe-clamp post, and the curvature cutouts of the heel and toe clamps.

Figure 4 illustrates the position of the knee pad. Note that the patellar tendon is used in this case and that the block has to be shaped to concentrate pressure on the patellar tendon.

Step 3 (fig. 5). With the shoes on the patient, clamp the lower part of the brace in place. Hold the knees in the desired position (anteroposterior and mediolateral) and mark the cutout for the knee on the foam block.

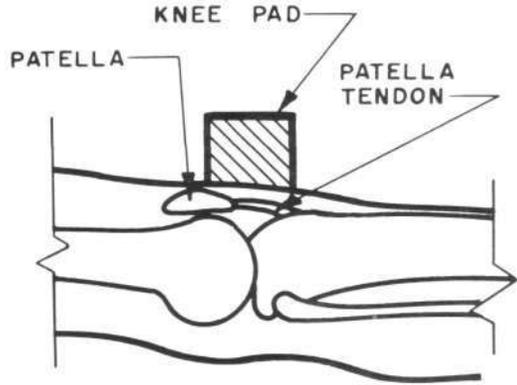


Fig. 4.

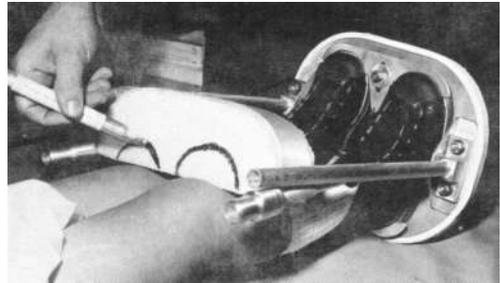


Fig. 5.



Fig. 6.

Step 4 (fig. 6). With the marked knee pad over the patellar tendon, mark the length of the tube shin section.



Fig. 7.

Step 5 (fig. 7). The knee cutouts are shaped as marked.



Fig. 8.

Step 6 (fig. 8). Check the fit of the knee cutouts. At this time, only a rough fit is necessary; a final check and smoothing is done later.

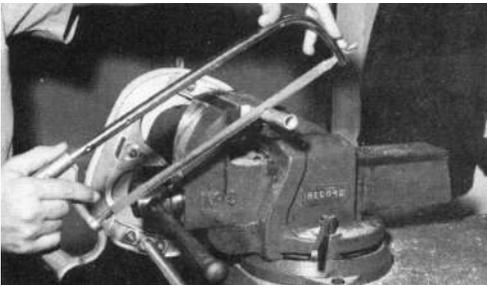


Fig. 9.

Step 7 (fig. 9). Cut off the tube shin sections as marked in step 4. File the end flat and clean out the burr from the inside of the tube.

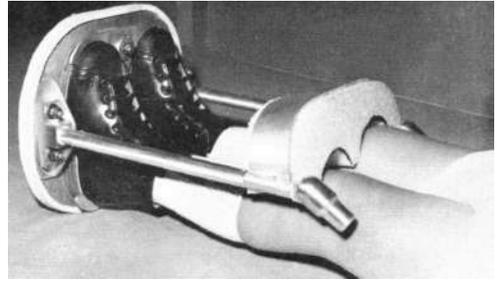


Fig. 10.

Step 8 (fig. 10). Clamp the lower section in place and check the fit of the knee cutouts to ensure patellar-tendon pressure-bearing, and also check the length of the shin sections.

BACK PANEL

The back panel is effective only in cases of good spine stability, minor deformities, and meningocele protuberance higher than the sacral area. For fitting of more severe cases, see the "Spinal Deformities" section.

The panel should be fitted rather loosely because the width across the greater trochanters increases with weight-bearing (fig. 11).

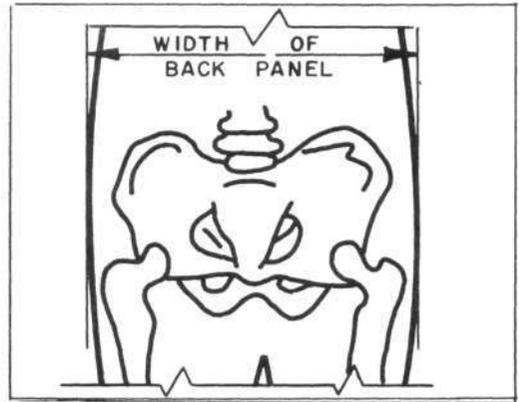


Fig. 11. Fitting of the back panel.

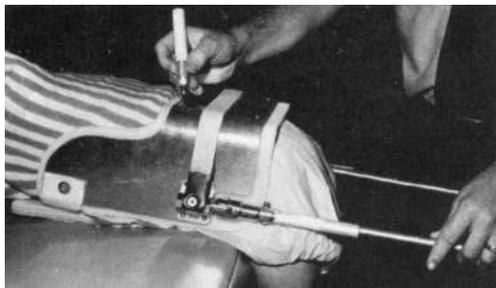


Fig. 12.

Step 9 (fig. 12). With the patient on his stomach, and his legs over the edge of the fitting table, place the two halves of the back panel on the patient's back and mark the width. Two pop rivets are used to hold the halves together temporarily; the final adjustments and riveting are made when the patient stands in the brace.



Fig. 13.

Step 10 (fig. 13). With the patient sitting, check the fit at the greater trochanters, in the sacral area, and the axilla. Sometimes it is necessary to place padding over the sacrum, especially in cases of tenderness, scarring, and bony protuberances. Also, the side supports might have to be lengthened or shortened to be one inch lower than the axilla border.

Figure 14 shows the desired position of the front panel, anterior view, with the center of the panel on the xiphoid process.

Step 11 (fig. 15). Rivet and fasten the Velcro strap. Check the position of the panel, the length of the strap, and the angle of the rotation stops. Sometimes they are pinned incorrectly and have to be repinned. The tubular thigh sections should be lined up parallel.

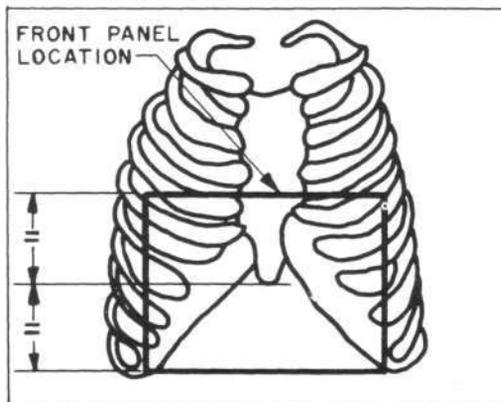


Fig. 14.



Fig. 15.



Fig. 16.

Step 12 (fig. 16). Place the lower and upper sections of the brace in the correct position and mark the length of the tube thigh section.

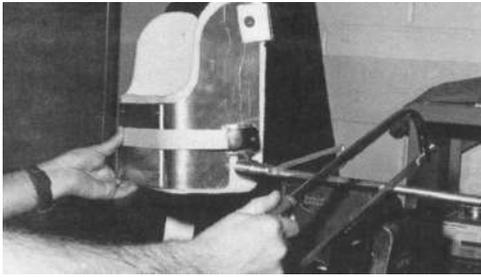


Fig. 17.

Step 13 (fig. 17). Cut off the thigh sections to the length marked; file the ends square and remove the burr.

Step 14. Using Vaseline as a lubricant, insert the tube sections in the knee joint. *Note: This should be a sliding fit only; do not force or hammer these parts in or they will be damaged permanently.* In some cases, an adjustable reamer is needed to get a good fit. This should be done carefully because a sloppy fit will cause instability of the brace. *Do not rivet* the lower and upper sections to the knee joint yet, but rather, slide the tubes in place (use Vaseline).



Fig. 18.

Step 15 (fig. 18). Have the patient sit on a chair, with hips and knees flexed 90 degrees (more than the figure shows). There should be 1/4-in. to 1/2 in. space between the loam cutouts and the front of the knee in this position. The back panel should be touching the sacral area, and the tubes should be fully inserted in their receptacle.

Step 16. Place the patient in his brace on the fitting table. Using the handles to turn the hip joints, and by manually turning the knee joints, lock the brace for standing. Hold the brace parts together at the knee with both hands. With assistance, slowly stand the patient up (fig. 19). Provide plenty of physical and moral support at this time.

Carefully check (a) the position of the back and front panel (the lower edge of the panel at the crease of the buttocks), (b) the width of the back panel (see fig. 11), and (c) the position of the knee pad (see fig. 4).



Fig. 19.

It is important to ensure that the panel does not rise up significantly in standing as compared to sitting. If that occurs, first check the operation in step 12; if that is satisfactory, then the mounting plates have to be raised the distance of the rise, usually 1 in. to 2 in. Also, be sure that the side of the back panel does not interfere with function of the upper extremity.

After the Parapodium has been fitted, it is assembled permanently and the knee cutouts are smoothed.

(a) The knee bar sleeve is lubricated with Vaseline, and the nylon washer is inserted under it. This washer is needed because it prevents the brace from squeaking.

(b) Insert the knee joints, with the bar and washer, into the shin-tube section, drill a 1/8-in. hole for a pop rivet about 1/2 in. from the top of the tube, and pop-rivet together.

(c) Insert the thigh sections (upper part of the brace) into the knee joints and fold the brace into a sitting position; drill a 1/8-in. hole and pop-rivet the thigh section in place.

(d) Stretch the elastic back strap and fasten with a pop rivet.

(e) Straighten and fold the brace a few times to check for stiffness and joint misalignment.

Step 17 (fig. 20). Put the brace on the patient and check the alignment. Optimal alignment is achieved when the patient (without crutches, hands on sides) can almost balance on a quarter-inch dowel. The footplate is divided into three equal parts, and the dowel is placed at the junction of the front one-third and the back two-thirds.

If adjustment in alignment is needed (fig. 21), it is accomplished by tightening one alignment-block nut and loosening the other. The alignment blocks can be rotated, and inclining the brace with a patient in it should always be done to the cutaway side of the block.

Step 18. Crutchless standing in the assembled brace is now possible, but should not be forced on the patient; it will come with time. From now on, wearing tolerance should be built up gradually and activities increased.

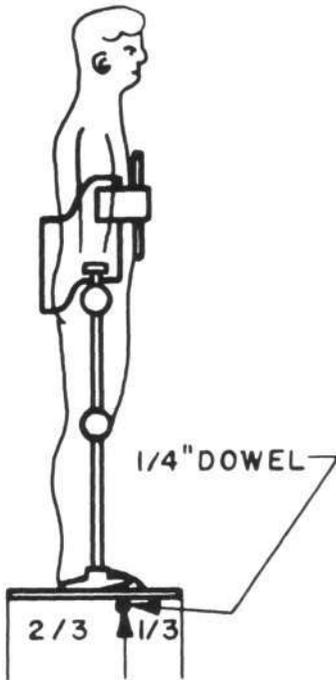


Fig. 20.

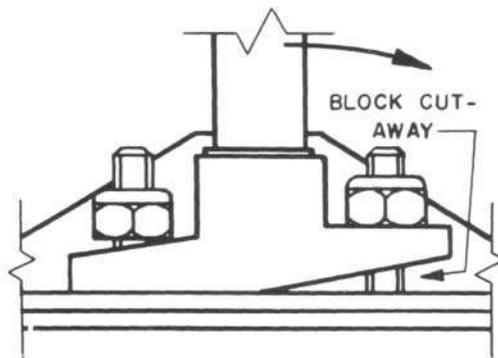


Fig. 21.

ORTHOTIC CHECK-OUT

A form such as is shown in figure 22 can be used for the orthotic check-out.

ORTHOTIC EVALUATION CHART

PATIENT'S NAME: AGE:

Type of Orthotic Device:

Standing Brace Parapodium Reciprocal Gear Box....
 Paraplegic Brace - Cord & Pulley....

OTHER

1. ON-OFF TEST - Done by patient..... Others.....

	<u>mins.</u>	<u>secs.</u>		<u>mins.</u>	<u>secs.</u>
Shoes on	.....	.....	Unlock on floor	.....	.....
Brace off	.....	.....	Brace off	.....	.....
Lock on floor	.....	.....	Shoes off	.....	.....
			Total Time Taken:	.....	.....

2. STAND-TO-STAND TEST

	<u>mins.</u>	<u>secs.</u>
From standing to rigid position on chair	.....	.....
Rigid on chair to unlock	.....	.....
Back to rigid to lock	.....	.....
From locking to standing

3. STABILITY TEST

Front...degrees	Back...degrees	Right...degrees	Left...degree
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4. MOBILITY TEST

Time to walk 10 yds.mins.secs.

Specify gait: swing to Specify walking
 swing through.... aid: parallel walker
 reciproca' H-frame
 pivoting Crutches

5. PRESSURE TEST (Highest recorded pressures in psi)

Front panel	Right Hip	Right Knee	Right Heel
Sacral area	Left Hip	Left Knee	Left Heel

6. WEIGHT TEST

Weight of shoes:

Weight of brace (without shoes)
 divided by:

Weight of patient _____ =

Date: Evaluation Supervisor

Fig. 22. A form suitable for recording orthotic-evaluation information.



Fig. 23.

Figure 23 shows a tipping platform that is used for objectively measuring and comparing the stability of lower-extremity orthotics while they are being worn.

A pressure-sensing device, if used routinely, significantly reduces trouble spots by detecting excessive pressure before it causes breakdown of the desensitized skin.

The Parapodium is aligned properly if the patient can tolerate the same number of degrees to the left as to the right, and about one-third forward as compared to two-thirds backward. In this way, the brace is equally stable towards either side, but it is about 30% easier to fall forward than backward, thus facilitating swing-through gait with the use of crutches.

ADAPTATIONS

LEG-LENGTH DISCREPANCY

Sometimes it is necessary to build up the footplate and to change the height of the toe and heel clamp to accommodate leg shortening. A Plastazote (TM) block equal to the shortening is glued to the base plate. The shoe is placed on it, and the clamps are then modified (fig. 24) to hold the shoes in place.

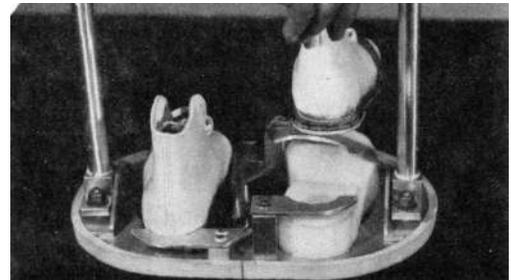


Fig. 24.

SIGNIFICANT PLANTAR FLEXION

There are two ways of dealing with this problem. If possible, wedged Plastazote shoe inserts should be fabricated and glued in as insoles. However, if the plantar flexion is too great for insoles, a combination of insole wedge and outside wedge can be used. A wedge of Plastazote, with a proper slope, is glued to the base plate, and the heel clamp is raised by lengthening the heel-clamp post.

KNEE HYPEREXTENSION

If the knee has a tendency to go into hyperextension, a 2-in. webbing with Velcro should be used for control. Velcro hooks are pop-riveted to the front of the knee crossbar, and Velcro pile, with a strap, is placed around the back to the front (fig. 25).

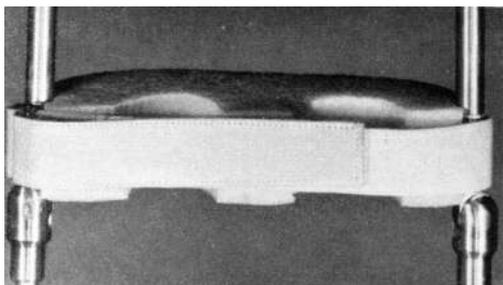


Fig. 25.

HIP AND KNEE INSTABILITY

Some children find it difficult to extend their brace prior to locking. A doubled 1-in. elastic strap is riveted to the most anterior point of the knee bar and the most posterior point of the back panel. The strap runs medially to the sidebars, anterior to the knee joint, and posterior to the hip, and is riveted while stretched (fig. 26).

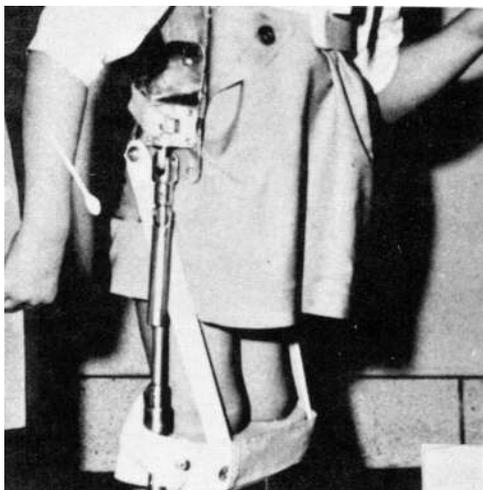


Fig. 26.

TRUNK HYPEREXTENSION

A 2-in. webbing strap is useful in extending the back panel before locking, and it should be put on routinely. It should be riveted as high as possible to the side supports of the back panel. Also, it prevents the patient from hyperextending his trunk while standing (fig. 27).

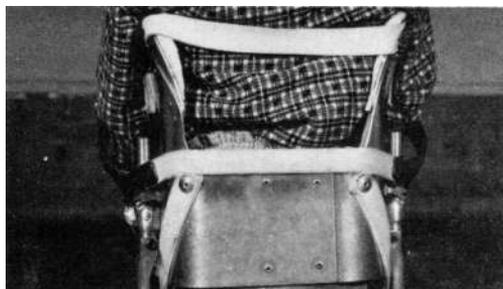


Fig. 27.

SPINAL DEFORMITIES

Severe deformities of the trunk and pelvis cannot be satisfactorily fitted with the two-half-type back panel that is supplied in the Parapodium kit. Instead, a molded body jacket should be used.

With the patient sitting, a plaster-of-paris wrap of the trunk and pelvis is made. Both sides of the wrap must be flat and parallel.

A polyester-laminate lay-up can be molded on the plaster positive (fig. 28), or a vacuum-formed jacket can be made (fig. 29).

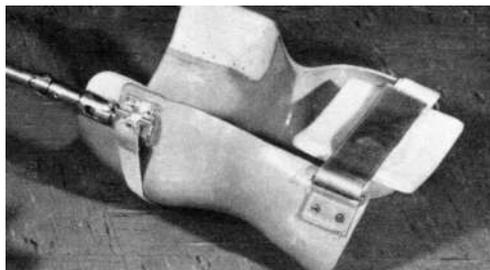


Fig. 28.

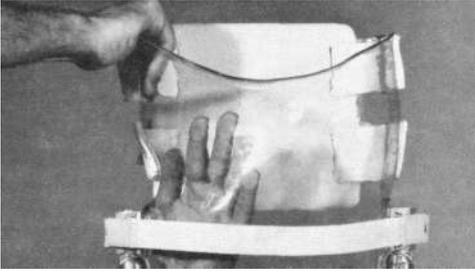


Fig. 29.

Lately we have been vacuum-forming jackets out of a transparent polycarbonate plastic, Lexan (TM), because the fit can be checked very carefully (4). The side mounting plate and front panel are removed from the panels that come with the kit and are transferred to the molded jacket (fig. 30).

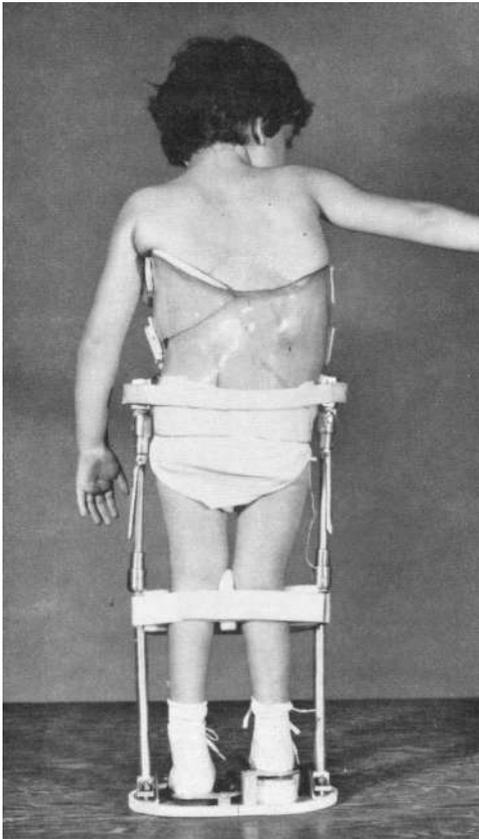


Fig. 30.

When the patient is not able to sit up without leaning to one side, the lower edge of the body jacket can assist him to maintain sitting balance. The lower edge of the back panel touches the sitting surface, thereby providing a reaction point on each side of the thorax that helps the trunk to remain upright.

OTHER MODIFICATIONS

SHOES

When the lateral border of the shoe is touching the rib of the alignment unit, the lateral side of the sole of the shoe is sanded down until the shoes fit well into the footplate.

HEEL AND TOE SPRING

When the patient is rolling on the floor in the brace, occasionally the shoes will come out because the spring is not strong enough. In this event, the spring should be shortened, but not too short, so as to prevent the patient from clamping his shoes independently.

ROTATION STRAPS AND WEDGES

Uneven hip contractures can cause pelvic rotation, and a 2-in. webbing strap with Velcro can help. If, for instance, the left hip is contracted more than the right, the pelvis will rotate to the left. A padded strap that is riveted to the inside surface of the back panel on the right side and taken to a loop on the left side will tend to counteract the rotation. The padding over the iliac spines should be Plastazote glued to the inside of the strap.

To correct rotation of the trunk, the same principles are applied. In this case, the front panel strap is riveted to the inside support of the back panel.

BACK PANEL

Anterior-Posterior Instability

Patients who have difficulty sitting up without falling forward or backward can be assisted in two ways. The most common and effective method is to shape the back panel so that the lower lateral sides have substantial anterior extension and can then act

as a 90-degree stop for the back panel. The second method is to supply them with 90-degree hip locks.

Protruding Coccyx

A cutout in the back panel, lined with Plastazote, relieves the pressure. In the case of one of our patients, before the cutout was made, a pressure reading of 35 psi was recorded.

FRONT PANEL

Instability of the Upper Thorax

With a high thoracic myelomeningocele, it is often difficult to prevent the head and shoulder from falling forward. A modified front panel with shoulder straps on the brace can help.

Lordosis

An enlarged version of the front panel with an extra set of lower straps might have a beneficial effect, but on the mobile curvature only.

Ileostomy

The front panel can be modified to accommodate an ileostomy conduit.

HANDLES

Handles are used to rotate the whole upright section; a 90-degree rotation locks and unlocks the brace. *Note:* The patient should never unlock the brace while standing; he should lie on the floor or sit in a chair first, then turn the handles to unlock the brace. If the brace unlocks inadvertently while the patient is walking, the direction of the knee

axes should be checked (fig. 31). Also, the elastic strap of the back panel should be shortened.

As shown in figure 31, if a ruler is placed on the flat of the knee joint, there should be a 1/4-in. to 1/2-in. space between the ruler and the other joint body.

ORDERING KITS

At the present time, the Parapodium is being manufactured in four children's sizes: no. 603319, "super small," shoe length 5 1/2 in. to 6 1/2 in.; no. 603320, "small," shoe length 6 1/2 in. to 7 1/2 in.; no. 603321, "medium," shoe length 7 1/2 in. to 8 1/2 in.; and no. 603338, "large," shoe length 8 1/2 in. to 9 1/2 in.

It is anticipated that various adult sizes of this device will be produced in the future.

NOTE: When ordering a Parapodium kit, obtain a pair of properly fitted lace-toe boots and measure the length of the sole in inches. This measurement determines the size of the kit. Once the shoe length (in inches) is given to the ordering department, the other parts can be selected.

Extra aluminum tubing (AL 2024T4) for lengthening the upright bars should be kept in stock: shin section ID 1/2 in., OD 5/8 in.; thigh section ID .430 in., OD 1/2 in.

Further information can be obtained from: Orthotic Research and Development Project, Spina Bifida Unit, Ontario Crippled Children's Centre, 350 Rumsey Road, Toronto 350, Ontario, Canada.

ACKNOWLEDGMENTS

My sincere thanks to Dr. N. C. Carroll, Dr. J. R. Corless, Dr. G. J. Lloyd, and Dr. C. A. McLaurin, and to all patients and staff who so generously helped to make this project possible.

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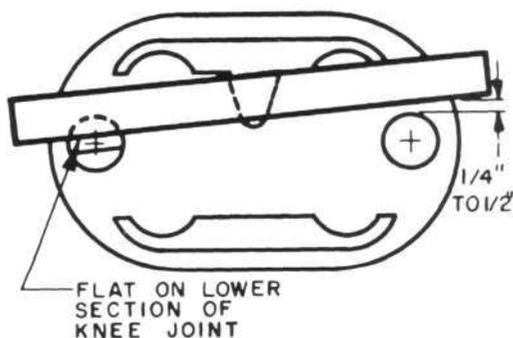


Fig. 31.

Book Review

Amputationen der unteren Extremität

("Amputations of the Lower Extremities, Operative Technique and Immediate Postsurgical Prosthetic Fitting"). By Rolf Dederich. Introduction by Helmut Rossler. Paperbound, 152 pages, 126 illustrations. Stuttgart: Georg Thieme Verlag, 1970.

Dr. Dederich presents a rather extensive review of the history of amputations, prosthetics, and immediate postsurgical prosthetic fitting, and he reports on various techniques and systems developed from early times through to the present day.

The various types of stump problems are discussed along with the techniques of amputation surgery, including a detailed description of muscle-stabilization procedures. All major levels of lower-extremity amputations are presented and supplemented by detailed line drawings and illustrations. Myodesis and osteoplasty receive extensive discussion, and detailed coverage is given to the handling of skin, muscle, bone and

periosteum, nerves, and blood vessels. The author does not limit his writing to personal experiences only, but includes a critical review of earlier works by others in the fields of amputation surgery, patient management, and prosthetics.

A section on modern patient management by immediate postsurgical prosthetic fitting techniques for above- and below-knee amputations is supplemented with a detailed review that analyzes results of the particular form of treatment in 118 amputees. The detailed historical review points out the various early endeavors in developing immediate postsurgical prosthetic fitting.

The author adds to the scientific and technical value of the book by the interjection of several humorous anecdotes and personal experiences, which makes for informative and interesting reading for individuals other than those interested for strictly professional reasons.

This book is indeed a very fine contribution, one which should be of major interest to those active in the medical-paramedical profession, specifically those dealing with today's amputees—their needs, requirements, and rapid, effective rehabilitation.—*Joseph H. Zettl, C.P., and Ernest M. Burgess, M.D.*

News and Notes

Prosthetics-Orthotics Education

University of California, Los Angeles

The Prosthetics-Orthotics Education Program schedule of courses for 1971-72 is:

For physicians and therapists:

Prosthetics-Orthotics for Physicians, X-482; *Prosthetics-Orthotics for Therapists*, X-481: Dec. 6-17, 1971; Mar. 13-24, Apr. 10-21, June 5-16, 1972

For rehabilitation personnel:

Prosthetic-Orthotic Rehabilitation, M-840: Jan. 12-14, Feb. 23-25, May 24-26, 1972

For prosthetists, orthotists, and certificate students:

Prosthetic Orientation for Certificate Students, X-422**: Aug. 30-Sept. 10, 1971

Upper-Extremity Prosthetics, X-468: Sept. 13-Oct. 15, 1971

Special Clinical Problems in Upper Extremities, X-468.1** *: Oct. 18-22, 1971

Below-Knee Prosthetics, X-480-A: Oct. 25-Nov. 19, 1971

Special Clinical Problems, Upper-Extremity and Below-Knee Prosthetics, X-480.1* *: Nov. 22-Dec. 17, 1971

Below-Knee Prosthetics, X-480-B*: Nov. 22-Dec. 17, 1971

Above-Knee Prosthetics, X-463-A: Jan. 3-Feb. 4, 1972

Special Clinical Problems, Upper-Extremity, Below-Knee, Above-Knee Prosthetics, X-463.1* *: Feb. 7-Mar. 17, 1972

Above-Knee Prosthetics, X-463-B*: Feb. 7-Mar. 10, 1972

Hip Disarticulation and Syme Prostheses, X-486: Mar. 20-Apr. 7, 1972

Orthotic Orientation for Certificate Students, X-422**: Apr. 17-21, 1972

Lower-Extremity Orthotics, X-485: Apr. 24-May 19, 1972

Child-Amputee Prosthetics, X-469: May 22-26, 1972

Special Clinical Problems, Lower-Extremity Orthotics, X-485.1** *: May 30-June 9, 1972

Upper-Extremity Orthotics, X-476: June 19-23, 1972

Final examinations for certificate students: June 26-28, 1972

Applications can be obtained upon request to: University of California Prosthetics-Orthotics Education Program, 1000 Veteran Ave., Room 22-46, Los Angeles, Calif. 90024.

* Not for certificate students

** Certificate students only

New York University

The Post-Graduate Medical School schedule of courses in prosthetics and orthotics for 1971-72 is:

For physicians and surgeons:

Lower-Extremity Prosthetics, 741: Oct. 11-16, Nov. 15-20, 1971; Mar. 6-11, May 15-20, 1972

Upper-Extremity Prosthetics and Orthotics, 744: Dec. 13-17, 1971; Apr. 10-14, 1972

Lower-Extremity Orthotics, 751: Oct. 4-8, 1971; Mar. 20-24, Apr. 24-28, 1972

Spinal Orthotics, 755: Dec. 1-3, 1971; Mar. 1-3, May 24-26, 1972

For therapists:

Lower-Extremity Prosthetics, 742: Sept. 13-24, Nov. 1-12, 1971; Jan. 17-28, May 1-12, 1972

Lower-Extremity Orthotics, 752: Oct. 4-8, 1971; Mar. 20-24, Apr. 24-28, 1972

Upper-Extremity Prosthetics, 745: Dec. 6-11, 1971; Apr. 3-8, 1972

Upper-Extremity Orthotics, 757: Feb. 7-11, Apr. 10-14, 1972

For prosthetists:

Above-Knee Prosthetics, 743: Oct. 11-29, 1971; June 5-23, 1972

Below-Knee Prosthetics, 740: Aug. 30-Sept. 17, 1971; Jan. 3-21, 1972

Advanced Below-Knee Prosthetics, 7402: Jan. 24-29, 1972

Upper-Extremity Prosthetics, 746: Nov. 8-19, 1971; May 1-12, 1972

Immediate and Early Postsurgical Prosthetics, 7401: June 26-30, 1972

For orthotists:

Lower-Extremity Orthotics, 753: Sept. 20-Oct. 1, Dec. 13-23, 1971; Feb. 22-Mar. 3, 1972

Advanced Lower-Extremity Orthotics, 7531: Oct. 4-8, 1971; Mar. 6-17, 1972

Spinal Orthotics, 756: Nov. 29-Dec. 10, 1971; Mar. 27-Apr. 7, May 15-26, 1972

Upper-Extremity Orthotics, 758: Feb. 7-18, Apr. 10-21, 1972

Requests for further information should be addressed to Dr. Sidney Fishman, Prosthetics and Orthotics, New York University Post-Graduate Medical School, 550 First Avenue, New York, N.Y. 10016.

Dr. Sidney Fishman, Program Director of Prosthetics and Orthotics at New York



The scientific exhibit "Bioengineering Research Application in Lower-Extremity Orthotics" was awarded the Certificate of Merit at the 1971 annual meeting of the American Medical Association in Atlantic City, N.J. Previously, the exhibit won a Gold Medal at the 1970 annual meeting of the American Congress of Rehabilitation Medicine in New York.

University, was appointed chairman of the Education Committee of the International Society for Prosthetics and Orthotics (ISPO) at its founding meeting in Rungsted, Denmark. The committee, whose members will be representative of prosthetic-orthotic interests throughout the world, is charged by the organization's constitution and by-laws with conducting international teaching programs initiated by ISPO and by other organizations in cooperation with the society.

The New York University Post-Graduate Medical School organized and pro-

vided the major faculty for three courses in prosthetics and orthotics at the Centro de Medicina de Reabilitacao, Alcoitao-Estoril, Portugal—the foremost rehabilitation facility in that country. The invitation was extended by the medical director, Dr. Victor M. Santana Carlos.

On July 5, 1971, a two-week course in "Lower-Extremity Prosthetics for Prosthetists" included a review and updating of fitting principles and procedures for above- and below-knee prostheses. This was followed on July 19 by a three-week basic course in "Lower-Extremity Orthotics for Orthotists," which also included instruction in newly developed "insert-brace" techniques.

On July 15, a formal course in "Lower-Extremity Prosthetics for Physicians and Surgeons" was offered in Portugal for the first time. This three-day course emphasized procedures for immediate and early postsurgical prosthetic management and included amputation surgery; normal and pathological locomotion; biomechanics; prosthetic components; fitting, alignment, and suspension of above- and below-knee prostheses; and prescription and evaluation principles. Special attention was given to the quadrilateral socket for the above-knee amputee and the patellar-tendon-bearing prosthesis, and its variants, for the below-knee amputee.

The visiting faculty consisted of Dr. Sidney Fishman, Warren Springer, Ivan Dillee, Dr. Leon Kruger, and Clauson England.

Northwestern University

The Northwestern University Medical School Prosthetic-Orthotic Center schedule of courses for 1971-72 is:

For prosthetists:

Above-Knee Prosthetics, 601: Oct. 18-Nov. 5, 1971; July 17-Aug. 4, 1972
Below-Knee Prosthetics, 611: Mar. 13-31, June 12-30, 1972
Management of the Juvenile Amputee, 631: Nov. 15-18, 1971; May 15-18, 1972
Review Course in Prosthetics, 641: May 10-12, 1972
Upper-Extremity Prosthetics, 661: Jan. 10-28, 1972

For orthotists:

Spinal Orthotics, 701: Mar. 27-Apr. 7, 1972
Lower-Extremity Orthotics, 711: Mar. 6-17, 1972
Upper-Extremity Orthotics, 721: Nov. 29-Dec. 10, 1971
Review Course in Orthotics, 731: June 6-8, 1972
Advanced Plaster and Plastic Orthotic Techniques, 741: Dec. 13-17, 1971
Fitting and Fabrication of the Milwaukee Brace, 751: June 12-23, 1972

For rehabilitation counselors:

Orientation in Prosthetics and Orthotics, 640: Nov. 1-4, Nov. 29-Dec. 2, 1971; Feb. 7-10, Apr. 3-6, 1972

For therapists:

Lower-Extremity Prosthetics, 622: Sept. 13-17, Sept. 27-Oct. 1, Oct. 11-15, Nov. 8-12, Dec. 6-10, 1971; Feb. 14-18, Feb. 28-Mar. 3, Apr. 10-14, May 1-5, June 12-16, 1972

Management of the Juvenile Amputee, 632: Nov. 15-18, 1971; May 15-18, 1972

Upper-Extremity Prosthetics and Orthotics, 652: Nov. 1-5, Nov. 29-Dec. 3, 1971; Feb. 7-11, Mar. 27-31, Apr. 3-7, 1972

Lower-Extremity and Spinal Orthotics, 722: Oct. 18-22, 1971; Feb. 21-25, Apr. 17-21, May 8-12, 1972

For physicians and surgeons:

Lower-Extremity Prosthetics, 623: Sept. 13-17, Sept. 27-Oct. 1, Oct. 11-15, Nov. 8-12, Dec. 6-10, 1971; Feb. 14-18, Feb. 28-Mar. 3, Apr. 10-14, May 1-5, June 12-16, 1972

Management of the Juvenile Amputee, 633: Nov. 15-18, 1971; May 15-18, 1972

Review Course in Prosthetics and Orthotics, 643: June 5-7, 1972

Upper-Extremity Prosthetics and Orthotics, 653: Nov. 1-5, Nov. 29-Dec. 3, 1971; Feb. 7-11, Mar. 27-31, Apr. 3-7, 1972

Lower-Extremity and Spinal Orthotics, 723: Oct. 18-22, 1971; Feb. 21-25, Apr. 17-21, May 8-12, 1972

For nurses:

Management of the Amputee, 644: June 5-7, 1972

Requests for further information should be addressed to Charles M. Fryer, M.A., Director, Prosthetic-Orthotic Center, Northwestern University Medical School, 401 East Ohio St., Chicago, Il. 60611.

Committee on Prosthetic-Orthotic Education

Reorganization of CPOE

At the annual meeting of the Committee on Prosthetic-Orthotic Education held in Washington, D.C., on May 18, 1971, a proposal for reorganization of the Committee on Prosthetic-Orthotic Education (CPOE) was presented to the members. The proposal read in part:

In order that the Committee on Prosthetic-Orthotic Education (CPOE) may more effectively and efficiently accomplish its mission, it is proposed that its organizational structure be changed to one that is more adaptive and more readily responsive to changing needs.

It can be seen that certain drawbacks are inherent in an organization strongly supported by subcommittees, and that a major contributing factor is the permanent nature of the subcommittees. It appears that the formation of transient committees to accomplish specific tasks would offer certain advantages and that a project- or problem-oriented organization should be considered.

In view of these (and other) considerations, it is proposed that:

1. The Subcommittee on Prosthetics Clinical Studies, the Subcommittee on Orthotics, the Subcommittee on Publications and Educational Materials, and the Subcommittee on Special Education Projects in Prosthetics and Orthotics be dissolved;

2. The parent committee assume responsibilities currently assigned to the subcommittees, unless otherwise delegated;

3. Task forces or projects teams be formed, as required, to pursue specific major endeavors, and that (a) the task-force leader be directly responsible to CPOE, and (6) the ad hoc group be disbanded upon completion of its task.

The proposal was unanimously approved by the members of CPOE. The chairman, Herbert E. Pedersen, M.D., pointed out that CPOE members must now assume increased responsibility in planning and guiding the program of activities, and he expressed appreciation to the subcommittees and their chairmen for the splendid contribution they had made to the CPOE program.

Standardization of Prosthetic-Orthotic Terminology

CPOE, in cooperation with several other groups, has initiated a project directed toward standardization of prosthetic and orthotic terminology. Development of terminology lists has been attempted by many separate groups at different times, but none has been universally accepted as standard. In the meantime, disparity in the use of terms has led to misunderstanding and confusion in clinical situations, in educational endeavors, and in the area of costs and payments of various devices, particularly in connection with Medicare, Medicaid, and similar programs. This situation, along with the prospective publication of a rewritten *Orthopaedic Appliances Atlas* by the Committee on Prosthetics and Orthotics, American Academy of Orthopaedic Surgeons, created an urgent need for a solution to this dilemma.

A Task Force on Standardization of Prosthetic-Orthotic Terminology, with Jacquelin Perry, M.D., as chairman, was established this spring. Represented on the task force are the American Orthotic and Prosthetic Association—American Board for Certification, the Veterans Administration, the University Council on

Prosthetic-Orthotic Education, the American Academy of Orthopaedic Surgeons, the Social and Rehabilitation Service (DHEW), the Committee on Prosthetics Research and Development, and the Committee on Prosthetic-Orthotic Education.

At the first workshop, held in Dallas, Texas, on March 28-30, 1971, Dr Perry proposed the following goals in development of standard terminology: (1) to establish a master prosthetic and orthotic nomenclature system with a functional and anatomical orientation designed for current use, but sufficiently flexible to allow for future development; (2) to classify and define basic prostheses and orthoses; (3) to develop subclassifications for the purpose of identifying differences in function, materials, and design; (4) to define terminology as derived from the master system and its subclassifications; and (5) to incorporate terms and definitions in a prosthetic-orthotic glossary.

Members of the task force who participated in the Dallas workshop were:

Panel on Prosthetics Terminology

Frank W. Clippinger, Co-Chairman
 Robert G. Thompson, Co-Chairman
 Joseph M. Cestaro
 John E. Eschen
 Henry Gardner
 Frederick L. Hampton
 Warren Springer
 Keith Vinnecour

Panel on Orthotics Terminology

Arthur Guilford, Chairman
 Norman Berger
 Clauson F. England
 Robert E. Fannin
 Charles Fryer
 William J. McDmurray
 Paul R. Meyer, Jr.
 Clyde L. Nash, Jr.
 Harold W. Smith

Review Group

E. E. Harris
 Herbert E. Pedersen
 James E. Smith
 Anthony Staros
 A. Bennett Wilson, Jr.

Recorders

Herbert B. Warburton
 Barbara R. Friz

Arthur Guilford, Harold Smith, Robert Fannin, William McIlmurray, and Clauson

England, members of the Panel on Orthotics Terminology, met again for three days in Minneapolis, Minnesota, on May 22-24. The entire task force will reconvene in early fall, 1971.

Educational Program for Surgeons

The Ad Hoc Committee on Educational Programs for Surgeons, CPOE, met at New York University on June 10, 1971, for the purpose of discussing a proposed short course in prosthetics for general surgeons. Present were Richard Warren, M.D., chairman; Sidney Fishman, Ph.D.; Charles Fryer; and Warren Springer. Dr. Warren pointed out the long-felt need for such a course and noted that most of the lower-extremity amputations in this country are performed by surgeons with no training in prosthetic rehabilitation.

Dr. Warren is working with the various surgical societies to stimulate interest and seek their support.

"Amputee Census" to be Repeated

The survey study implemented ten years ago known as the "Amputee Census" will be repeated as a joint effort of CPOE and the American Orthotic and Prosthetic Association (AOPA). The first study yielded findings that significantly influenced the emphasis in instruction, particularly in the area pertaining to surgical practice for amputees with vascular disease. Representatives from both CPOE and AOPA appeared at the 1971 AOPA regional meetings to encourage prosthetists' participation in the study.

Publications

The recently published monograph *The Geriatric Amputee: Principles of Management* is a consolidation of papers developed from the proceedings of a workshop sponsored by the Committee on Prosthetic-Orthotic Education; 82 pages; 21 illustrations; available from the Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418. Price: \$3.50. With this monograph, CPOE hopes to reach surgeons who perform amputations on elderly

patients with vascular disease. Most surgeons have not been exposed to, or are unaware of, the implications for rehabilitation of these amputees. Consequently, the importance of conservative amputation is not fully recognized, and optimal rehabilitation for many is not achieved. This monograph outlines the basic principles in management of geriatric amputees, starting with the preoperative period and continuing through the rehabilitative process. A convincing case is made for saving the knee joint in most amputations for gangrene.

Published by CPOE this spring were supplements to the annotated bibliographies *Amputees, Amputations, and Artificial Limbs and Braces, Splints, and Assistive Devices*. The bibliographies cover published articles on prosthetics and orthotics for 1969-70 and supplement earlier ones which covered 1956-68. All bibliographies have been distributed to schools of medicine, physical therapy, occupational therapy, social work, prosthetics, or orthotics.

Also published was the roster *Amputee Clinics in the United States and Canada—1971*. The roster includes the names, types, and locations of the clinics, names of clinic chiefs, and clinic schedules, and identifies the specialties represented or available at clinic sessions.

CPOE Meeting

Members who attended the CPOE meeting held in Washington, D.C., on May 18, 1971, were Herbert Pedersen, chairman, William M. Bernstock, Clinton L. Compere, Jacquelin Perry, Lena M. Plaisted, Augusto Sarmiento, Roy Snelson, Walter A. L. Thompson, and Richard Warren. Guests included Dudley S. Childress, Mary Dorsch, Sidney Fishman, Victor H. Frankel, Hector W. Kay, Colin A. McLaurin, Eugene F. Murphy, Clarke Russ, Patricia H. Serling, Robert E. Stewart, Joseph E. Traub, Herbert E. Warburton, and A. Bennett Wilson, Jr. From the National Academy of Sciences—National Research Council were Charles L. Dunham, M.D., chairman of the Division of Medical Sciences; Barbara R. Friz, ex-

ecutive secretary of CPOE; Charlotte L. Cranmore; and June D. Newman.

Dr. Pedersen presented reports of the activities of the committee and its subcommittees for the fiscal year 1970-71. All reports were accepted.

A proposal for reorganization of the CPOE was presented and adopted unanimously by the members. Inasmuch as the change in organization would abolish all standing subcommittees, it was agreed that the committee now had authority to reconstitute any group, retaining membership as indicated.

The following activities were discussed and approved by the committee members for fiscal year 1971-72: (1) continuation of the project on standardization of prosthetic and orthotic terminology; (2) the educational program for general surgeons; (3) continuation of the literature-retrieval systems project; (4) repeat of the "Amputee Census"; (5) exploration to determine feasibility of sound-slide program in prosthetics and orthotics; (6) exploration of various systems of recording, storing, and retrieving clinical information; and (7) continuation of CPOE publications.

Committee on Prosthetics Research and Development

Workshop on Fracture Bracing

The Second Workshop Panel on Cast-Bracing of Fractures was held at Fitzsimons General Hospital, Denver, Colorado, on January 27-28, 1971. The program was organized to determine the current status of cast-bracing procedures for fractures of the tibia and femur. Robert G. Thompson, M.D., served as chairman.

Papers were presented by Augusto Sarmiento, M.D., and William Sinclair, C.P.O.—"Tibial Fractures"; Paul W. Brown, M.D.—"The Early Weight-Bearing Management of Tibial Fractures, Open and Closed"; Vert Mooney, M.D.—"The Use of Cast-Brace for Tibial Fractures"; Robert G. Addison, M.D.—"Experiences at Northwestern University"; John Connolly, M.D.—"The Management of Open Tibial Fractures"; Ernst Dehne,

M.D.—"Weight-Bearing Treatment of the Fractured Tibial"; Philip A. Deffer, M.D.—"Treatment of Fractures of the Shaft of the Tibia by Immediate Ambulation"; Augusto Sarmiento, M.D., and William Sinclair, C.P.O.—"Femoral Fractures"; William E. Burkhalter, M.D.—"Experience with Brace Cast for Femoral Fractures"; Paul W. Brown, M.D.—"Cast-Bracing for Fractured Femurs"; Vert Mooney, M.D., Vernon L. Nickel, M.D., J. Paul Harvey, Jr., M.D., and Roy Snelson, C.P.O.—"Cast-Brace Treatment for Fractures of the Distal Part of the Femur"; Robert G. Thompson, M.D., "Cast-Bracing"; John Connolly, M.D.—"The Evaluation and Use of Early Cast-Brace Ambulation for Femoral Shaft Fractures"; Ernst Dehne, M.D.—"Cast-Brace for Treatment of Fresh Fracture of the Femur and Other Conditions"; and Philip A. Deffer, M.D., Ira A. Roschelle, M.D., and Floyd G. Goodman, M.D.—"The Management of Fractures of the Femur by Early Ambulation Utilizing a Minispica Cast-Brace."

The workshop report, *Cast-Bracing of Fractures*, has been published and distributed.

Subcommittee on Sensory Aids

The sixth meeting of the Subcommittee on Sensory Aids was held in Annapolis, Maryland, on February 26-27, 1971. The primary objective was to consider the status of present research efforts and make recommendations for future work.

The members of the subcommittee and invited participants were divided into groups and asked to develop position papers on six subjects: mobility aids, independent reading of inkprint, braille developments, other communications for the disabled (closed-circuit TV readers; aids for the hard-of-hearing, deaf, and deaf-blind), vision prostheses, and education, training, and vocational evaluation.

A report is presently being prepared for publication. Of especial interest is the unanimous recommendation for the establishment of a formal evaluation program for the various devices that are now becoming

available as a result of many years of research and development.

Cosmesis and Modular Limb Prostheses Conference

The Committee on Prosthetics Research and Development sponsored a Conference on Cosmesis and Modular Limb Prostheses in San Francisco, California, on March 3-7, 1971. James B. Reswick, Sc.D., served as chairman.

The objectives of the conference were: (1) to provide an environment in which interested people could discuss mutual problems and goals in cosmesis and modular limb prostheses, (2) to establish international standards, insofar as possible, that would permit the use of components and systems interchangeably, and (3) to delineate areas in which research is needed for the improvement of cosmetic, modular prostheses for limb amputees.

The conference discussions, recommendations, and agreements have far-reaching implications for future practice and research in prosthetics throughout the world. In summary, it was generally agreed that:

1. Modular, endoskeletal systems for upper- and lower-extremity prostheses offer definite advantages in function and cosmesis over existing, conventional systems.

2. Research and clinical practice should be directed toward the use of modular endoskeletal systems.

3. Modular endoskeletal prostheses provide both function and cosmesis, although to maximize one is to compromise the other.

4. Cosmesis is important, regardless of the function desired in a prosthesis; an immediate, major effort should be directed toward improving cosmetic coverings.

5. The metric system should be adopted internationally as soon as possible.

6. International standards and agreements should be adopted as soon as possible that would allow the exchange of systems and components between manufacturers and countries and encourage wider distribution of prostheses in needy countries.

7. CPRD should coordinate these efforts

in the United States, and ISPO should coordinate these efforts internationally.

Committee on Prosthetics Research and Development Meeting

The twenty-second meeting of the Committee on Prosthetics Research and Development was held at the National Academy of Sciences on May 17, 1971. Because the activities of CPRD and the Committee on Prosthetics-Orthotics Education are so closely related, the CPRD meeting was scheduled just prior to the meeting of CPOE in order to facilitate attendance at both meetings by members of both committees.

Progress reports were given by the chairman of the subcommittees on fundamental studies, design and development, evaluation (see below), child prosthetics problems, and sensory aids. In the discussion that followed each of the presentations, the importance of involving education groups in all phases of the research and development program to close the gap between research and application was brought out repeatedly.

A round-table discussion was held in the evening. Though no formal action was taken, it was the consensus that CPRD should expand its role to include internal structural prostheses.

Subcommittee on Evaluation

The following is a summary of the activities of the Committee on Prosthetics Research Subcommittee on Evaluation from July 1, 1970, through June 30, 1971.

Three projects were completed during the year.

Evaluation of Synthetic Batata for Fabricating Sockets for Below-Knee Amputations Stumps. Studies and trials of the use of the synthetic balata Polysar X-414 (TM) for on-stump fashioning of sockets, using a technique developed at the Veterans Administration Prosthetics Center, New York, were conducted at five clinics: Rancho Los Amigos Hospital, Duke University, the University of Miami, the Veterans Hospital in Los Angeles, and the Veterans Hospital in Buffalo, N.Y. Initial experiences in

1968 and early 1969 revealed problems in obtaining satisfactory fittings, particularly on short stumps. This resulted in the developer revising the molding procedure.

Conclusions and recommendations: (1) synthetic balata is a suitable material for rapid fabrication of below-knee sockets, which can then, within limits, be adjusted and refitted; (2) this material and the VAPC technique are appropriate for fabrication of the temporary below-knee sockets being financed by state and federal agencies; and (3) the technique should be included in the curricula of all below-knee prosthetics courses.

Implementation: Details of the technique have been published in the *Bulletin of Prosthetics Research* and in CPRD Report E-3, prepared by A. Bennett Wilson, Jr., May 1970.

Significance of evaluation: The experience of the evaluation teams pointed out the necessity of revising the procedure, which was initially thought by the developer to be satisfactory.

Veterans Administration Prosthetics Center Patellar-Tendon-Bearing Brace, Clinical Application. This project involved evaluation of a fabrication technique for a proximal-weight-bearing below-knee brace. An instruction manual was available, this having been prepared by VAPC, who had submitted a favorable report of the technique.

CPRD involvement was started in 1967, with five clinics participating: the University of Alabama; Goldwater Memorial Hospital, New York; the University of Miami; Rancho Los Amigos Hospital; and the Rehabilitation Institute of Chicago. Local problems at several of these institutions required postponement of completion. The clinical study was reactivated in early 1970 to include the experience of the University of Alabama and Duke University. Results were obtained from fittings on 34 patients. A substitute fabrication technique had been developed at Duke University that appeared to have merit.

Conclusions and recommendations: (1) the patellar-tendon-bearing brace is an effective and applicable device for the

treatment of delayed union or nonunion of fractures and arthodeses in the distal leg and the foot, and for treatment of otherwise intractable, chronic pain arising from traumatic arthrosis, osteomyelitis, fracture of the os calcis, and the like; (2) results of the study should be disseminated by publication; (3) the prosthetics-orthotics schools should be encouraged to include this item in their lower-extremity orthotics curricula; and (4) a new fabrication manual should be prepared by collaboration of VAPC and Duke University.

Implementation: The study was described in CPRD Report E-2, prepared by Hector W. Kay, November 1970.

Significance of evaluation: Modification of the original technique by an evaluating clinic, which appeared to be a substantial improvement over the developer's original protocol.

Externally Powered Prosthetic Elbows. This is a clinical evaluation of three available electrically powered prosthetic elbows developed at the Army Medical Biomechanical Research Laboratory, Rancho Los Amigos Hospital, and the Massachusetts Institute of Technology. Seven clinics participated in the study: New York University, Northwestern University, the University of California at Los Angeles, Rancho Los Amigos Hospital, the University of Miami, VAPC, and J. E. Hanger of Atlanta, Georgia. Twenty-one patients were fitted with the devices, and both objective and subjective data were collected.

Conclusions and recommendations: (1) the externally powered elbows evaluated are not yet ready for routine manufacture and use by patients, (2) the clinical experience suggested that the criteria and specifications for externally powered elbows be radically revised, and (3) the externally powered elbows should be referred back to the Subcommittee on Design and Development for further study.

Implementation: The study was described in CPRD Report E-4, prepared by Maurice A. LeBlanc, December 1970.

Significance of evaluation: The need for revision of operating and design criteria for externally powered elbows was recognized

prior to acceptance and manufacture of expensive, attractive, but inadequate and immature, devices.

The following projects concerning lower-extremity orthoses are current.

Clinical Study of UCBL Dual-Axis Ankle Brace and UCBL Shoe Insert. These two items are under clinical study by five clinics: New York University, Northwestern University, the University of California at Los Angeles, Rancho Los Amigos Hospital, and the Texas Institute for Rehabilitation and Research. An orientation course for physicians, orthotists, and therapists was held at UCLA on August 24-28, 1970. Criteria for patient selection and evaluation forms were developed. The estimated date for completion is late 1971.

Clinical Study of VAPC Single-Bar Brace and NYU Insert Brace. This is a parallel study with the above, involving five clinics: New York University, UCLA, Northwestern University, the University of Miami, and VAPC. An orientation course was held at NYU on October 26-30, 1970. The estimated date for completion is late 1971.

Comparative Study of Lower-Extremity Orthoses. A biomechanical analysis of nine similar devices, and a comparative clinical study, is being undertaken at Moss Rehabilitation Hospital in Philadelphia on: the AMBRL posterior-bar drop-foot brace, the AMBRL two-rod drop-foot brace, the IRM spiral brace, the NYU insert brace, the Rancho polypropylene drop-foot brace, the Teufel Ortholen drop-foot brace, the TIRR below-knee brace, the UCBL dual-axis ankle brace, and the VAPC drop-foot brace.

A meeting for orientation, development of the evaluation procedure, and preparation of the final report was held in Philadelphia in December 1970. The work is progressing. It is anticipated that several visits by CPRD staff will be required to assist with the acquisition of technical help, parts, and patients. The estimated completion date is 1972.

Clinical Evaluation of the Ljubljana Functional Electrical Peroneal Brace. This is a device that incorporates the principle

of controlled stimulation of muscle, rather than exoskeletal support, and, as such, is the first of its type to be subjected to the evaluation procedure. One hundred units are to be fabricated and supplied by the developer, the University of Ljubljana. All units are being tested for reliability by VAPC. To date, 45 kits have been received and tested. A number of these have been returned because they have not met standards for specified electrical characteristics. In addition, there were defects in mechanical components that required the acquisition of extra parts for each evaluating clinic.

It is anticipated that this device will be evaluated at four centers: Moss Rehabilitation Hospital, Wadsworth Veterans Administration Hospital in Los Angeles, Rancho Los Amigos Hospital, and Northwestern University. An orientation seminar was held at TIRR, Houston, Texas, on April 19-21, 1971; initiation of the clinical study will depend on the receipt, testing, and distribution of the units. The estimated date for completion is undetermined at present; however, at least a preliminary report will be available by May 1972.

Future plans of the subcommittee include (1) completion of current projects, (2) evaluation of surgical procedures such as osteoplasty and silicone-capping of nerve ends, and (3) consideration for evaluation of modular prosthetic components, cosmetic covers, implanted functional electric stimulators, and fracture bracing.

As a result of the meeting of the Subcommittee on Design and Development in Annapolis in the fall of 1970, certain needs in the field of rehabilitation engineering were delineated, and appropriate specific projects were identified for concern during the years 1971 through 1975.

Evaluation is a time-consuming and seemingly expensive process. The experience we have had to date, however, has been invaluable in the proper transition of the products of design and development to the field. In every instance, of the completed projects cited above, either modification of the original technique or reassessment of the criteria for design

has resulted. This has been done at far less expense and in a far shorter time than would have occurred by hit-or-miss methods.

The time needed for evaluation is still too long, and every effort should be made to assist the evaluating clinics in every way possible to avoid unnecessary delays.

The subcommittee recommended that:

1. The Subcommittee on Evaluation should continue its present format of (a) an orientation session with developers, (b) clinical application of the device by multiple facilities, (c) reorientation and critique, and (d) development of the final report.

2. Where applicable, the final report should be expanded to include more details of indications, technique, and pitfalls; the report could then serve as the basis for a teaching or shop manual.

3. Evaluation of simple devices and comparative studies, where technique is not a primary consideration, should be assigned to appropriate single centers.

4. The CPRD staff should be expanded to include at least one more full-time member. This is necessary to facilitate liaison with evaluating clinics, to develop evaluation procedures, and to prepare reports. This should be done as soon as it is fiscally possible and the proper individuals) can be found.

5. Because of staff limitations, for the present the subcommittee should continue to be involved primarily with the formal evaluation of techniques and components applicable to prosthetics and orthotics in the usual sense.

6. Definite consideration should be given to clinical evaluation of sensory aids, in order to support and assist the Subcommittee on Sensory Aids in their endeavors.

7. The subcommittee should embark on a study directed toward consideration of evaluation of endoprostheses, including joint replacement, adhesives, and new implantable materials. This is a natural outgrowth of this committee's interest in skeletal attachment of artificial limbs. The experience with the U.S. Food and

Drug Administration's evaluation of acrylic cement suggests that there may be a need for a nongovernmental agency, such as the NAS-NRC, to act as a coordinating facility in such matters. If done, close cooperation between government agencies, professional societies, and the Committee on the Skeletal System of the Division of Medical Sciences, NRC, would be essential.—*Frank W. Clippinger, M.D.*

Subcommittee on Child Prosthetics Problems

The Subcommittee on Child Prosthetics Problems convened at 2:30 p.m. on October 16, 1970, at the Mayflower Hotel in Washington, D.C. The members who attended were: George T. Aitken, M.D., chairman; Charles H. Epps, Jr., M.D.; Sidney Fishman, Ph.D.; Douglas A. Hobson, P. Eng.; Leon M. Kruger, M.D.; and Yoshio Setoguchi, M.D. Claude N. Lambert, M.D., was absent. Others present were: Robert Burtch, Joan Edelstein, Shirley Furgerson, Hector Kay, Ernst Marquardt, M.D., Colin A. McLaurin, D.Sc, Milda Vaivada, and A. Bennett Wilson, Jr.

The minutes of the meeting on June 11, 1970, were approved as circulated.

At the June 1970 meeting of cooperating clinic chiefs, held in Toronto, children's orthotic problems were discussed in detail. The questionnaire distributed at that time was analyzed by New York University, and the results were distributed to the subcommittee members.

New York University requested the opinion of the subcommittee as to its recommendations for future planning in the orthotics field. It was the consensus of the subcommittee that New York University staff should identify a nucleus of clinics interested in cerebral palsy, Legg-Perthes disease, and myelomeningocele. It was further recommended that orthopedic surgeons currently participating in the cooperative prosthetics program be surveyed to identify clinics they know to be interested in these problems.

Pertaining to the manufacture of Delrin wrist units, the University of California has

relinquished its patent rights. One manufacturer (Lawrence Orthopaedics) is interested in the production of this item, but not in its distribution.

Mr. Kay discussed the cooperating amputee-clinic program and announced that there are currently 29 clinics within the program. Fourteen additional clinics are approaching readiness for participation. Eighteen other clinics have indicated an interest but do not qualify at the present time.

Mr. Kay presented the status of publications and stated that, in addition to the 500 copies distributed by the Committee on Prosthetics Research and Development, 1065 copies of the Proceedings of the Symposium on Proximal Femoral Focal Deficiency have been sold. It is anticipated that the Proceedings of the Symposium on Lower-Limb Anomalies and of the Symposium on the Child with an Acquired Amputation also will be published. It was recommended that commercial printing be investigated, and that 500 copies be obtained for complimentary distribution, plus additional copies for purchase. The anticipated date of publication for *Lower-Limb Anomalies* is January 1971, and the Toronto symposium will be published in May 1971.

Reports on the evaluation projects were presented.

1. On the evaluation of the CAPP electric cart, it was stated that it has been determined that the electric carts are a useful adjunct to the management of the multihandicapped child amputee. Dr. Setoguchi reported that the reason the bid by U.S. Manufacturing Company was so high was due to welding and custom handwork in manufacturing. He also stated that U.S. Manufacturing Company has agreed to do another cost analysis; if, however, this cost is also determined to be too high, CAPP will need a letter from the subcommittee instructing it to investigate other manufacturers. Mr. Wilson recommended that a market survey be made to determine the need for these carts, and that this then could be submitted to manufacturers. New York University

was asked to contact the cooperating clinics and others to determine projected needs for the cart.

It was reported that 8 of the 12 new control systems are ready for installation in the existing carts, and they are being recalled one at a time for such replacement by CAPP. It is anticipated that all conversions will be completed by the end of December 1970.

2. In a report on the evaluation of OCCC items, New York University reported that 12 OCCC coordinated electric arms have been fabricated. They are in the process of fitting one of these arms to gain experience, and following this they will be ready to field-test the remaining units (probably within two months). Thirteen clinics have indicated an interest in fitting. The subcommittee recommended that children who have been fitted with and have outgrown the Michigan feeder arm should have priority for fitting with the OCCC coordinated arm.

3. Five OCCC elbows have been received and bench-checked. Only one met minimum specifications. The four that were rejected were too slow and are being returned to the manufacturer. The New York University report on the preliminary evaluation of these elbows was presented. It was agreed that the manufacturer of the OCCC electric elbow should be held to the original specifications, and that no changes are to be made in those specifications at this time. It was recommended that New York University write a protocol for the evaluation of the OCCC electric elbow.

4. New York University reported that eight RLAH elbows (six medium and two small) have been purchased. All have been committed to field clinics for testing. New York University had also ordered eight additional elbows, but they were rejected for not meeting specifications.

5. Two Otto Bock and two Viennatone hands have been received and checked. They have been shipped to selected clinics for field-testing. New York University has developed a protocol for evaluation of these elbows and hands. It was recom-

mended that this protocol be distributed to the members of the subcommittee for review.

6. Twenty NYU distal-contact regulators have been received from the manufacturer, and New York University is now prepared to fit several of these units in its laboratory.

7. In another evaluation project, the Area Child Amputee Center in Grand Rapids, Michigan, had previously agreed to purchase 10 Otto Bock hands and 5 Viennatone hands. The hands are to be fitted with University of New Brunswick electronics which have been ordered. In addition, the Viennatone Company has agreed to furnish ten complete hands free of charge for testing. All companies involved have indicated a willingness to provide instruction in the installation and maintenance of their devices. New York University was requested to write a protocol for the evaluation of these devices.

In reporting on plans for the future, Dr. Aitken said that the Maternal and Child Health Service has indicated willingness to support the subcommittee through June 30, 1971. He has requested a summary report of the subcommittee's current activities and what its plans are for the future. A document, "Children's Prosthetics and Orthotics—Past, Present, and Future," was submitted to subcommittee members and they were asked to review it and indicate desired changes or additions.

It was agreed that the next meeting of the Subcommittee on Child Prosthetics Problems be held in San Francisco following the March 1971 meeting of the American Academy of Orthopaedic Surgeons. At the time, plans for the next clinic chiefs' meeting to be held in June 1971 will be finalized.

Mr. Wilson stated that during the clinic chiefs' meeting in June 1969, Dr. Kuhn and Dr. Marquardt of Germany had given reports. Dr. Kuhn's report has been edited and includes appropriate illustrative material. Mr. Wilson recommended that this article be printed in a special edition of the *Inter-Clinic Information Bulletin*.

Mr. Wilson also discussed plans for a special workshop on body-powered upper-extremity prostheses. The subcommittee is anxious to cooperate with the Committee on Prosthetics Research and Development in developing such a workshop to review prosthetic fitting and harnessing.

The Subcommittee on Child Prosthetics Problems convened at 2:00 p.m. on March 7, 1971, at the Civic Center in San Francisco, California. The members who attended were: Claude N. Lambert, M.D.; Charles H. Epps, Jr., M.D.; Sidney Fishman, Ph.D.; Leon M. Kruger, M.D.; Colin A. McLaurin, D.Sc.; Yoshio Setoguchi, M.D.; and Douglas A. Hobson. George T. Aitken, M.D., was absent. Guests and staff present were: Shirley Furgerson, Hector W. Kay, and A. Bennett Wilson, Jr. In the absence of Dr. Aitken, Dr. Lambert acted as chairman.

The minutes of the meeting of October 16, 1970, were approved as circulated.

A report on the clinics interested in cerebral palsy, myelomeningocele, and Legg-Perthes disease was presented. Pursuant to a request that clinic interest in an orthotics cooperative program be investigated, New York University had explored possibilities in the New York area. Three clinics (the New York State Rehabilitation Hospital, the Hospital for Special Surgery, and the Long Island Hospital) have exhibited an interest. One of these clinics was chosen because it does not have a staff orthotist, i.e., uses an outside commercial shop. NYU will endeavor to work out a program of mutual interest with these clinics. Some of the problems anticipated are: (1) NYU and the subcommittee are not in a position to offer these clinics any extensive new gadgetry; (2) OCCC developments are commercially available and do not have to be obtained through the subcommittee. Nevertheless, meetings have been planned to discuss some type of working relationship in addition to a system for the compilation of statistical data. Mr. Wilson suggested that an instructional course be offered to

these clinics to expose them to various types of equipment and management procedures available for the spina bifida patient.

To accommodate the subcommittee's expansion into orthotics, Dr. Lambert thought it would be better to enlarge the subcommittee to include some members in the orthotics field, rather than to set up a separate subcommittee. Dr. Kruger suggested that some of the items demonstrated in Toronto be obtained for field-testing in selected clinics to determine indications for fitting, etc. The subcommittee recommended that NYU continue to investigate the possibilities for a cooperative orthotic program.

Dr. Setoguchi reported that the Hosmer Corporation would like to market the Delrin wrist units (and also the snap fasteners). Matt Lawrence of Oakland, California, has agreed to manufacture the wrist units and supply same to Hosmer.

Dr. Setoguchi further reported that U.S. Manufacturing will not submit a bid on the electric carts until the needs (market) for the cart have been determined. Mr. Greene (U.S. Manufacturing) has been referred to New York University for this information.

The NYU report on the positive results of the CAPP cart field-test will be published within a month.

Dr. Setoguchi distributed a flyer on the Model 1 (SCAT) electric wheelchair, a development of the R&D Engineering Company. This model does not have vertical control, but the company is willing to add this adjunct to its present model. The subcommittee recommended that, as soon as the NYU report on the CAPP chair has been received, Dr. Setoguchi should contact R&D Engineering relative to their supplying this subcommittee with one or two of their Model 1 electric wheelchairs with vertical control for clinical evaluation.

Mr. Kay reported on the cooperative amputee-clinic program. There are currently 29 clinics in this program. Mr. Kay reported that Shriners Hospital in Houston, Texas, now meets the criteria for

participation in the cooperative amputee-clinic program. The subcommittee recommended that Shriners Hospital, Houston, Texas, be accepted.

In a report on the status of publications, it was stated that the proceedings of the 1969 symposium on Selected Lower Limb Anomalies are in the final state of preparation prior to printing. The proceedings of the 1970 symposium are in an early stage of development; at present not all presentations have been received by the editor.

Twenty-eight hundred copies of the *Inter-Clinic Information Bulletin* are now being printed. Over 1000 copies are allocated to overseas distribution. Mr. Kay reported that the response of the contributors has been maintained at a high level.

Funding of this publication is a critical matter. For the next several months it will be possible to continue to have free distribution. The subcommittee members approved the policy of charging a subscription fee for the *Inter-Clinic Information Bulletin* in principle, and it was recommended that the matter of charging a fee for the publication and means of handling subscriptions be investigated by Mr. Kay and a report submitted to the subcommittee at its next meeting.

Reports on current projects were presented.

1. Dr. Setoguchi reported that all CAPP electric carts have now been converted to the new control system.

2. The manufacturer of the OCCC elbow, Variety Village in Toronto, has now received the motors for the elbows, and it is anticipated that they will be shipped to NYU prior to the end of April 1971.

3. Fabrication of 12 OCCC coordinated arms has been completed, and the arms are ready for field-testing. One has been fitted in the New York area, and two months of clinical wear are almost completed. The field-test protocol has been written. It was recommended that the remaining 11 arms be distributed to selected clinics for field-testing. NYU will be responsible for any repairs which may become necessary. The arms will be provided

with three-fingered hooks, with a planned change to two-fingered (NYU-type) hooks after two or three months of testing.

4. Three out of four of the RLAH elbows are currently being worn. There has been no clinical feedback on the value of these elbows for children. The quality control is exceedingly poor, and several units have been returned to the factory for repair. It was recommended that this item be continued under investigation.

5. Eight Viennatone hands with Viennatone electronics are now available for testing. Mr. Kay was requested to contact the manufacturer to determine whether they would be willing to send a representative to the clinics selected to field-test this item so that those clinics might be instructed in the proper fabrication techniques.

6. Dr. Fishman reported that 20 NYU distal-contact regulators have been fabricated. The fabrication technique for below-knee prostheses has been documented, and the above-knee fabrication technique is now being written. This item will continue under study, and a further progress report will be submitted at the next meeting.

The 1971 clinic-chiefs' meeting was discussed. No funds are available for a spring meeting of the clinic chiefs. Plans will, therefore, be made for a fall meeting.

Publications

Four papers presented to a symposium sponsored by the Committee on Prosthetics Research and Development in 1969 have been published in a booklet entitled *Selected Lower-Limb Anomalies: Surgical and Prosthetics Management*. The contributors, George T. Aitken, M.D., Frederic W. Brown, M.D., Charles H. Frantz, M.D., and Leon M. Kruger, M.D., present a comprehensive review of the clinical findings in and recommended treatment of fibular hemimelia, tibial hemimelia, and complete absence of the lumbar spine and sacrum. The report is available from the Printing and Publishing Office, National Academy of Sciences, 2101 Con-

stitution Ave., Washington, D.C. 20418. Price: \$2.95 + 250 handling charge.

AAOS Postgraduate Courses

The American Academy of Orthopaedic Surgeons will sponsor a three-day postgraduate course on "Lower Extremity Fracture Care" at the Disneyland Hotel, Anaheim, California, on December 1-3, 1971. Orthopedic surgeons and other physicians interested in fracture care, and allied medical personnel with a special concern in that area, are invited to attend. The course will be held in cooperation with the Department of Postgraduate Training of the University of Southern California School of Medicine, under the sponsorship of the AAOS Committee on Injuries. Further information can be obtained from the course chairman; Vert Mooney, M.D., 7847 East Florence, Downey, Calif. 90241.

The American Academy of Orthopaedic Surgeons has scheduled 23 postgraduate courses in 1972 sponsored by its Committee on Continuing Education. The courses are designed for orthopedic surgeons, but also are open to other interested physicians and allied health personnel. Registration limits will be set by the course chairman to avoid overcrowding of the course facilities. For information on these 1972 courses, contact the individual course chairman or the Educational Director, American Academy of Orthopaedic Surgeons, 430 North Michigan Ave., Chicago, Ill. 60611.

The course titles, dates, sites, producing committees, and chairmen are:

Sports Medicine: Mar. 4-11; Aspen, Colorado; Committee on Sports Medicine; Arthur E. Ellison, M.D., Williamston, Mass. 01267.

Orthopaedic Rehabilitation: Mar. 13-15; Cleveland, Ohio; Committee on Orthopaedic Rehabilitation; Alvin A. Freehafer, M.D., 3901 Ireland Dr., Cleveland, Ohio 44122.

Genetic and Heritable Disorders: Mar. 19-21; Salt Lake City, Utah; Committee on the Handicapped Child; Sherman

Coleman, M.D., 50 N. Medical Dr., Salt Lake City, Utah 84112.

Complex Trauma of Childhood: Mar. 29-31; Atlanta, Georgia; Committee on the Handicapped Child; Wood W. Lovell, M.D., 340 Boulevard, N.E., Atlanta, Ga. 30312.

The Neck: Apr. 9-12; New York, N.Y.; Committee on Injuries; J. Wm. Fielding, M.D., 105 East 65th St., New York, N.Y. 10021.

Biomechanics: Apr. 24-28; Cleveland, Ohio; Committee on Basic Science; Victor H. Frankel, M.D., 2065 Adelbert Rd., Cleveland, Ohio 44106.

Complications of Trauma: May 3-5; Memphis, Tennessee; Committee on Injuries; R. A. Calandrucchio, M.D., 869 Madison Ave., Memphis, Tenn. 38103.

Surgery of the Adult Foot: May 14-17; Chicago, Ill.; Committee on Adult Orthopaedics; Paul R. Meyer, Jr., M.D., 737 N. Michigan Ave., Chicago, Ill. 60611.

Sports Medicine: May 28-June 1; Atlanta, Georgia; Committee on Sports Medicine; Jack C. Hughston, M.D., 105 Physicians Bldg., Columbus, Ga. 31901.

Sports Medicine: July 24-26; Eugene, Oregon; Committee on Sports Medicine; Robert L. Larson, M.D., 750 East 11th Ave., Eugene, Ore. 97401.

Current Concepts/Children's Orthopaedics: Aug. 17-19; Seattle, Washington; Committee on the Handicapped Child; Lynn T. Staheli, M.D., 4800 San Point Way, N.E., Seattle, Wash. 98105.

Basic Science: Aug. 23-26; Fort Wayne, Indiana; Committee on Basic Science; Frederic W. Brown, M.D., 2609 Fairfield Ave., Fort Wayne, Ind. 46807.

Upper Extremity in Sports: Sept. 11-13; New York, N.Y.; Committee on Sports Medicine; James A. Nicholas, M.D., 150 E. 77th St., New York, N.Y. 10021.

The Hand: Sept. 13-16; San Antonio, Texas; Committee on Injuries; Charles A. Rockwood, Jr., M.D., 7703 Floyd Curl Dr., San Antonio, Texas 78229.

Tumors of Bone and Soft Tissues: Oct. 5-7; New York, N.Y.; Committee on Adult

Orthopaedics; Kenneth C. Francis, M.D., 215 E. 68th St., New York, N.Y. 10021.

Arthritis: Oct. 12-15; Atlanta, Georgia; Committee on Arthritis; F. James Funk, Jr., M.D., 1938 Peachtree Rd., N.W., Atlanta, Ga. 30309.

Neuromuscular Problems of Childhood: Oct. 16-18; Charlottesville, Virginia; Committee on the Handicapped Child; Warren G. Stamp, M.D., and Wilton H. Bunch, M.D., University of Virginia Hospital, Charlottesville, Va. 22901.

Modern Concepts of Fracture Healing and Treatment: Oct. 22-24; Los Angeles, California; Committee on Injuries; J. Paul Harvey, Jr., M.D., 1200 N. State St., Los Angeles, Calif. 90033.

Prosthetics and Orthotics: Nov. 5-8; Chicago, Illinois; Committee on Prosthetics and Orthotics; Robert G. Thompson, M.D., 737 N. Michigan Ave., Chicago, Ill. 60611.

Biomechanics: Nov. 6-10; Cleveland, Ohio; Committee on Basic Science; Victor H. Frankel, M.D., 2065 Adelbert Rd., Cleveland, Ohio 44106.

Scoliosis: Nov. 12-14; New York, N.Y.; Committee on Scoliosis; Hugo A. Keim, M.D., 161 Ft. Washington Ave., New York, N.Y. 10032.

The Hip: Nov. 13-16; Boston, Massachusetts; Committee on Injuries; Wm. R. MacAusland, Jr., M.D., 412 Beacon St., Boston, Mass. 02115.

Spinal Cord Injured Patient: Dec. 8-10; Miami Beach, Florida; Committee on Orthopaedic Rehabilitation; Augusto Sarmiento, M.D., P. O. Box 875, Biscayne Annex, Miami, Fla. 33152.

Award to Dr. Murphy

Dr. Eugene F. Murphy, chief of research and development in the Veterans Administration's Prosthetic and Sensory Aids Service, was named VA's outstanding handicapped employee of the year, and one of the top ten in the entire federal government. He has also received the VA's Meritorious Service Award for leadership of the prosthetics research program.



Eugene F. Murphy, Ph.D.

A native of Syracuse, N.Y., Dr. Murphy became a victim of poliomyelitis when he was 11 years old. Despite the handicap, he completed undergraduate work at Cornell University, received a master's degree from Syracuse University, and obtained a doctorate in mechanical engi-

neering from the Illinois Institute of Technology.

From 1945 until he joined the Veterans Administration, Dr. Murphy served as staff engineer for the Committee on Artificial Limbs, now the Committee on Prosthetics Research and Development.

Dr. Murphy has been chief of the Research and Development Division of the Prosthetic and Sensory Aids Service since 1948. In that capacity, he has been responsible for the VA's program of research, development, evaluation, and education in the fields of prosthetic devices and sensory aids.

Dundee Conference on the Advance in Orthotics

A conference was held in Dundee, Scotland, on June 21-25, 1971, to review current practice and to present recent advances in orthotics. About 250 people (including many participants from the United States) attended the conference, which was organized by Mr. George Murdoch, an orthopedic surgeon in Dundee.

The topics highlighted were: modular construction, use of plastics, new nomenclature, and education. The proceedings of the conference will be published in book form in 1972.



Thea P. Wiegand

Thea P. Wiegand died on March 4, 1971, at the Holy Cross Hospital, Silver Spring, Maryland.

Mrs. Wiegand was the librarian for the Army Prosthetics Research Laboratory for 17 years prior to her retirement in 1963. Before coming to the laboratory,

Thea Wiegand had been the librarian for the Walter Reed Army Medical Center and was most proficient in her chosen specialty. She had a long history in serving the medical profession, having served as secretary to Dr. Arthur Steindler, head of the Department of Orthopaedic Surgery at the University of Iowa, before coming into the government service during World War II.

Thea Wiegand was responsible for setting up an original and efficient library system at the laboratory and was of immeasurable help in the formation of this project, a new concept in medical-mechanical research. She was well known to many early pioneers in the national prosthetics research program and was always willing to delve into the literature and summarize the references in the area of research requested. She was an intelligent, kind, and warmhearted person, and was always exceedingly eager to cooperate with anyone desiring information on a given subject, regardless of how obscure it might be. She possessed a most pleasant personality and was deeply admired and respected by all who came in contact with her.

Mrs. Wiegand will be missed by her host of friends in the prosthetics research program.