Prosthetics and Orthotics International

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Contents

Executive board of ISPO

Editorial

The last issue of the Journal carried a number of proposals for change in our Constitution. By the time you read this they will have been democratically voted upon by your representatives on the International Committee and accepted or rejected. This reminds us of a number of important issues.

Change demonstrates that we are a living, growing society, evolving our rules and codes of behaviour to satisfy the members of the society. And, of course, we have a system of representation which permits national groups to vote and express the views of their members and initiate and influence such change. The system, however, was carefully designed to ensure that no national grouping could dominate the international view—even the largest National Member Society can have no more than two representatives on the International Committee, the same as any national grouping of more than fifteen members.

Representation and consequently real influence on events, however, is lost to those who do not belong to a National Member Society. To form such a society requires a national grouping of only five members. If there are not five members in the one nation, the Constitution permits the integration of the membership of two nations to achieve the necessary minimum. It is a source of great concern to the Executive Board that many members are deprived of a voice on the International Committee simply for want of an initiative leading to the formation of a National Member Society. If on reading this you realise that this is your position, we invite you to communicate with the Secretariat. We will provide you with the names of the other members in your country. Meet them, or enter into correspondence with them. Form your own National Member Society.

Of course, the benefits of forming a National Society are far greater than simply legislative representation. A National Member Society consists of dedicated professionals working in the same field and with a further bond of being united by the same environment, the same culture and the same problems. The Society then forms a focal point for interdisciplinary communication and mutual education providing the one forum which crosses all professional boundaries. This has proved to be the case in all the thriving active National Member Societies. They organize national meetings; success breeds success; they grow and become capable of widening their professional influence, enlarging their field of activities and attracting still more members.

Such success brings its own problems. The national identity which we are so anxious to foster is not an end in itself. Just as our Society crosses professional boundaries, it also crosses national boundaries. ISPO is committed to promoting high quality orthotic and prosthetic care of all people with neuromuscular and skeletal disabilities, serving as an international, impartial and non-political coordinating, correlating and advisory body, working with other national and international bodies, offering appropriate guidance and advice to avoid duplication of effort and encourage maximum use of resources. This is the core of our existence. Our record over the first decade was impressive. Our potential, with strong national groups working together to tackle the international problems, is enormous.

In this the International Year of Disabled Persons, our 'united nations' is one of the most effective forces for continued progress.

John Hughes
Honorary Secretary.

The operative treatment of congenital limb malformation—part II, case study

E. MARQUARDT

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The patient was born on 13 May 1965 with bilateral transverse upper arm $\frac{1}{3}$ deficiency. Malformations of the lower limbs consisted of bilateral longitudinal femur subtotal deficiencies, bilateral fibula total deficiencies and bilateral ray (metatarsal and phalangeal) IV and V deficiencies. She suffered recurrent incidents of osseous overgrowth of the humerus on both sides and between 1969 and 1973 six reamputations were performed for this reason. Stump capping procedures employing autogenous cartilage-bone transplants were successfully carried out on each humeral stump in 1974.
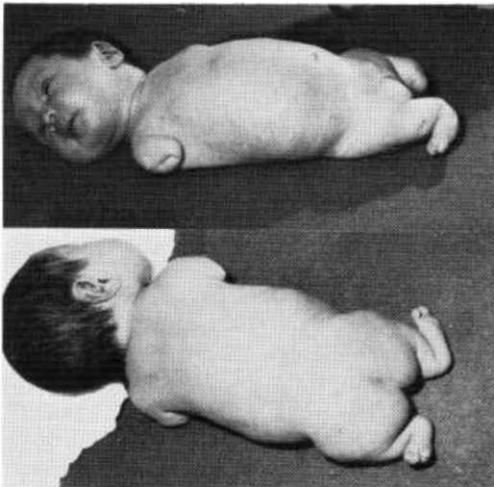
1. The newborn child showing the congenital scar at the end of the short above-elbow stump and extreme pes valgus. Left and right sides are almost identical.
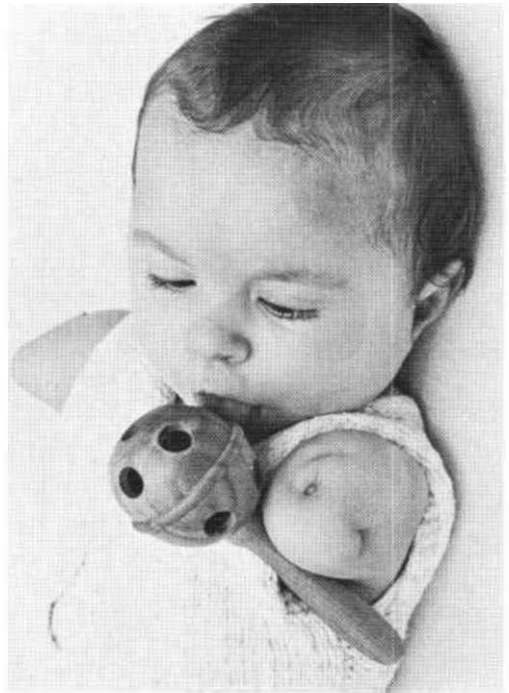
2. The lower limbs were placed in a plaster of Paris cast; an orthosis was fitted at the age of three months. During this time the child used the stumps, chin and mouth for touching and grasping.

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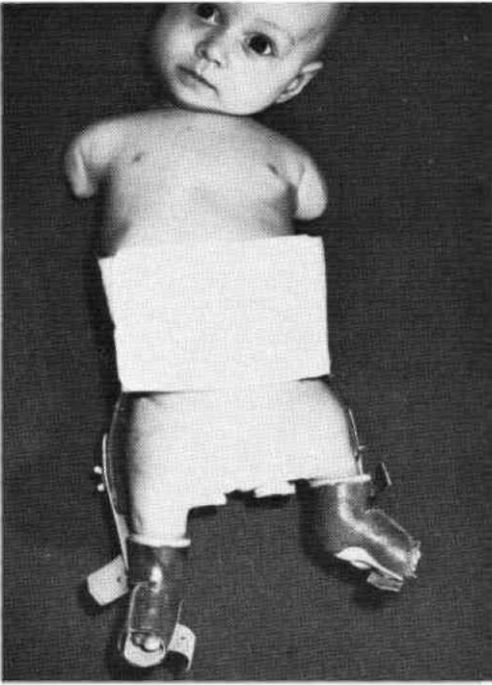
3. The orthosis showing the orthopaedic leather shoes and metal foot supports. The orthosis could be extended while maintaining the feet in the optimum corrective position.
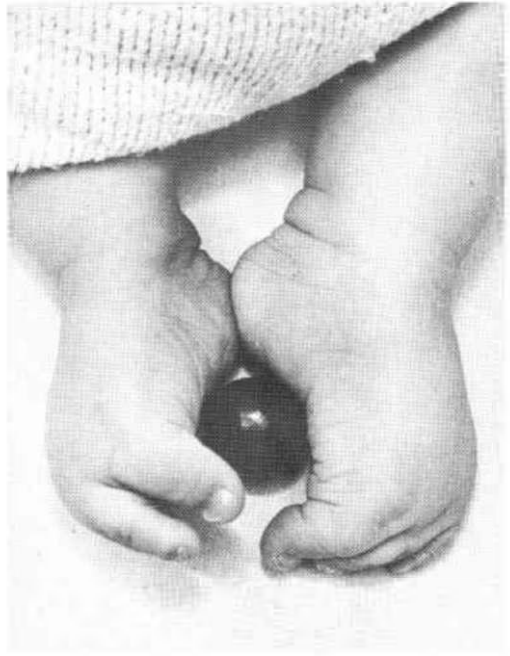
4. The active use of both feet for play and motivated exercise is very important for the correction of deformity and the development of foot function.
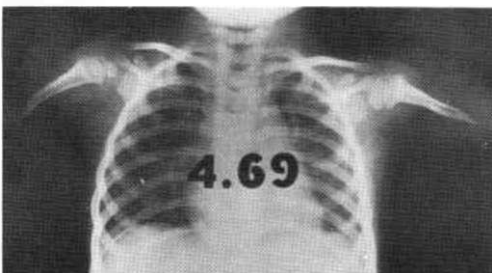
5. The X-ray of the upper limbs shows osseous overgrowth in this congenital case which is identical to that seen in children following traumatic amputation.
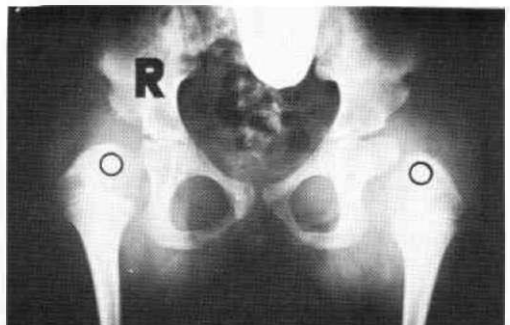
6. The X-ray of the pelvis shows a rudiment of the femoral head in each hip joint and femoral elements in the form of a cap in synostosis with the proximal tibia bilateral. The fibula deficiency bilateral, is complete. The circled areas indicate the sites used for the cartilage-bone transplants.
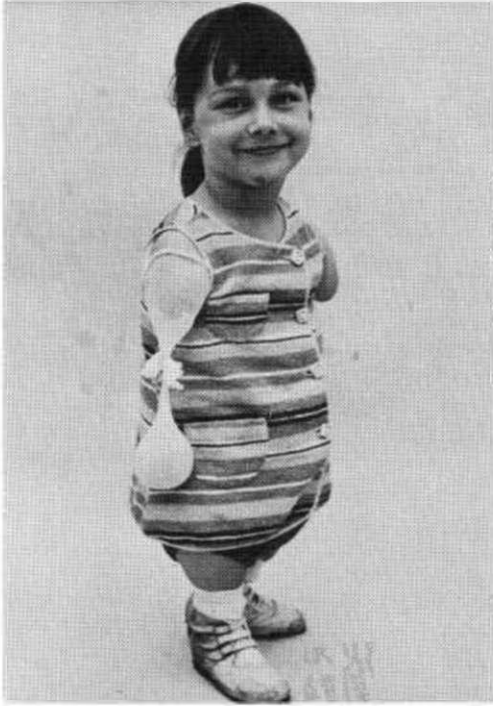
7. Between 1969 and 1973 the patient endured six reamputations because of osseous overgrowth. The illustration shows a simple method of skin traction to prevent further perforation prior to the stump capping procedure. At this stage she was fitted with cable controlled upper limbs and lower limb extension prostheses.
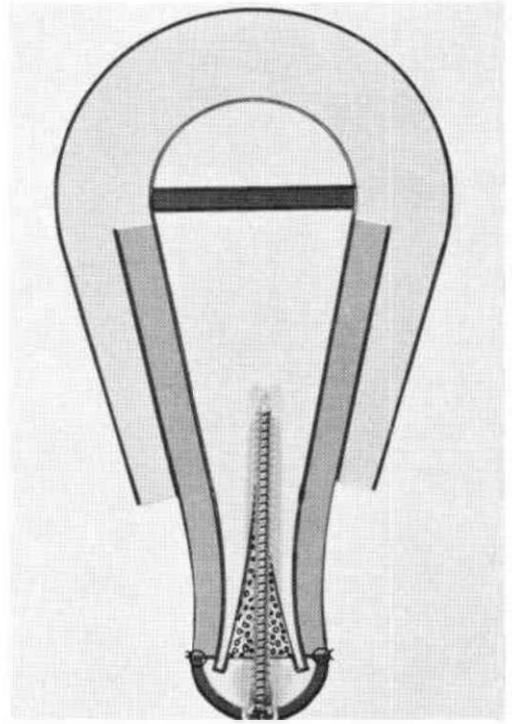
8. Sketch of the stump capping procedure using a cartilage covered cap. The distal end of the humerus is split into two pillars which are fitted into corresponding holes in the cartilage-bone transplant. Fixation to the humerus is by a screw (in some cases by two Kirschner wires) and the musculoperiosteal flaps are attached to the transplant. Cancellous bone graft is packed between the split ends of the humerus.

9. Stages during the stump capping operation. The pictures show the procedure carried out on the right side in March 1974. The same procedure had been performed successfully on the left side in January 1974. Left, the end of the humerus is split and the musculo-periosteal flaps prepared for fixation to the transplant. Right, the transplant is fixed by a screw. In this case the pillars proved to be too long and the transplant was removed. The pillars were shortened by about 1 cm, the transplant was replaced and the musculoperiosteal flaps could then be attached to the transplant.
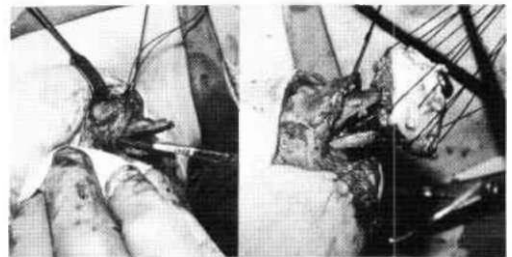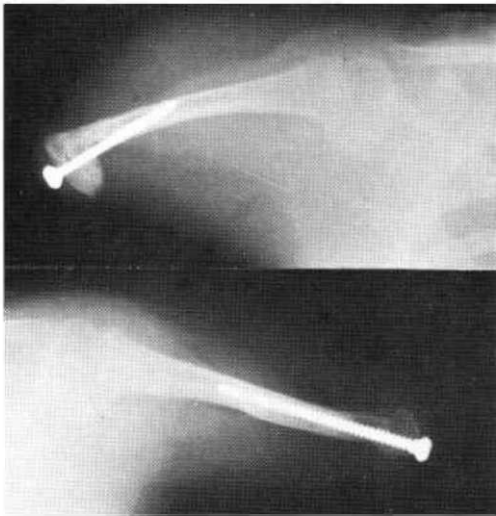
10. Right humerus (top) and left humerus
    (bottom) in December 1974 just prior to
    removal of the screws. The transplant on the
    right side has been fashioned to provide
    better prosthetic fixation. Thickness of the
    cartilage is indicated by the distance
    between the distal end of the screw and the
    bone.

11. Daily end-bearing training is essential after
    the stump capping procedure to stimulate
    normal development of the humerus and to
    prevent osseous overgrowth.
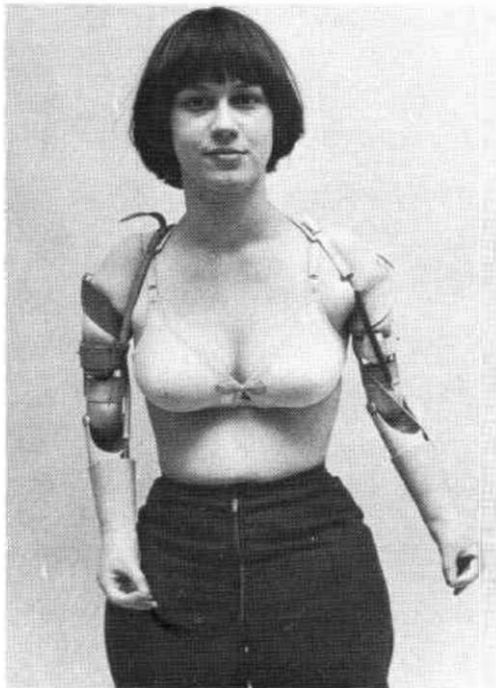
12. It is also essential that the patient be
    encouraged to make daily use of active
    prostheses. Those shown are body powered
    with open socket construction to
    accommodate the bulky stump end. The
    length of the arms is a compromise; the
    patient's height varies as she does not always
    wear her extension prostheses.
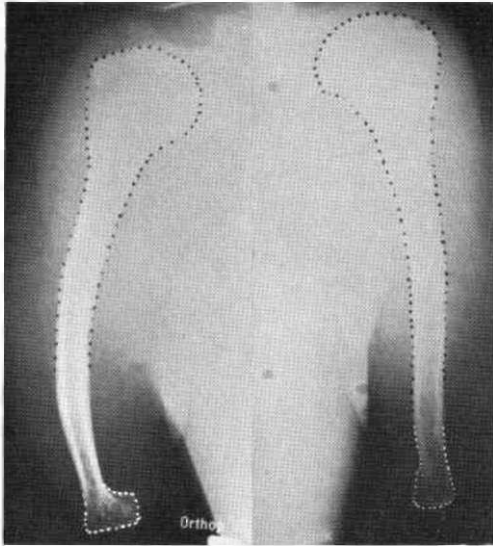
13. The patient was last X-rayed in 1976; the pictures demonstrate good growth of both humeral stumps amounting to 3·4 cm on the right side and 3·2 cm on the left since December 1974.

14. The capping procedure has prevented a recurrence of osseous overgrowth and produced almost normal development. Note the pterygium and the absence of axillary hair on the right side.

In the case of a patient who had not suffered perforation of the bone through the skin and reamputation, the incision for the stump capping procedure would be proximal to the stump end to provide a scar-free end bearing area. However up to November 1980 the patient has experienced no problems with her stumps.

Part III will be published in the August 1981 issue of Prosthetics and Orthotics International.

Preamble

Stimulated by the President of ISPO, Anthony Staros, I have, in my capacity as Chairman of the Research Committee, persuaded Newton McCollough to publish this most interesting paper in our Journal. Newton McCollough is Chairman of the Centre of Orthopaedics and Rehabilitation in Miami, Florida, with a wide experience in the dynamic field of prosthetic rehabilitation. He has written his paper on Orthopaedic Research in Amputation Surgery, Prosthetics and Orthotics, looking ahead at different future possibilities of evolution. It contains his evaluation of the important areas requiring research effort. It makes most stimulating reading of basic importance to all who are concerned with the creation of better methods for the treatment of the increasing number of amputees, and for those who seek a better understanding of the categories of amputees in relation to different causes, ages and environments.

A number of distinguished practitioners from the different professions have been invited to comment on, and supplement, the views expressed by Professor McCollough. Their comments will be published in forthcoming issues. Readers are also invited to comment so that we may create a stimulating discussion on the priorities for the 1980's.

Björn Persson

Orthopaedic research in amputation surgery, prosthetics and orthotics

N.C. McCOLLOUGH

School of Medicine, University of Miami.

Amputation surgery

A number of advances have been made in amputation surgery over the past 15 years. These include the development of new surgical techniques for the Syme amputation, below-knee amputation, knee disarticulation and certain upper limb amputations. The techniques of myodesis and myoplasty have been introduced along with the concepts of immediate postsurgical fitting and emphasis upon the salvage of the knee joint has resulted in a complete reversal of the old 2 to 1 ratio in favour of the above-knee amputations to below-knee amputations in vascular disease. Postoperative care of the amputee has also been improved through the use of specialized postoperative dressings and early return to functional activity. The areas for continued research are as follows:

1. Development of a system to obtain current data base on amputations performed in the United States including cause, level, age of patient, healing information, time to discharge and incidence of rehabilitation.

2. Continued research into the accuracy of level selection in the dysvascular amputee which will permit healing in the vast majority of cases and eliminate the necessity for revision. Most promising in this area are the use of Doppler Ultrasound techniques as well as Xenon Clearance studies.

3. Continued research into the area of postoperative stump management including controlled environment studies which are already in progress at the Veterans Administration Prosthetic Study in Seattle.

4. Improved methods of management of the congenital limb deficient child including reconstruction of the hip in proximal femoral focal deficiency, lengthening of short stumps through the use of microsurgical techniques, and new methods of lengthening of congenitally short femurs through epiphyseal distraction, a re-evaluation of epiphyseal stimulation and other methods. Also investigation of procedures

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to prevent bony overgrowth in amputations in children should be pursued including further evaluation of capping the bone ends with inert materials as advocated by Swanson and Meyer as well as osteochondral transplants advocated by Marquardt.

5. Continued investigation should be encouraged into the direct skeletal attachment of prostheses as advocated by Mooney of the University of Texas and Hall of the Southwest Research Institute. Particular problems in this regard are bone interfacing with the prosthetic component and overcoming the cutaneous interface between the body milieu and the external environment.

6. Research into the provision of sensory feedback of the upper extremity amputee by the use of implantable radiofrequency receivers as advocated by Clippinger et al.

7. Further refinement of myoelectric control, particularly in upper extremity amputations would be desirable with the possibility of utilizing more definitive muscle activity to provide control of the prosthetic fingers to allow manipulation of objects within the grasp of the terminal device.

Lower limb prosthetics

Significant advances in the area of lower limb prosthetics which have been made in recent years include the advent of immediate postsurgical and early postsurgical fitting of temporary prostheses to allow earlier functional recovery as well as new designs of permanent prostheses including the endoskeletal design for improvement of cosmesis and decrease in weight, and new designs for Syme prosthesis as well as the new disarticulation prosthesis. The latter developments have encouraged the more frequent utilization of amputations at the Syme and knee disarticulation level which provide a superior prosthetic performance. Also the utilization of energy studies being conducted primarily at Rancho Los Amigos and Tufts University have shed new light on the energy requirements for various levels of lower extremity amputation and prosthetic fitting.

Important research areas to be supported in the area of lower extremity prosthetics include the following:

1. Continued support of energy studies in various levels of amputation, including

multimembral amputations to determine efficiency of use of various prosthetic designs in the management of the amputee.

2. Continued work in the area of ultra-lightweight prostheses which further reduce energy consumption particularly in the geriatric amputee. Work in this area is currently being done at Rancho Los Amigos Hospital, Moss Rehabilitation Center and the University of Texas in Dallas.

3. The development of simpler and yet more accurate measurements of prosthetic alignment for the lower limb should be encouraged such as the laser display of the weight line being developed at Moss Rehabilitation Center and the clinically applicable objective alignment techniques being developed at Rancho Los Amigos Hospital.

4. Work should be encouraged in the area of development of adjustable prosthetic sockets for lower limb amputees to continuously accommodate to the changing volume of the amputation stump following surgery or following chemotherapy. Some work along this line has been done at the Veterans Administration Prosthetic Center in New York and at the University of Miami.

5. The application of myoelectric control to control the prosthetic knee in the above-knee prosthesis should be further investigated and refined from the standpoint of producing increased stability and decreasing energy requirements in the above-knee amputee.

6. Investigation of possible self-adjusting sockets to accommodate for growth in the child amputee should be undertaken. This would result in a considerable cost saving to child amputees by reducing the number of prostheses necessary during the growing period.

7. Further refinement of technology in the area of hydraulic control of above-knee prosthetic knee joints to permit both stance and swing phase control in the geriatric patient. Present designs prohibit the use of such a unit due to the relative stiffness of operation.

8. Further research into developing a hydraulic ankle unit such as that being developed at Mauch Laboratories. Such a unit ideally would allow motion in the transverse, saggital and coronal planes and reduce shear and friction forces upon the stump within the socket.

9. Research into the area of utilizing myoelectric control to provide voluntary

dynamic push off at the foot and ankle should be considered.

10. Further refinement of endoskeletal design prostheses to ensure comparable durability to the exoskeletal prosthesis. This would require investigation of new materials and attachments. Particularly promising would be the graphite epoxy materials which are light in weight and strong and durable.

11. Further research into a better prosthetic "skin" for lower limb endoskeletal prostheses which would be more durable and more cosmetic than the present applications.

Upper limb prosthetics

Significant developments in recent years in upper limb prosthetics have included utilization of immediate postsurgical fitting for early return of function, particularly in the bilateral traumatic amputee and the development of myoelectric control systems as well as the utilization of external power sources to control prosthetic joints.

Research objectives in upper limb prosthetics are suggested as follows:

1. Further refinement of current myoelectric prosthetic designs to improve their durability and maintenance. These designs would be in particular applicable to the high upper limb amputee.

2. Further research into the area of sensory feedback in upper limb prosthetics to provide greatly enhanced function in the utilization of these devices.

3. Research should be undertaken to permit manipulation of objects within the grasp of the terminal devices of upper limb amputees in combination with sensory feedback techniques.

4. The use of self-suspending sockets to eliminate harnessing should be further developed to include designs for the below-elbow amputee as well as the above-elbow amputee. Work in this regard has already been conducted at Northwestern University and self-suspending sockets are currently available for wrist disarticulation and elbow disarticulation amputees.

5. Research into designs of upper limb prosthetics which would provide improved cosmesis compared to current standard designs. Such an effort must incorporate further refinement of exoskeletal designs, improved prosthetic skin, utilization of external power and/or myoelectric control so that harnessing may be eliminated.

Lower limb orthotics

Advances in lower limb orthotics over recent years have included the utilization of new materials such as polypropylene to improve cosmesis as well as enhance weight reduction and at the same time provide continued optimum function. The reduction of weight in newer designs, both in plastic and metal, has enabled many children with muscular dystrophy, myelomeningocele and other paralytic disorders to achieve useful ambulation.

Areas for research support in lower limb orthotics should include the following:

1. Development of a self-locking knee joint in stance phase for the ankle-foot orthosis so that normal swing phase can be permitted and energy consumption can be reduced.

2. Energy studies should be further undertaken to ascertain the relative energy requirements in walking with various types of lower limb orthoses so that design evaluation can be more objective.

3. Continued research into new orthotic materials, namely the graphite reinforced epoxy and plastic materials to provide superior strength, adjustability and lightness of weight should be pursued.

4. Research should be undertaken to interdigitate myoelectric control with orthotic joints in higher levels of paralysis including the hip and knee joints.

5. In upper motor neuron lesions further investigation of internal orthotic devices which are physiological such as the use of radio frequency peripheral motor control should be encouraged. Multichannel computerized peripheral motor control through radio-frequency signals to muscles affected in upper motor neuron lesions could effectively permit a paraplegic patient to walk with appropriate computerized programming.

6. Further evaluation of biofeedback techniques to enhance control of the lower limb in conjunction with orthotic applications.

7. Continued refinement of orthotic devices for fracture bracing should be encouraged. Present methods are not applicable in the private practice clinical setting. Research in this area should be in new materials as well as new designs and the utilization of prefabricated components.

Work in this area is ongoing at the University of Miami, University of Southern California and the University of Texas at Dallas.

Upper limb orthotics

Relatively few advances have been made in the area of upper limb orthotics due to the complexity of function of the upper limb and the difficulty in providing a truly functional orthosis as compared to a supportive type of brace.

Areas for further research include:

1. Possible development of myoelectric control in conjunction with upper limb orthotic devices.

2. The development of sensory feedback in combination with upper limb orthotic devices.

3. The utilization of biofeedback techniques in conjunction with upper limb orthotic devices in the stroke patient.

4. Continued investigation into the use of functional electrical stimulation in both the stroke patient and the quadriplegic patient such as is being carried out at Rancho Los Amigos and Case Western Reserve University.

Spinal orthotics

Recent advances in the area of spinal orthotics have primarily been confined to the area of scoliosis management and have included many new designs which have come to replace the Milwaukee brace in many instances. These designs have been made possible by the utilization of new materials and improved fabrication techniques to permit bracing of the scoliotic spine with underarm types of orthotic appliances.

Areas for research activity in the area of spinal orthotics include:

1. The development of a modular spinal orthosis which could be adjustable in the control of motion in all three planes, depending upon the particular type of motion restriction desired.

2. Further research into spinal orthoses which provide an unloading effect to the spine such as have been developed by Dr. James Morris at the University of California at Berkley and at Newington Children's Hospital principally in the treatment of myodysplasia.

3. Possible utilization of biofeedback techniques in conjunction with orthotic devices to correct posture and thereby reduce low back pain.

4. Further evaluation of the utilization of functional electrical stimulation in the correction of scoliosis either independently or in conjunction with orthotic devices.

5. Research and development in the area of emergency orthotic devices for use in traumatic injuries of the spine to reduce the neurological complications in such patients who must be moved from the scene of the accident to the hospital.

6. Clinical and laboratory investigations should be encouraged to determine the effect of bracing on the scoliotic spine including the various types of new braces. Forces required, length of time required and the effect of exercises in conjunction with bracing as well as night bracing should be investigated.

Balance in lower limb child amputees*

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Abstract

Postural stability of five unilateral above-knee amputee children was measured when wearing the SACH and the experimental Child Amputee Prosthetic Project (CAPP) prosthetic foot. Excursions of the centre of pressure of the supportive forces were recorded via force platform during sustained weight-shifting forward, backward, left, right, and during normal standing. Visual proprioception effects on upright stance were also demonstrated with these child amputees. Total base of support did not differ for the two types of prosthetic feet, but the functional base of support for SACH foot was significantly larger than CAPP. Fluctuations of centre of pressure about a mean position in normal standing were less when children used CAPP foot. Focusing on a static target had no effect on postural stability in either anterior-posterior or lateral direction for CAPP foot conditions, but lack of visual target had a deleterious effect on lateral stability when SACH foot was worn.

Balance is one of the most difficult problems for a lower limb amputee (Hellebrandt et al, 1950; Moncur, 1969; Murdoch, 1969). The absence of part or all of a lower limb reduces the amount of proprioceptive information about the surfaces on which the foot is resting and the precise location of the prosthetic limb. While limited data have been reported on the balance and stability characteristics of adult amputees (Fernie and Holliday, 1978; Hellebrandt et al, 1950), information about balance of child amputees is almost non-existent. We have found only one report of the postural stability characteristics of a child amputee; Shambes and Waterland (1970) studied an 11-year-old quadrilateral amputee who had congenital Lisfranc amputations of both lower limbs, long above-elbow amputation of the left upper limb, and medium below-elbow amputation of the right upper limb.

The purpose of this study was to detail the postural stability characteristics for lower limb child amputees. In addition, the conventional SACH prosthetic foot was compared with the experimental Child Amputee Prosthetic Project (CAPP) foot for various postural tasks. The SACH foot (Fig. 1a) is usually constructed with a moulded polyurethane material which incorporates a heel cushion to allow some compression of the heel during heel strike in walking to simulate plantar flexion of a normal foot. The CAPP foot (Fig. 1b) is an experimental prosthesis undergoing development at the UCLA Child Amputee Prosthetic Project. It is designed to provide more knee stability during early stance phase during walking and also to respond to torsional loads occurring in the stance phase of walking. The heel projection of the CAPP foot is non-weight bearing and deflects upward at heelstrike. With the ground reaction forces shifted more anteriorly on the supporting foot there is an expected increase in dynamic knee stability during the stance phase of walking. While additional research is being conducted on the dynamic characteristics of the CAPP foot, the present study provides some preliminary information about the postural stability of child amputees using the experimental CAPP foot, as well as providing a comparison with the conventional SACH foot.

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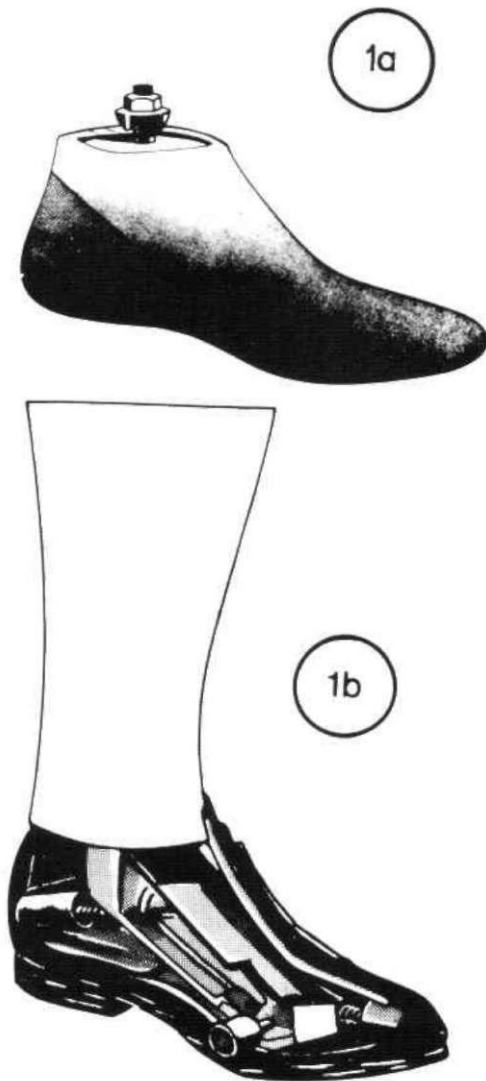
Fig. 1a. Conventional SACH foot. Fig. 1b. Child Amputee Prosthetic Project (CAPP) foot, see text.

Methods

Subjects

Five children, one boy and four girls, participated in the study. Their mean age was 11 yrs 3 months (±25·7 months), mean height was 139·2 cm (±6·2 cm), and average weight was 36·6 kg (±11·9 kg) when wearing their prostheses. The average weight of the prostheses with the SACH foot was 2·8 kg (±0·6 kg), while the mean weight of the prostheses with the CAPP foot was 2·7 kg (±0·4 kg). All the children were unilateral lower limb amputees who had worn a prosthesis for at least four years. Two of the children were above-knee (AK) amputees; one acquired the amputation as a result of an automobile accident and the other as a consequence of fibrosarcoma. The three remaining children were knee disarticulation (KD) amputees; etiologies were congenital, automobile accident, and gangrene. Two of the KD amputees wore prostheses with 4-bar modular knee units, while the other children had been fitted with constant-friction knee joints. Each child normally wore the SACH foot and was tested wearing first the SACH foot and then the CAPP foot on the same prosthesis. The evaluation of the prosthesis fit and function was done when each child was wearing his/her regular prosthesis.

Experimental procedures

Each child was asked to assume seven different positions while standing on a 40×60 cm force platform (Kistler 9261A) which was flush with the surrounding floor. The manoeuvres that each child performed were: (1) standing with eyes open with feet shoulder width apart and arms relaxed in a comfortable, dependent position at the sides, (2) from the initial position, weight-shifting forwards and holding, (3) from initial position, weight-shifting backwards and holding, (4) weight-shifting left and holding, (5) weight-shifting right and holding, (6) standing with feet together, medial borders touching, and (7) standing with feet together, medial borders touching and eyes focused on a target placed one metre from the child at eye level. All positions were maintained for ten seconds. The locations of the feet were the same for positions 1 through 5; similarly, foot placements for positions 6 and 7 were not changed.

The total base of support for each child was determined from the outlines of the child's shoes which were traced on graph paper taped to the surface of the force platform. The perimeter of the total base of support consisted of: (1) a line passing through the most posterior point of each heel, (2) a line passing through the most anterior point of each shoe, and (3) lines drawn along the lateral border of each shoe, thereby producing a

quadrilateral. The intersection of the two diagonals (A) of the quadrilateral was defined as the geometric centre (GC) of the total base of support (Fig. 2).
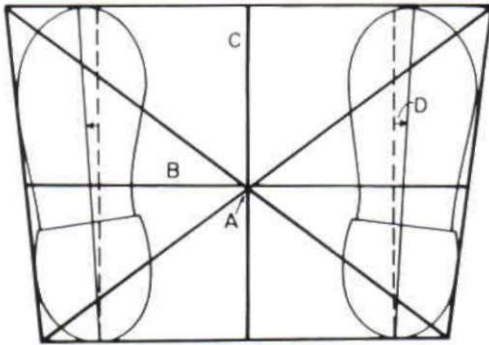
Fig. 2. Total base of support. Geometric centre (A), lateral width of base (B), anterior-posterior length (C), out-toeing angle (D).

locations of the COP for normal standing and forward, backward and lateral leans were plotted on the footprints. Locations of the various mean positions were quantified as polar co-ordinates (r, θ) as shown on Figure 3.

Fig. 3. Functional base of support for a right amputee. Excursions of centre of pressure (COP) for normal standing (N), leaning forwards (F), leaning backwards (B), leaning left (L), and leaning right (R). Geometric centre (GC) of functional base (B).

The foot and stance dimensions for each child were calculated with respect to the GC of the total base of support. The anterior-posterior length of the total base (C) was determined by a line drawn perpendicular to the heel line, passing through the GC and intersecting the top and bottom of the quadrilateral figure; the angle of toe-in or toe-out (D) was measured relative to the line perpendicular to the heel line. The width of the total base of support (B) was determined by a line drawn parallel to the heel line, passing through the GC and intersecting both sides of the quadrilateral.

Centre of pressure (COP) excursions within the base of support resulted in calibrated voltage variations in the force platform which were recorded on a polygraph (Grass 7B). The analogue records of the rectangular co-ordinates of the COP were manually digitized with a Hewlett-Packard programmable calculator and digitizer (HP 9830 and HP 9864). Measurements were taken at 100 ms intervals during the 10 sec that each position was maintained. A printer (HP 9862) plot of the absolute excursions of the COP was also produced by the calculator programmes. The relationship between the excursions of the COP in the base of support was determined by overlaying the printer plots on the footprint tracings. Scatterplots and mean

The per cent of the area of the functional base of support in relation to the total base of support was calculated for the five amputee children. The functional base of support was defined by the perimeter of the excursions of the COP made while the child stood normally, leaned anteriorly, posteriorly, and laterally. Perimeter of the functional base of support is shown as a dashed line (–·–·–·–·–) in Figure 3. The distance (r) from the average excursion of the COP from the GC was determined by drawing a line from the GC to the mean location. The angle (θ) of the average excursion of the COP about the GC was measured counterclockwise from a right ray which originated at the GC. Note that any COP position that was *between* 1·57 rad and 4·71 rad fell to the *left* of a sagittal line through the GC of the base of support, while any COP position at an angle *less than* 1·57 rad or *greater than* 4·71 rad fell to the *right* of the centre line. The four corners of the quadrilateral figure were digitized along with the perimeter formed by the excursions of the COP from the five standing

positions. A computer programme calculated the areas.

The variation in the positions of the COP about the mean position was used as a measure of postural stability of the amputee child when standing with the medial borders of his/her feet together and focusing and not focusing on a target. Therefore, the standard deviation of the COP excursions about a mean position was used to compare the amputee stability with and without a specific visual target.

Results

The absolute dimensions of the total base of support for the child amputees were not significantly ($p > 0.05$) different when standing with the SACH versus CAPP foot for either feet apart or feet together. Unless specifically noted, all significance tests were done with Student's t test for paired observations (Marascuilo, 1971). The mean anterior-posterior length of the base was 24·5 cm ($\pm 2 \cdot 1$cm) and was simply a function of the children's shoe sizes. The lateral dimensions of the base of support were related to the positions of the feet, feet approximately shoulder width apart versus feet together. The mean base widths for the SACH foot with feet apart (26·9 cm$\pm 3 \cdot 8$) and feet together (15·3 cm$\pm 1 \cdot 2$) were only 0·1 cm wider than the respective mean dimensions when using CAPP foot. The mean foot angles also showed no significant differences ($p > 0.05$) between the CAPP and SACH conditions: (1) during normal

standing with the SACH foot, the average toeing-out angle was 0·209 rad ($\pm 0 \cdot 126$ rad) and with the CAPP it was 0·220 rad ($\pm 0 \cdot 143$ rad), and (2) while standing with feet together, the SACH condition average toeing-out was 0·185 rad ($\pm 0 \cdot 122$ rad) versus the CAPP condition with 0·129 rad ($\pm 0 \cdot 059$ rad).

During normal standing the average COP with the CAPP foot had a tendency to be located closer to the GC of the total base of support than the mean COP for the SACH foot; however, statistically this difference was not important ($p > 0.05$). The relationship between the mean COP to the GC for normal standing was 39 per cent of the distance of the COP from the heel line for the SACH foot and 43 per cent of the distance for the CAPP foot.

During normal standing and during leaning forward and backward, the children always favoured their normal side (Table 1); for a right amputee the COP was located to the left of a sagittal line through the geometric centre and in left amputees the effect was in the opposite direction. When the children were volitionally weight-shifting to the left or to the right, the COP moved to the side of the shift, regardless of the side of amputation. The SACH foot appeared to permit a greater weight-shift backwards, left, and right than did the CAPP foot.

As expected, with the almost identical absolute dimensions of the total base of support, the mean area of the total base of support for the

Table 1
Polar co-ordinates of centre of pressure locations[a]

Direction	r	SACH Right amputee θ	SACH Left amputee θ	r	CAPP Right amputee θ	CAPP Left amputee θ
Normal	3.7(1.4)[b]	3.71(L)[c]	0.46(R)	3.9(1.9)	3.35(L)	0.91(R)
Forward	6.4(1.2)	2.08(L)	1.10(R)	7.2(1.6)	2.39(L)	1.06(R)
Backward	6.8(1.2)	3.74(L)	5.75(R)	5.5(2.8)	3.77(L)	6.23(R)
Left	9.1(2.9)	3.24(L)	2.60(L)	6.6(1.9)	3.58(L)	1.98(L)
Right	6.7(1.4)	6.21(R)	0.18(R)	3.9(2.5)	0.83(R)	0.82(R)

[a]The distance (r) in centimetres of the mean position of the centre of pressure from the geometric centre and the angle (θ) in radians of the mean position (see Figure 3 for example).
[b]Mean value with ± 1 standard deviation in parenthesis.
[c]Note that the letter in parentheses, L (Left) or R (Right), refers to a mean centre of pressure location to the left or right of a sagittal line through the geometric centre of the base of support.

SACH foot did not significantly differ from that of the CAPP foot (p>0·05). The mean area of the base with the SACH foot was 689·9 cm² (±121·2 cm²) and 704·7 cm² (±182·3 cm²) for the CAPP foot. However, the functional base of support for the SACH foot was significantly (p>0·01) greater than the CAPP. The mean area of the functional base of support was 83·4 cm² (±30·8 cm²) for the SACH foot and 40·4 cm² (±12·0 cm²) for the CAPP prosthesis. Thus the amputee children wearing the SACH foot used 12 per cent of their total base of support compared with those same children wearing the CAPP foot who used only six per cent of the total base of support available to them.

During each task of standing or sustained weight-shifting, the COP constantly fluctuated about the mean position (Table 2). The standard deviation of the COP fluctuations about the mean position provided a measure of stability during weight-shifting. Although the variability of the anterior-posterior excursions were always greater than in the lateral directions, no

significant (p>0·05) differences were demonstrated between the SACH and CAPP conditions for any of the postural tasks during normal foot placement.

When the amputees stood with their feet placed together, with differing visual conditions, they consistently had greater stability with the CAPP foot than the SACH foot in both anterior-posterior and lateral directions (Table 3). Even with the small number (4) of comparison conditions, i.e., Anterior/Posterior and Lateral with and without target for SACH versus CAPP, there still was less than a 25 per cent probability (Sign Test; Marascuilo, 1971) that the consistently larger SACH COP fluctuations were due to chance alone.

With the CAPP foot, the presence or absence of a static visual target had no significant (p>0·05) effect on either anterior-posterior or lateral stability. With the SACH foot, however, the lack of a specific focusing point in the field of view had a pronounced influence on lateral stability. Without a target, the COP lateral

Table 2
Average standard deviations (mm) for amputees—feet apart

Standing	SACH		CAPP	
	A/P	Lat	A/P	Lat
Normal	6.1(3.2)	3.5(0.6)[a]	6.5(4.2)	4.6(2.9)
Forward	8.3(3.5)	5.1(2.4)	8.9(6.4)	5.9(4.4)
Backward	6.1(2.2)	5.9(3.7)	5.1(2.9)	4.5(3.6)
Left	6.1(2.3)	5.4(2.4)	3.4(1.9)	4.2(1.5)
Right	6.1(4.2)	5.3(1.8)	3.7(2.1)	4.8(3.4)

[a]Standard deviation of the values about the mean are given in parentheses.

Table 3
Average standard deviations (mm) for amputees—feet together

Visual condition	SACH		CAPP	
	A/P	Lat	A/P	Lat
Target	5.1(6.5)[a]	6.4(5.6)	2.9(1.2)	3.2(1.6)
No target	4.9(3.9)	7.4(5.4)	3.1(0.9)	3.4(0.8)

[a]Standard deviation of the values about the mean are given in parentheses.

variations for the children with the SACH foot (7·3 mm, Table 3) were significantly (p>0·05) greater than all other conditions examined. No significant (p>0·05) effects were observed in any other pairs of the tested conditions for standing with feet together.

Discussion

Postural stability is affected by the overall size of the base of support. There were no practical or statistical differences between the SACH and CAPP prosthetic feet in the width, length, or out-toeing angles for their total base of support when standing with feet apart; the amputee children maintained the same total base of support when wearing either prosthetic foot.

The functional base of support is a good indicator of the area over which the child could move and still maintain her/his balance. Thus, during normal standing, the COP may be expected to be positioned equally between both feet and near the middle of the base of support. Murray et al, (1975) found that the mean location of the COP for normal men was 43 per cent of the fore-aft distance of the base of support. The amputee children wearing the SACH prosthetic foot had a smaller per cent distance (39 per cent) than did the normal men, but while wearing the CAPP foot, the children had the same percentage of the distance (43 per cent) as the adult men. Thus, with the SACH foot the children tended to shift the COP closer to the heels during normal standing.

During volitional weight-shifting, the children wearing the SACH prosthetic foot were able to lean further backward, left, and right, while the CAPP prosthetic foot allowed greater movement forward than the SACH. Because of the construction of the CAPP foot, i.e., a non-weight supportive heel which focused the weight at the ball of the prosthetic foot, the child may not have felt that he/she was stable enough to move in a direction where there was a lack of support. The SACH foot provided the support in the heel necessary for stability during backward shifting, while the CAPP foot provided support in the anterior portion of the prosthetic foot.

COP locations for the amputees were affected by the side of amputation; the amputees favoured their normal side. In contrast, Murray et al, (1975) found that with normal adult men,

the mean position of the COP did not relate to the side of the dominant upper limb. There were no comparable data for normal children.

A large functional base area will allow the amputee a greater range of movement over which he/she can maintain balance. The SACH and CAPP prosthetic feet had smaller functional base areas, 83·4 cm² and 40·4 cm² respectively, than normal men (Murray et al, 1975) whose functional base area was estimated to be 96·3 cm². As a percentage of standing height, the functional base area of the SACH foot was 60 per cent and the CAPP foot was 29 per cent, while the functional base area to the total height for the normal men (Murray et al, 1975) was 55 per cent. The SACH prosthetic foot allowed twice the functional base over which movement and balance could be maintained than did the CAPP prosthetic foot. The large difference between the SACH and CAPP feet was probably related to the familiarity that the children had with the SACH foot, the one they normally used.

Even though the actual sizes of the functional bases of support were significantly different between the CAPP and SACH feet, it was interesting to note that there were no significant differences in the amount of COP fluctuations (steadiness) at the extremes of the shifted positions. Comparable steadiness was found in each of the weight-shifted positions for both CAPP and SACH feet. The magnitude of the COP fluctuations may provide important information to the child about the degree of unsteadiness permitted to safely maintain balance.

In assessing the total anterior-posterior base of support available, it was determined from Murray's data that normal men used 54 per cent of the total fore-aft direction possible. The children amputees wearing either prosthetic foot were not able to move over as large a portion of their anterior-posterior base of support as normal men. The per cent area in the fore-aft direction was approximately the same for the right and left amputees wearing the SACH foot, 40·2 per cent and 36·6 per cent respectively. The values for the right and left amputees wearing the CAPP foot were 30·5 per cent and 28·4 per cent respectively.

The dynamic nature of upright balance is such that the COP underfoot fluctuates incessantly during each of the sustained positions. Apparently the movements of the COP result

from contractions and relaxations of the supporting muscles and the shifting of the masses of various body segments. Musculoskeletal proprioception is an important factor in the control of upright posture, but the potent effect of visual proprioception should not be underestimated. The effect of an absent or available target provided evidence for the importance of specific visual proprioception in the control of stance for amputee children. A static planar target failed to affect significantly the postural deviation in the anterior-posterior direction for the amputee children; this finding was similar to that reported for normal children (Zernicke et al, 1978). By comparison, Lee and Lishman (1975) reported a significant decrease in anterior-posterior trunk sway as adults focused on a static nearby object, as opposed to looking at more distance surrounds. A dynamic visual reference system has also been demonstrated to be a potent influence on anterior-posterior postural control for both infants (Lee and Aronson, 1974) and adults (Lee and Lishman, 1975). The strong effect of visual proprioceptive information, however, was evident in the lateral deviations of the COP. There was a significant decrease in lateral sway when the amputee children, with the SACH foot, and the normal (Zernicke et al, 1978) children focused on a target. The target had no comparable effect on lateral sway when the amputee children wore the CAPP foot; with the CAPP foot, fluctuations of the COP were small with or without the target.

Both normal and amputee children have specific postural stability needs which are not simply scaled down characteristics of adults. Prostheses for amputee children, therefore, should be designed to incorporate the biomechanical characteristics of normal children, not normal adults. The CAPP prosthetic foot was designed to provide increased stability during dynamic weight-support in walking or in static weight-support during standing. Our initial postural tests with the new prosthetic foot have provided some unique information about children amputees' stability in general, and about the SACH and CAPP prostheses specifically. A next stage of testing would be to define the alignment criteria to use when the CAPP foot is worn in conjunction with existing prosthetic systems or when the new foot is aligned with a total prosthetic limb specifically designed for the

CAPP foot. Amputee children should then be allowed an extensive familiarization period with the new prosthesis, to experience fully its limits and functional characteristics. Clinical tests on a larger child population may also result in more definitive assessment of the prosthesis; differences and similarities in stability between the two prosthetic feet would then either be proved generalizable or shown to be non-inferential and strictly applicable to only these five children and their immediate situation.

Conclusions

On the basis of the data collected on these unilateral child amputees, the following conclusions were warranted: (1) There was no significant difference in the absolute dimensions, foot angles, or areas of the base of support in normal standing with the SACH versus the CAPP prosthetic foot. (2) During normal standing and during forward and backward weight-shifting, the COP of the supportive forces was always shifted toward the normal limb, regardless of the type of prosthesis. (3) The functional base of support for the SACH foot was significantly greater than for the CAPP foot; the children used 12 per cent of their total base of support compared with those same children who used only six per cent of the total base of support available to them when wearing the CAPP foot. (4) When standing with feet together, medial borders touching, the children consistently displayed less COP fluctuation while wearing the CAPP foot than with the SACH. (5) Visual proprioception had a significant effect on lateral stability when the children were wearing the SACH foot. Focusing on a target did not significantly alter the anterior-posterior or lateral stability when the children were using the CAPP foot.

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The dynamics of walking using the hip guidance orthosis (hgo) with crutches

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Abstract
The variation of ground reaction forces with time for a complete hgo gait cycle using crutches has been synthesized from video recordings and force platform data. This has led to an understanding of the dynamics of hgo ambulation. The results show that when a patient uses the orthosis the crutches provide a subtle control mechanism taking maximum advantage of forward momentum and produce small propulsive forces when needed to make up energy losses.

Introduction

Effective reciprocal ambulation for paraplegic patients has long been the aim of many surgeons. Swing through gait on crutches, with the legs and hips braced by means of long leg calipers and body brace is used by many such patients, but carries the penalty of high energy consumption. Other devices such as Swivel Walker (Edbrooke, 1970; Rose and Henshaw, 1972 and Stallard et al. 1978) and the parapodium swivel walker (Motloch and Elliott, 1966) permit lower energy independent ambulation without crutches, but are limited to flat smooth surfaces. Both of these forms of locomotion suffer from poor dynamic cosmesis and are frequently rejected by patients or their parents, on the grounds that they are so far removed from normal walking.

Rose (1974 and 1979) outlined the theoretical means by which reciprocal ambulation might be achieved by paraplegics with stabilized knees. From this analysis a clearer understanding of paraplegic gait emerged and as a result the Hip Guidance Orthosis (hgo) (Rose, 1979) was

developed (Fig. 1). The mechanics then described omitted inertial considerations for simplicity. Monitoring the ground reaction forces during the gait cycle of a patient using hgo has enabled the dynamics of such reciprocal ambulation to be demonstrated.

Method and equipment

The subject was an eight year old girl with an L2 lesion who is totally flail in the lower limbs after operative procedures, having a lumbar
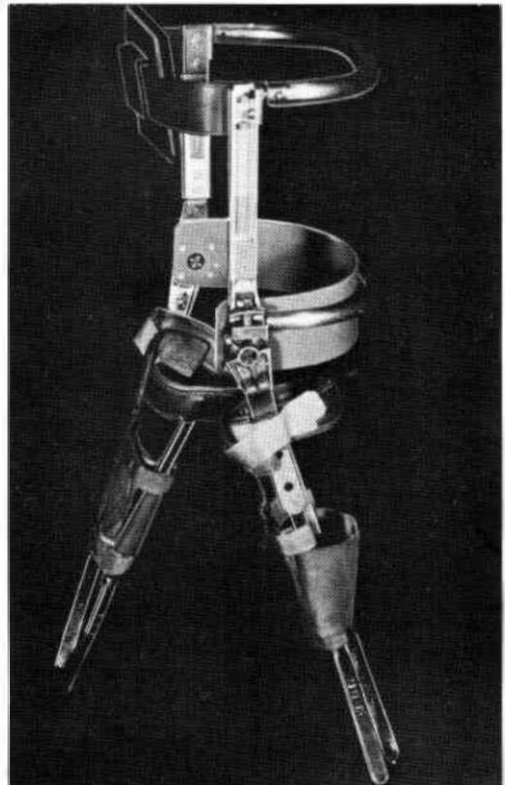

Fig. 1. The hip guidance orthosis (hgo).

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kyphosis, well contained hips, with no hip flexion contractures.

Figure 2 shows the subject wearing the standard hgo which provides freely moving hip articulations with limited flexion extension range (Fig. 3) and abduction guaranteed by a rigid structure. The walking aids used by the subject were Canadian crutches.

Fig. 2. Patient walking in hgo with Canadian crutches.

The dynamic description of ambulation was obtained from video recordings of the patient derived from three orthogonally placed cameras and from the output of a six channel force platform (Kistler 9261A) recorded on a U.V. recorder. Two channels (the vertical force and horizontal force in the line of progression) from the force platform were also displayed on a storage oscilloscope and a video picture of this mixed with the patient/force platform image (Fig. 4) to provide a synchronized reference between the two recording mediums. A diagram of the whole monitoring system is shown in Fig. 5.

An inherent limitation of the force platform is that data will be invalid if more than one limb or crutch is in contact with the measuring surface at

Fig. 3. hgo hip flexion stop.

any one time. Thus the complete picture of ground reaction forces from the two limbs and crutches requires a minimum of four runs. A run was considered representative when the subject walked without hesitation with only the limb or crutch in question striking the force platform.

The temporal relationship between the resulting force patterns for selected runs was determined by matching known events in the gait cycle (e.g. heel strike, crutch strike, etc.) which can be identified both on individual video frames
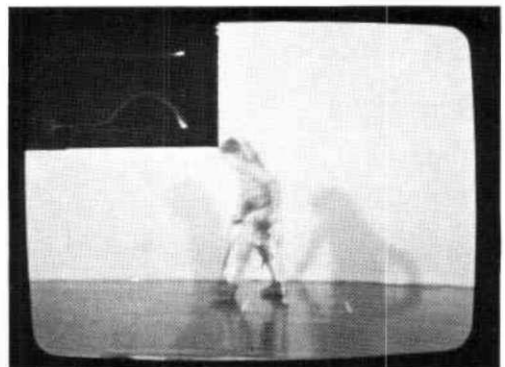

Fig. 4. Composite video picture—used for temporal reference.

1. Video Camera
2. Force Platform
3. Force Platform Electronics
4. U.V. Recorder
5. Split Beam Storage Oscilloscope
6. Video Mixer
7. Video Recorder
8. Video Monitor

Fig. 5. Schematic diagram of gait analysis apparatus.

and on force diagrams, the video vertical sync. signal providing the overall timebase.

Forces in the gait cycle

In the following description any force directions given refer to the force that the limb or crutch exerts on the ground.

The variation of ground reaction forces with time on the lower limbs of the patient and on the crutches shows that momentum of the patient moving forward plays a very important part in the overall function of gait. During stance phase the body has to rise up over the hip before it can take advantage of gravity and drop onto the opposite leg, which has by then swung forward as a pendulum (Rose, 1979). Momentum carries the body a long way up that "uphill" phase but a small injection of energy via the crutches which is manifested in the form of a backwards force on the ground is necessary to make up inevitable
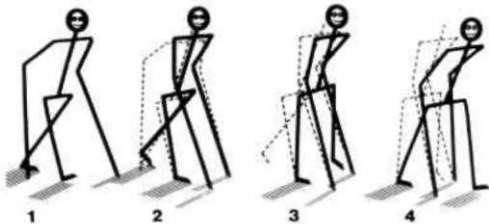

Fig. 6. Diagrammatic representation of hgo ambulation. 1, Right heel strike. 2, Right crutch strike. 3, Left mid swing. 4, Left heel strike.

energy losses. This mechanism is clearly indicated from a careful study of the magnitude and temporal relationships of the various ground reaction forces.

Figure 6 shows a diagrammatic representation of hgo ambulation and Fig. 7 the synthesized force pattern of the gait cycle.

At right heel strike with the left foot starting to unload, the vertical load on the right leg rises rapidly to 0.9 body weight (B.W.), with the vertical ground reaction force on the left crutch
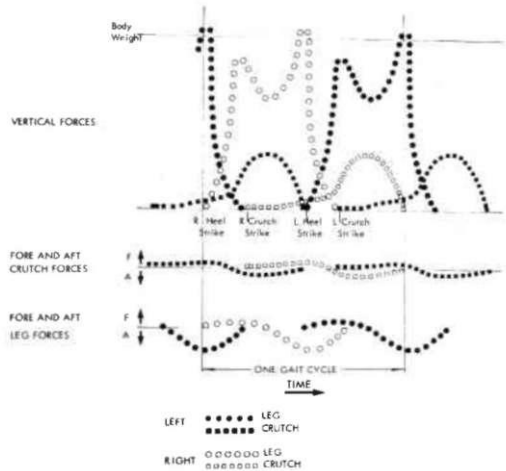
Fig. 7. Ground reaction forces when walking using hgo and crutches.

rising from 0.05 B.W. to 0.22 B.W. As the vertical load on the crutch continues to rise the right leg is then unloaded to 0.65 B.W., at which point the left crutch vertical load peaks at 0.35 B.W. at approximately half way through the right stance phase. The combined support of the right leg and left crutch permits the left leg to swing through due to gravity and inertial reaction to truncal movement. The body continues to move forward under the momentum gained from having dropped onto the right leg and passes through the "uphill phase" with some small assistance from the backwards force on the left crutch making up the inevitable energy losses. On reaching mid stance phase on the right, gravity again propels the body forwards since the centre of mass falls when the hip rotates about the ankle. The right crutch has been previously grounded, well forward, and now exerts only a small force of approximately 0.05 B.W. vertically and 0.01 B.W. forwards to

act as a control element. During this phase the left crutch is progressively unloaded until left heel strike.

Immediately prior to left heel strike the vertical loading on the right leg rises rapidly again to a second peak of 1.1 B.W. This happens as a result of the removal of the supporting load on the left crutch, the lack of an effective supporting (as opposed to control) load on the right crutch, and the inertial effect of trunk rotation in the sagittal plane. Left heel strike completes one half of a description of the full gait cycle and since examination of the force patterns confirmed that the opposite side follows a virtually identical pattern, further description is not necessary.

The transverse horizontal forces on the crutches occur in phase with the vertical loadings and come about mainly because of the angle of the crutches to the ground in the medio lateral plane. Their sense is such that they tilt the body to assist clearance of the swing leg, and the peak load is approximately 0.05 B.W. Transverse horizontal loadings on the lower limb again peak in phase with the vertical loadings of the lower limb in the expected senses according to the inclination of the limb in the medio lateral plane. These forces are too low to be conveniently shown on the graphs of ground reaction forces.

Initiating the gait cycle

In order to commence ambulation the patient leans forwards at an angle of approximately 10 degrees with the legs in line and hips at full extension, support being provided by the crutches held in front at an angle of approximately 15 degrees from the vertical. Increased loading on the right crutch tilts the body to the left and causes the right leg to swing forwards under the influence of gravity. As the right leg swings forwards, the body rotates slightly clockwise on the left leg, when viewed from above, which aids the pendulum effect of the right swinging leg, and the body also moves forward slightly over the left ankle, so increasing right step length. At maximum forward swing of the right leg, the right crutch support is removed and this permits the body to fall forwards, so gaining momentum to initiate the gait cycle previously described at right heel strike.

Clearly, lead off with the left foot would be equally effective.

Discussion

The synthesized force pattern has enabled a satisfactory description of the dynamics of hgo walking to be made. Different patterns of gait have been observed on less ideal surfaces, but the same general dynamic system has fitted these variations in ambulation. The observations of the dynamic mode of use reinforce the criteria contained in the description of the static requirements of hgo ambulation elucidated by Rose (1979). This form of walking for handicapped patients is now well understood, which should encourage the development and wider application of effective orthotic ambulation devices.

With the inherent restrictions of the force platform described it is recognised that the force diagrams obtained are of a composite nature and as such represent an idealized picture. The accuracy of this composition was checked by taking the vertical force x time integral of the four wave forms summed for one cycle and showing that this agreed with the equivalent body weight x time integral for the same period to better than five per cent. Although only four runs are necessary for a complete synthesis, in practice considerably more are required because a correct single strike on the platform cannot be guaranteed when working with a handicapped patient having a short step length. Thus the analysis required the co-operation of a particularly helpful and well motivated patient. The fact that she was able to make a large number of runs without getting tired demonstrates vividly that the hgo does provide low energy ambulation.

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The assessment and description of amputee activity

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Abstract
The activity achieved by a lower limb amputee is usually assessed by clinical judgement or physiological tests. The former is seldom absolute, being affected by factors such as patient age, and is expressed in categories which may not be equivalent to those used by other observers. Physiological testing provides a measure of the patient's capabilities, but not his activity which may be dependent more on social requirements than physical state.

This paper describes a method of questioning the patient using multiple choice answers attracting positive and negative scores, which summate to provide an overall "Activity Score". The procedure takes about 15 minutes and uses the minimum of observer judgement. The technique has been developed over six years and 2400 patients have been investigated. Validation procedures are described, including the use of step counters which show a substantially linear relationship between annual step rate and "Activity Score".

Introduction
If communication in medicine is to be of value, it is necessary to describe patients, their treatment and the results obtained in terms which can be understood by the reader. Thus any account of the rehabilitation of a lower limb amputee must include, not only a description of the patient and his treatment, but also a measure of the activity achieved with his prosthesis. Inclusion of such information could aid the monitoring of patient progress and assist in the evaluation of treatment methods.

Present methods of assessment include:

1. *Performance and/or physiological testing* which provides, usually in a laboratory environment, a measure of the patient's ultimate capability rather than his day to day activity. Whereas the heavily handicapped patient may need to walk as much as his physical state will allow, the less disabled amputee may never need or want to stretch himself to his physical limit.

2. *Step counting* using a miniature electronic counter gives an accurate measure of the activity level reached, (Holden et al, 1979) but would be costly and logistically difficult to apply to a large number of patients. Furthermore it has the disadvantage that modifications to the prosthesis are required.

3. *Clinical judgement* in which the observer questions the patient about his life and capabilities, compares his answers with those given by others and expresses the result in words or categories. This, the most commonly used method has advantages of cheapness and simplicity but is subject to certain inaccuracies. Various patient factors, such as age, site of amputation, gait and concurrent disabilities lead the observer to an expectation of activity which may influence his interpretation of the account given by the patient, and indeed pose problems of scale when trying to obtain some comparison with the "average amputee". This difficulty may be illustrated by considering two imaginary patients:

A is a young man with a B/K amputation, excellent gait and no other disability.

B is an elderly A/K amputee with peripheral vascular disease of the contralateral leg, who walks leaning on 2 sticks.

From these brief descriptions A could be expected to be more active than B, but questioning discloses that "A" has a sedentary occupation and spends his free time reading, while "B" is retired, but walks his dog every day and does some gardening. The difficulty in

quantifying the difference between A and B from their descriptions is increased by the questioning which demonstrates that A is less and B is more active than some of their respective peers. If, to complicate the matter, A is taciturn and complaining while B is cheerful any fair comparison becomes almost impossible.

But even assuming that an assessment can be made how can it be expressed in a way which is understandable to other clinicians who might want to compare A and B with their own patients?

Proposal

Any improved system, based on the patients' usual activity must be unrelated to age, sex, gait and other disability. The method should be quick and simple to apply and use the minimum of observer judgement. Results should be expressed symbolically, rather than by verbal description and ideally should have some known relationship with the number of steps taken annually.

Method

This procedure, first formulated in 1974, refined during the next three years, but unaltered since 1977 has been applied to some 2400 patients. It derives a numerical ACTIVITY SCORE from the subject's answers to a series of formal questions put to him by an interviewer. (Fig. 1). The enquiries cover the ability to don and doff the prosthesis, the length of time it is worn, stairs climbing, details of employment, aids used, domestic responsibilities, regular walking habits and social activity. Some questions require a simple direct response, others are of the multiple choice variety. The interview, which takes about 15 minutes, should be conducted by someone with knowledge of amputee rehabilitation and who has been trained in this method, as he or she may need to ask supplementary questions if the patient appears to be exaggerating or diminishing his capabilities. The details of this training is beyond the scope of this paper but is quite simple and takes only a few hours. "Observer judgement" is limited to asking the patient to reconsider his answers if they appear unlikely. At no time should the interviewer alter a final answer without the patient's agreement.

The completed report sheet is inserted into a marking aid and the figure appropriate to each section determined (Fig. 2). Some of the answers attract simple positive or negative marks, whilst other scores awarded depend on the combination of answers to more than one question. The individual section scores are summed to provide the overall ACTIVITY SCORE, which will lie between -70 and $+50$. It should be emphasized that marking is a straightforward office procedure, taking about two minutes, and requires no interpretation providing that the interviewer has completed the form in detail.

This system appears to satisfy the criteria suggested earlier, but its validation must be considered. Throughout the period of

Table 1. Clinical Assessment

		Very High	High	Average	Restricted	Inactive
A C T I V I T Y S C O R E S	More than + 30	100%	10%	—	—	—
	+ 10 to + 29	—	58%	7%	—	—
	− 9 to + 9	—	32%	56%	3%	—
	− 40 to − 10	—	—	35%	61%	—
	Less than − 40	—	—	2%	36%	100%

Amputee Activity

Name.................................. Number ....

| M | F | M | S | W | Age.......... Level ....

Cause......................................

....

Date of amputation | D | M | Y |
Date of assessment | D | M | Y |

SCORE

Can you—

Yes | No | Put leg on?

Yes | No | Take leg off?

Leg worn Days Per week

Lives—

Alone

With spouse

With relative/friend of same gen.

With relative/friend of younger gen.

In—

House

Bungalow

Flat & lift

Institution

Upstairs—

Can you go? Yes No

Do you go? Yes No

Flights/day

Limb worn
Hours/day

14+

11–14

6–10

3–6

< 3

Employment—Hours/week

How much
Sitting
Standing
Walking
Load carrying

0 ¼ ½ ¾ 1

Journeys—

Cycle

+ Walking distance

↓ Car

Public transport

Do you use stairs at work?

No

Some

A lot

Aids used

Frame

T/Pods crutches

STICKS

2 Sticks

1 Stick

None

INDOORS

2 Sticks

1 Stick

None

OUTDOORS

What do you do with your (spare) time?—

House person

Adults
Working Other

Children
5–16 < 5 Elderly

Total score

Do you do your own—

All Some None

Shopping

Cooking

Cleaning

Clothes washing

Have you help in the house?—who?—how much?

Wheelchair—

Never

Sometimes

Often

INDOORS

Regular walking—

INDOOR

> 75% | 50–75% | 25–50% | 10–25% | Hardly any

OUTDOOR

> 3 miles | 1–3 miles | ½–1 mile | ¼–½ mile | 50m–¼ mile | Hardly any

Never | Sometimes | Often | Always

OUTDOORS

Fig. 1. Report sheet to be completed by interviewer.

AMPUTEE ACTIVITY SCORING

Amputee Activity

Name.................... Number...................

M F   M S W   Age.......... Level...................

Cause....................

Date of amputation   D M Y

Date of assessment   D M Y

SCORE

INSERT FINAL SCORE

[1]

Yes=0/
Each No= −3

If not every day calculate how many hours/day

Can you—

Yes | No   Put leg on?
Yes | No   Take leg off?

Leg worn Days per week

Lives—

Alone
With spouse
With relative/friend of same gen.
With relative/friend of younger gen.

In—

House
Bungalow
Flat & lift
Institution

Upstairs—

Can you go?   Yes | No
Do you go?   Yes | No
Flights/day

STAIRS **[3]**

Cannot= −6
Can but does not
Living in house= −4
Living in flat = −2
Can and does=0
Flights × No/day 2=0
+1 for each additional 2 up to limit of +4

Limb worn Hours/day

+2   14+
0   11–14
−3   6–10
−6   3–6
−9   <3

Employment—Hours/week

How much

Sitting
Standing
Walking
Load carrying

0   ¼   ½   ¾

Journeys—

+ Walking distance

Cycle
Car
Public transport

Do you use stairs at work?

No
Some
A lot

Full time work= +4 basic
Plus work factor ↓
Must total to full time
+4 per ¼ or +5 if standing at machine
+6 per ¼
+8 per ¼

0
0
+2

Check against description **[4]**

[2] AIDS

Aids used

−12   Frame
−6   T/Pods crutches

STICKS

−2   2 Sticks
0   1 Stick

B/K A/K H/D
0 +1 +2   None

INDOORS

−1 0 0   2 Sticks
0 +1 +2   1 Stick
+1 +2 +4   None

OUTDOORS

What do you do with your (spare) time?—

House person

Adults — Working Other   Children 5–16 <5 Elderly

Total Score

[5]

House person +2
Household composition—
Adults—working +3 each
non-working +2 each
Children 5-16 +3 each
<5 +4 each
Elderly/disabled +4 each

INSERT FINAL SCORE

Do You Do Your Own—

	All	Some	None
Shopping			
Cooking			
Cleaning			
Clothes washing			

	All	Some	None
	+1	0	−2
	0	−1	−1
	+1	0	−1
	0	0	−1

Have you help in the house? who?— how much?

Help varies from −1 to −4

Wheelchair—

Never
Sometimes
Often

INDOORS

Wheelchair **[7]**

[6]

Regular walking—

INDOOR

>75% 50-75% 25-50% 10-25% Hardly any

OUTDOOR

>3 miles | 1-3 miles | ½-1 mile | ¼-½ mile | 50m-¼ mile | Hardly any

Sometimes   Always

Never | Sometimes | Often

OUTDOORS

n/p=not possible
▧ =unlikely

n/p	−8	−12	−16	−24	−30		n/p	n/p	n/p	−18
0	0	−8	−12	−16	−24		n/p	−9	−12	−15
+6	+3	−4	−8	−12	−20		−3	−6	−9	−12
+9	+3	0	−4	−8	−12		0	−3	−6	−9
+12	+9	+3	0	−4	−8					

N.B. Frequency of wheelchair use *is not* absolute but is related to amount of outdoor life.

Fig. 2. Marking aid with report sheet inserted (see text).
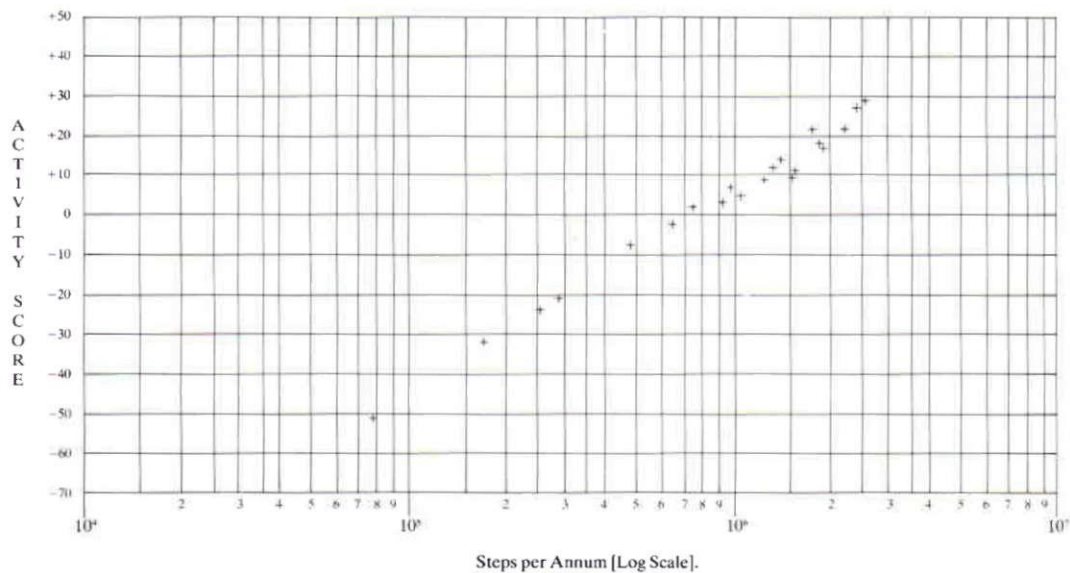
Steps per Annum [Log Scale].

Fig. 3. Annual step count plotted against the activity score confirms linearity of the scale.

development various tests were applied and it was in response to their result that refinements were made. The following validation procedure applies to the final method and is in three parts.

1. Some 390 patients were independently assessed by experienced clinicians and assigned to one of five categories: Very High, High, Average, Restricted and Inactive. These assessments were compared with the activity scores obtained (Table 1).

In each of the intermediate three categories some 40% of patients have scores outside the appropriate band. If the distribution of error was normal we would expect about 20% of those in each category to score either side of the band, but in each case far more score below than above. This indicates either optimism in the clinical assessment or pessimism in the questionnaire method. Examination of clinical records indicate that over optimism is the prime cause of error and indeed all those categorized as Inactive actually scored less than −50. The shift in the three intermediate groups of 11%, 15% and 16% respectively, confirm or are confirmed by the results of a separate small survey using only 3 categories of activity, High, Average or Low which showed an optimistic shift of 12%.

2. The second validation procedure is to test the system's repeatability. In a small number of amputees the process was repeated after an interval of a few months. In every case in which the two scores obtained differed by more than 5 points, a reason was clearly shown in the clinical records. Those whose score had increased had either returned to full time employment or undergone a successful reconstructive operation on the contralateral dysvascular leg in the period between the assessments. In those whose score had decreased, the symptoms and signs of further handicap had appeared and been noted before the second assessment.

3. Finally, it is necessary to correlate, the score with the annual step rate to confirm the linearity of the scale and to equate this to the amount of walking actually done.

A counter using C-MOS logic was designed. (Day et al 1978). This self powered unit, small enough to allow easy attachment to the prosthesis is connected by a thin cable to a flat foot switch which can be fastened temporarily with adhesive tape to the underside of the heel inside the shoe. After wearing the unit for about ten days the subject is questioned and a score derived in the usual way. An external interrogator determines the number of steps taken during the trial. This number is converted to an annual step count and the result plotted against the Activity Score (Fig. 3).

To date 21 patients have been investigated. The annual step rates range between 79,000 and 2,588,000 relating to scores of −52 and +29 respectively. The curve of the score plotted against the logarithm of the annual step count is substantially linear, but work continues to confirm this and to determine the end points. It will be noted that within the range of −50 to +25 an increase of 15 in the score is roughly equal to doubling the annual step count.

Conclusion

The method presented provides a means of assessment which is unaffected by consideration of age, disability etc. The result is described as a numerical score, providing no difficulties in communication, which can be related to an actual step rate with a substantially linear scale.

The method can be used internationally, metrication posing no difficulty, but for use in some societies individual questions, though not their score weighting, might require alteration. Indeed the system could be adapted for use with other locomotor disabilities.

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Myoelectric elbow and hand prosthesis controlled by signals from 2 muscles only, in a 9 year old girl

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Abstract

A nine year old girl with a congenital above-elbow amputation was supplied with a myoelectrically controlled arm prosthesis at the Regional Hospital, Örebro, Sweden, in May 1978. The prosthesis was equipped with an artificial hand as well as an elbow joint. The latter was designed at New York University, for switch control but adapted to myoelectric control in the Department of Clinical Neurophysiology at the Regional Hospital, Örebro. The electric signals from the biceps and triceps muscles were used for the control of hand closing and opening as well as elbow flexion and extension. Two different control methods have been applied and clinically tested.

The first is a three-level method in which slight contraction of biceps/triceps gives closing/opening motions of the hand and a higher contraction level in these muscles gives flexion/extension of the elbow.

The second is a contraction-rate detection method in which slow contraction of biceps/triceps gives closing/opening of the hand and faster contraction of these muscles gives flexion/extension of the elbow.

Both methods have been tested on the patient in a laboratory set-up and in a clinical trial which is still going on. Small electronic control circuits have been designed and placed inside the socket of the prosthesis, which is completely self-contained.

From the different tests performed, the second control method seems to be the most suitable for the actual patient. She is using her prosthesis every day, continuously improving her controlling ability.

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Introduction

Since 1971, young children with congenital below-elbow amputations have been successfully supplied and trained with myoelectrically controlled hand prostheses at the Regional Hospital, Örebro, Sweden, (Sörbye et al 1972; Sörbye, 1977 and 1980). When in early 1978 a 9 year old girl with a congenital above-elbow amputation was referred to the hospital, it was decided to use the same type of prosthetic hand. At about the same time an offer to test an electric elbow, developed by Fishman and Lembeck at the New York University, Post-Graduate Medical School, Prosthetics and Orthotics was received. For several reasons it was then decided to supply the girl with a myoelectrically controlled prosthesis where the hand as well as the elbow were externally powered.

Method

A 6·75 in (17 cm) prosthetic hand of Otto Bock type was chosen, equipped with passive rotation and a quick disconnect. The electric elbow from New York University was designed to be controlled by switches, but it was adapted to myoelectric control by means of some minor electrical modifications. To keep electrodes and wires inside the prosthesis it was decided to use only the two muscles biceps and triceps for control of both the hand and the elbow.

In order to control four movements from two muscles some type of multistate control system had to be used. A multi-state control technique was first presented by Dorcas and Scott (1968). Based upon their idea, Dillner and Hägg (1971) described three different methods to control two movements with one muscle only:

1. A sequence method. Each movement is performed every second time the muscle is activated.
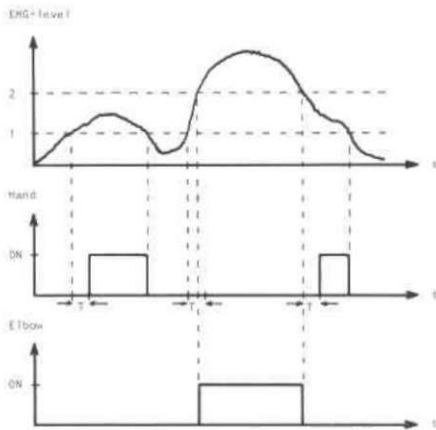
Fig. 1. Function of an EMG-level detector for three-state control (method 2)

2. A method that classifies the instantaneous EMG-level from the muscle as belonging to one of three level groups. The term "EMG-level" throughout this paper should be understood as the actual amplitude of the amplified rectified and integrated surface EMG-signal.

3. A method that classifies the initial EMG-level rate into one of three different categories.

Of these three methods the authors used the two latter ones.

Figure 1 illustrates the function of the EMG-level detector according to method 2. In the upper graph the EMG-level is plotted against time. Assuming that the EMG-level originates from biceps, the result will be that as long as the EMG-level is below the lowest threshold, level 1, there is no output from the control system. An EMG-level that resides in the interval 1–2 during at least a period of time T will start a hand closure. As soon as the EMG-level is found to be outside the interval 1–2 the hand activity is discontinued. An EMG-level exceeding the highest threshold, level 2, will immediately initiate an elbow flexion, which again stops when the EMG-level drops below threshold 2. By introducing the delay-time T it has become possible to operate the hand or the elbow exclusively. The activity from the triceps muscle will operate hand opening and elbow extension in the same way.

The function of the rate detection method (method 3) is illustrated in Figure 2. If again the EMG-level plotted is the one concerning biceps

the result will be that as long as the EMG-level is below threshold 1 there will be no output from the control system. As soon as the EMG-level exceeds threshold 1 a clock is started. After a delay-time T the EMG-level is checked. If the EMG-level is found to be within the interval 1–2 a hand closing motion will be initiated. Should the EMG-level be above level 2 an elbow flexion motion will result. Whatever movement was initiated will continue until the EMG-level drops below threshold 1.

With this method the rate of increase in EMG-level in the initial phase of a muscle contraction determines the output. It should be noted that the EMG-level, after a decision is made, is free to vary to a great extent without affecting the status of the output. The above discussion also applies for triceps and hand opening/elbow extension.

When two control sites are used, for instance over the muscles biceps and triceps respectively, each operating a three-state controller, the result is a five-state controller (generating four
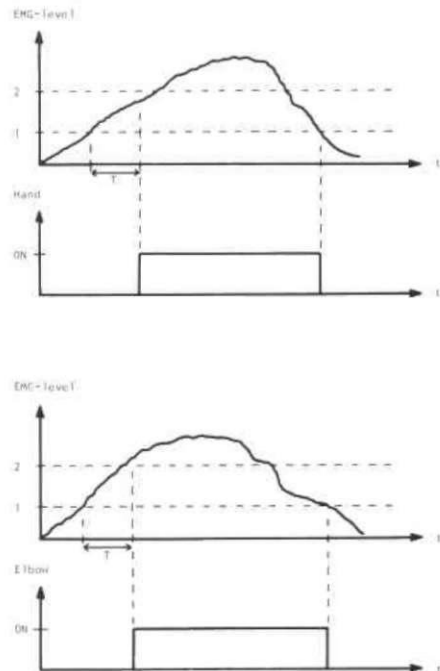

Fig. 2. Function of rate detection in the initial part of the increasing EMG-level for three-state control (method 3).

movements and a resting state). Similar techniques have been described by Childress et al (1971), Schmidl (1977) and the team directed by Scott at the University of New Brunswick (1978).

Application and clinical experience

To find out whether it was possible for the patient to operate a two-site/five-state control system, a test set-up was designed with the necessary electronics mounted on a prototype board to facilitate changes and adjustments. The hand and the elbow were placed on a stand in front of the patient (Fig. 3, top).

Two electrodes, serving the biceps and triceps muscles respectively, were mounted in a prosthetic socket fitted to the patient. In this project the electrode system developed at the Chalmers University of Technology and the Sahlgren Hospital, Göteborg, Sweden was used. The electrode includes amplifier, rectifier and integrator, and the output from the device is a DC voltage-level closely related to the EMG-activity in the muscle, as described by Almström (1977).
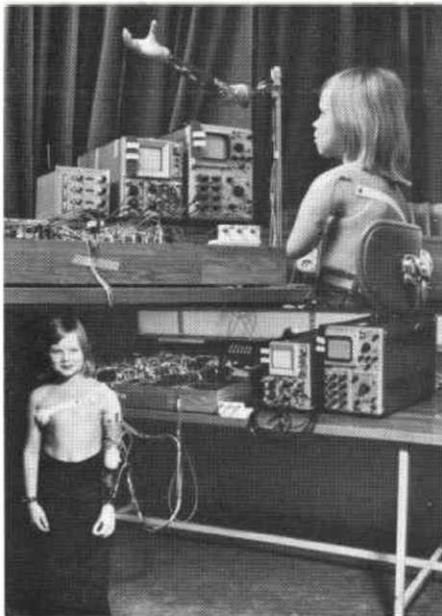
Initially control method 2 was tested (Fig. 1). With the devices arranged as described the girl was able to perform the four different movements of the prosthetic arm after some 15 minutes of practice. Later in the process of training the hand and elbow was attached to the prosthetic socket, thus achieving a test situation very similar to the use of a self-contained prosthesis. This test set up and the assembled prosthesis can be seen in Figure 3, bottom. After the necessary testing and training a miniaturized version of the control system was built and fitted inside the prosthetic socket.

Finally the patient went home with the self-contained arm prosthesis fully mounted.

Control method 2 (Fig. 1) gave the user good control over the four arm movements. There are, however, two drawbacks with this system.

Quite a high EMG-level is required for operating the elbow of the prosthesis. If elbow movements are frequently needed, the repetitive strong contractions of the control muscle will cause muscle fatigue.

Furthermore, while the hand is being used the patient will sometimes find it difficult to keep the EMG-level constantly within the actual interval.

Neither of these two drawbacks is present in the rate-detection method (Fig.2). For that reason, after about 6 months of experience with the patient using control method 2, it was then changed to control method 3. The electronics

Fig. 3. Top, test set-up as described in the text. Bottom, at a later stage in training the hand and elbow are attached to the socket.
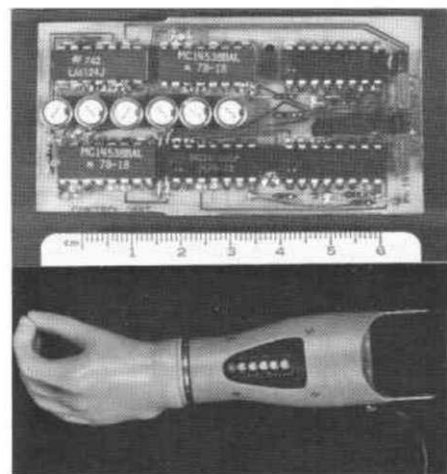

Fig. 4. Top, final version of the miniaturized control circuitry. Bottom, the control circuitry mounted in the forearm of the prosthesis.

were redesigned to function according to this method and the procedure of testing, training and constructing was repeated.

The anticipated improvements with this method turned out to be true. The system worked well and has now been in daily use by the patient for the last 2 years.

The miniaturized control circuitry for method 3 is shown in Figure 4 (top). The bottom picture shows the electronics mounted inside the forearm of the prosthesis. The assembled prosthesis showing the holders for the rechargeable batteries is illustrated in Figure 5 (left). Figure 5 (right) shows the patient wearing the complete prosthesis.
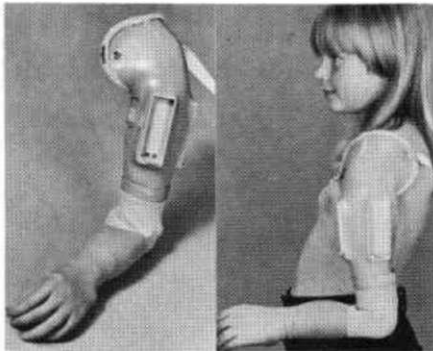

Fig. 5. Left, assembled prosthesis showing the holders for the rechargeable batteries. Right, the patient wearing the complete prosthesis.

The control system has been completed by a circuit that makes it impossible to perform more than one movement at a time; this is helpful to avoid unwanted movements.

When the two control systems were compared after each had been used for 6 months, test results and the opinion of the patient indicated that method 3 was the best. This method, was therefore adopted, the observation time of which now exceeds 2 years.

Improvements concerning the socket design have been made, the batteries have been moved to the forearm socket and some modifications regarding the electrode design have been worked out.

A new and more advanced control system for the hand/elbow prosthesis is now being prepared, according to a principle described by Philipson et al. (1981).

Conclusion

A myoelectric arm prosthesis containing externally powered hand and elbow has been controlled by two muscles only. Two different control methods have been tested, both in a laboratory setup and in clinical use by a 9 year old girl. The device has been functioning very well, with only a couple of minor breakdowns. It has been well accepted by the user. The control method that classifies the instantaneous EMG-level into three groups was useful, but in our opinion the method which is sensitive to the initial EMG-level rate is even better. The latter method therefore has been used in the actual patient during the greater part of the observation time which now exceeds 2½ years.

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Surgical footwear in rheumatoid arthritis—
a patient acceptability study*

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Abstract

One hundred patients with rheumatoid arthritis were questioned about the acceptability of the surgical shoes that they had been prescribed for their foot problems. The approach was made from the records of a surgical supplies manufacturer. While 90 per cent experienced good alleviation of symptoms, 50 per cent had complaints regarding fit, comfort and styling. The implications of changes in the supply of shoes and the staffing of orthotic concerns are discussed, and suggestions are made for the direction of future research.

Introduction

As part of its charter, the United Kingdom Health Service has provided since its inception various forms of orthoses to the general public on the recommendation of a surgical or medical practitioner through the agency of a surgical appliance manufacturer. Special footwear forms one facet of this practice both in the provision of tailor-made shoes and their repair, and in the adaptation of the patient's own footwear to suit their particular lower limb deformity or disability.

The present orthotic organisation (referral by general practitioner or hospital department and then on via an appliance officer to an independently contracting firm) is a complex one. The demand for surgical shoes is also great, considering the number of conditions that are amenable to correction by the appropriate footwear and the statutory allocation of two or three pairs to each patient. The cost is considerable and is increasing because of the cost of materials used and the unavailability of the skilled labour required to make the article. The total bill to the U.K. Exchequer for surgical shoes in 1978 was £8·5 million (D.H.S.S. 1979).

Because of these factors a survey commissioned by the U.K. Department of Health studying the problems of surgical footwear in the Health Service was recently published. This has served to highlight the overall usage of surgical shoes, the methods and problems of design, manufacture and supply, and the level of satisfaction the patient experiences in the treatment of his condition (Bainbridge, 1979).

This present survey was undertaken independently to assess the clinical impression that there was a moderately high level of disapproval with various aspects of bespoke footwear. The authors felt that they were in a particularly fortunate position in the fact that they could approach the problem from outside the Health Service and at the same time be critical of the methods of construction by the parent company which reflect the manufacturing techniques of the industry as a whole. Identification of the areas of dissatisfaction could lead to significant changes in all facets of shoe design and supply, and could indirectly produce worthwhile savings in the total footwear bill.

Patients and methods

The Bainbridge report deals with the whole spectrum of footwear. However, one particularly difficult group of patients who are supplied frequently with shoes are those suffering from rheumatoid arthritis. Usually occurring in middle age, the disease affects women three times as commonly as men, and is likely to affect 2 per cent of the population during their lifetime. The condition starts in the

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foot in 16 per cent of patients, and, running a long protracted course of exacerbation and remissions, the foot is involved at some point in 85 per cent. The common deformities are listed in Table 1, and as these change, the shoe requirements change also.

Table 1. Rheumatoid foot deformities

	Total	Percentage
Splayed forefoot	62	87
Clawed toes	58	82
Hallux valgus	41	57
Flat foot	28	40

A preliminary study confirmed the impression that rheumatoid patients in particular complained most about their footwear, and it was, therefore, decided to set up an enquiry into the various aspects of fit, comfort, style and wear characteristics. Patients that were included were drawn at random from the manufacturer's records. Although there were no facilities for independently checking this, only cases where a firmly committed diagnosis of rheumatoid arthritis had been made by the hospital departments of Rheumatology or Orthopaedics were included in the final assessment.

One hundred patients were sent reply-paid postal questionnaires. The age range was from 38 to 75 years (with an average of 58·3). There was a female to male preponderance of eight to one, and the survey dwelt on problems of the feet (metatarsalgia, bunions, etc.), rather than those of the ankle.

Results

Seventy-one patients returned their forms; 64 being female and 7 male. There was an immediately obvious difference between the number of people who found that their shoes did not relieve their symptoms, and those who were dissatisfied for other reasons. Thus 63 per cent of responders (Table 2) found that metatarsalgia was considerably improved to the extent that their pain disappeared and their walking ability was increased and over 90 per cent

Table 2. Relief of symptoms
(Metatarsalgia and walking ability)

	Total (71)	Percentage
Symptoms relieved	45	63
Symptoms reduced	22	31
Symptoms unrelieved	4	6

achieved significant amelioration of foot symptomatology. This may be associated with the fact that all shoes were used in conjunction with insoles. The most commonly used types are listed in Table 3 and the symptomatic relief corresponding to each is also annotated.

Table 3. Insole use

	Number prescribed	Satisfactory subjective relief of metatarsalgia
Sponge rubber	52	49
Plastazote	13	13
Leather	6	2
Total	71	64

On the other hand when patients were asked to comment on the shoes themselves, rather than on symptom relief, 50 per cent had complaints. It is also noticeable that women complained more often than men, and that even amongst those who found complete resolution of pain, shoes were poorly accepted for other reasons (Table 4).

Table 4. Footwear acceptability
(Excluding relief of symptoms)

	Male	Female	Total
Satisfactory	6	30	36
Unsatisfactory	1	34	35
			71

Table 5. Reasons for dissatisfaction with footwear

	Total	Percentage	Bainbridge percentage
"Difficult to break in"	26	36	14
Fit and comfort	25	35	30
Style	21	29	19
Weight	16	23	23

Table 5 outlines the main reasons for disapproval. Thirty-six per cent of patients remarked on the difficulty they experienced in breaking-in the shoes. This reflects the initial stiffness of the leathers commonly associated with conventional surgical shoes and the painful deformities of the feet that are supposed to fit into them. The overall figure in the Bainbridge survey showed only 14 per cent suffering from this problem, but this rose to 33 per cent when the arthritic foot was considered in isolation. However, it was noted that a large proportion found that their shoes became progressively more comfortable either as a result of persistent

wear or through the ministration of their orthotist. To some extent the weight of the shoe is related to the same phenomenon, and again it was the women in particular who were most concerned by this particular aspect.

Fit and comfort on the other hand does not detract from the number with relief of symptoms. Many found increased ease in walking, but still experienced chafing over bunions and clawed toes, and poor fit in the heel which had been made wider to allow entry of the splayed forefoot.

The complaints about styling were exclusively from women (29 per cent of the total). The commonest cause for dissatisfaction was the inability to match shoes with elegant fashion, restricting the subject largely to the wearing of trousers. There were also those who were at pains to point out that while the sturdy construction of the shoes was reasonable in wintertime, it became impossible to use them in the warmth of summer.

Table 6. Surgical shoe use

	Satisfied with shoes	Dissatisfied with shoes
Worn all day	23	14
Worn part of the day	12	13
Worn occasionally	1	6
Never worn	0	2

The relief of pain associated with weight-bearing is probably reflected in the length of time that the sufferer is prepared to wear the shoe each day (Table 6). Even allowing for disillusionment for other reasons, a large proportion of complainers (77 per cent) and virtually all of the others wore their footwear for all or a large part of the day.

Table 7. Supply problems

	Total	Percentage	Bainbridge percentage
Not enough pairs	20	28	35
Difficulty with re-ordering	16	22	15
Too long to make	12	17	13

Problems of supply have already been mentioned, and are outlined in Table 7. Each of the three main criteria here are interrelated. When shoes need to be repaired or replaced there is often a long chain of command with attendant waiting periods built into the system. Frequently shoes are replaced on an existing

prescription without further measurement to take into account changes in foot shape. Also shoes take time in construction because most stages require individual attention, and it is not uncommon for patients to wait weeks or even months for their shoes to arrive.

Discussion

The problems of the rheumatoid foot are multifactorial in terms of symptomatology, deformity and concurrent treatment. Often patients have problems with other joints as well as their feet, although this has not been considered in this survey. Relief of symptoms has usually been the over-riding criterion for success for the surgeon, rheumatologist and orthotist alike, and it is to an extent gratifying that both in this and other published surveys (Jay and Dunne, 1976) the feet of rheumatoid patients can be made functionally painless by shoes and appropriate insoles. It is not the purpose of this paper to consider the merits of the various inserts. but their importance has been stressed.

It is in the areas of complaint that the lesson of this survey must be found. United Kingdom Health Service surgical shoes are manufactured along traditional lines and styles and changing fashions are little considered. New synthetic materials that have been grasped by commercial concerns have been slow to be adapted to orthotic use. Certainly the complaints of stiffness and difficulty in breaking-in of shoes can easily be overcome by the use of soft leathers, and weight can be reduced by using non-leather soling material.

Style on the other hand is a much more difficult problem, particularly with the rheumatoid patient who is usually female. Fashion can give her a tremendous psychological boost at a time when middle age and a potentially chronic deforming illness often have to be faced in combination. It has long been known that the wearing of shoes is influenced firstly by fashion or sexual attraction, secondly by status and only thirdly for foot comfort and protection (Rossi, 1978), but the very nature of the deformity means that the foot is unsuitable for crushing into a stiletto-heeled, winkle-picker (but then what extremity is?). However, it should be pleasing to the ingenuity of the orthotist and surgical shoe manufacturer to devise a product

that approximates in appearance to those that may be found in the High Street store. It may be necessary to investigate further the possibility of adapting production line techniques that are used in the shoe industry. Already the colours available to the U.K. Health Service patient are more than adequate, and in fact the majority of shoes are made in brown or black. It is not desirable to follow all the vagaries of fashion in view of the tremendous cost that this would entail. However, the most expensive shoe in terms of cost-effectiveness is the one which the patient rejects and ultimately remains unused in the wardrobe.

Recent Department of Health directives have recommended increasing the provision of shoes to three current pairs. This will relieve directly the concern patients feel that they will be inconvenienced when a pair wears out or has to be left with the appliance officer for repair.

Greater use could be made of direct contact between the patient and his orthotist, whether by easier prescribing for stabilized feet, or by running combined out-patient sessions with clinicians which would enable some short-cutting of the chain of command that prevails in the U.K. Health Service. However, the problems associated with the length of manufacture may be more resistant to cure. It is known that the number of experienced shoe-makers is declining because of retirement, and the lack of apprentices in training. This may only be relieved by increased research into new production methods using non-standard materials, and this in itself may help the lot of the patient with the painfully deformed foot.

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Cost effective moulded seating for the handicapped child

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Derbyshire Royal Infirmary, Derby.*

Abstract

For many severely handicapped children requiring external trunk support there is probably no better solution than to provide custom moulded seating. This will improve the patient's posture, reduce the occurrence of pressure sores and facilitate such activities as feeding. However, if large numbers of patients are to be supplied with this type of equipment, it is important that it should be manufactured at the lowest cost compatible with an acceptable quality.

These manufacturing problems have been studied in considerable detail and a production method using vacuum consolidation casting together with a modified vacuum forming process has been developed. This has made it possible to produce custom moulded seating efficiently with the minimum of capital equipment. Much attention has been paid to the final appearance of the article and this has been enhanced by the use of commercially available items for the supporting structure and for the finishing of edges, etc.

It is suggested that other orthoses could be redesigned for production using an approach similar to that described in this paper.

Introduction

The severely handicapped patient may have difficulty in maintaining a comfortable seating position and this problem is frequently solved only by fitting pads, cushions, etc. to a standard wheelchair. If one considers the patient with a spinal deformity and associated problems, a conventional wheelchair will offer mobility but often with comfort and posture a poor second. In

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providing functional seating for the handicapped the main objective is to enable the patient to enjoy a comfortable and secure posture with the maximum independence and mobility.

One solution to these problems is the provision of a moulded seat and this has been shown to be successful by workers at Mary Marlborough Lodge, Oxford (Nicholas and Strange, 1971) and Chailey Heritage (Nelham, 1975) who have developed the techniques necessary to manufacture these items.

A seat which is individually moulded to the patient is intended to stabilize the pelvis and produce an even pressure distribution. This results in the relief of pressure areas together with improved respiration and a contribution towards the prevention of progressive growth deformities. Furthermore there are social and functional benefits which accrue from the improved posture; the successful moulded seat improves independence and can frequently improve a patient's functional abilities, as well as facilitating the tasks of feeding etc. for the attendant of the severely handicapped patient. In addition, it has been shown by Motloch (1978) that the choice of an optimum posture can significantly reduce spasticity in the athetoid patient.

The Orthotics and Disability Research Centre at Derby has been involved in the supply of custom seating since 1976 during which time considerable experience has been gained in manufacture and use and a number of new manufacturing methods have been developed which make it possible to produce a functional, low cost, device. This seat consists of a moulded polyethylene foam lining with a polyethylene skin to provide rigidity. After fabrication, the seat shell is attached to a tubular framework which provides stabilization and may be used as an interface for equipment such as a baby buggy or wheelchair frame (Fig. 1).
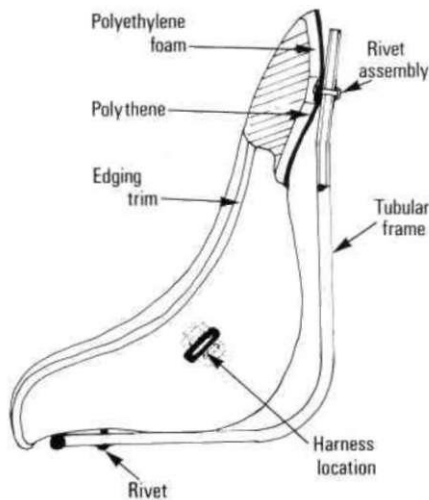
Fig. 1. Top, main features of the Derby moulded seat.
Bottom, finished seat.

Patient assessment and seating manufacture
Clinical assessment

When a patient is referred for a seat, it is likely that a number of other solutions have already been tried without success and it is, therefore, important that the patient's seating problems should be carefully assessed before deciding to provide a specific type of support. Clinical assessment of the patient is carried out by a multidisciplinary team containing the clinician, occupational therapist, engineer and parents or attendant. The assessment will take into account the degree of disability, the presence of deformity and the rehabilitation goals for the particular patient. For instance, if the patient has a fixed deformity, this will to a great extent decide the final form of the seat, whereas a 'floppy' cerebral palsy patient can be moulded in an optimum functional position.

Casting of the patient

The first stage of the manufacturing process is the production of a plaster of Paris cast of the patient in the required position. This is considered to be the most important part of the whole process in that the accuracy of the initial cast will decide the quality of fit of the final item.

The technique used to cast the patient is that of vacuum consolidation in which a thin flexible bag containing lightweight plastic beads becomes rigid when held under vacuum (Nichols and Strange, 1971; Nelham, 1975; Germans et al. 1975).

The bags used for this process are easily manufactured from 0.25 mm latex sheet and filled with 3 mm dia. beads of expanded polystyrene. The moulding process is carried out as follows:

(i) The bag is laid on the floor so that it has an overall even thickness of approx. 75 mm and partially evacuated until an easily pliable texture is obtained.

(ii) The bag is lifted while under a vacuum of 50 mm Hg and placed in the wheelchair to form a basic seat shape.

(iii) The patient is positioned in the wheelchair and the bag is formed around him in the required position to provide the necessary support. This is carried out by two people (engineering technician and O.T.) unless additional help is required in difficult cases.

(iv) The bag is fully evacuated and becomes sufficiently rigid to support the patient.

(v) The patient is left in the chair for 15–20 minutes in order to assess the comfort of the position, after which he is removed and then replaced to give an indication of the repeatability of the required posture.

(vi) Provided that the steps of (v) have been successfully carried out, the patient is removed from the chair and a positive replica is produced using 200 mm (8 in) slab plaster of Paris bandage. Once the plaster has set, the vacuum is released and the cast easily removed. Finally the cast is prepared

for the moulding of the seat by coating it with a plaster slurry to produce a smooth surface finish.

Moulding the seat
Materials used

The moulded seating shell is manufactured from polyethylene foam (Plastazote* density 40–50 kg/m³). This moulded shell is reinforced with a moulded outer skin of low density polyethylene (Vitrathene*).

Moulding process

The plastic moulding is carried out by a low cost vacuum forming process known as drape forming. The drape forming apparatus consists of a wooden framework with a solid base and hinged lid which is a wooden frame holding a high stretch synthetic rubber sheet. The lid can be closed and clamped shut against a rubber seal which excludes air during the moulding cycle, during which a vacuum is introduced causing the rubber sheet to drape itself around any mould within (Fig. 2).

Fig. 2. Thermo-forming of polyethylene foam.

Using this equipment the polyethylene foam shell is produced in the following manner:

(i) The cast is located on a polystyrene bead bag on the drape forming machine. This bead bag serves to stabilize the cast during the moulding process and to provide internal reinforcement.

(ii) The foam is clamped in an aluminium frame and heated in an oven to 140°–160°C. The frame is required to assist handling and to prevent creasing of the material during moulding.

(iii) The cast is covered by a layer of stockinette which serves to improve the surface of the final moulding and acts as a "wick" to ensure a consistent vacuum around the cast during moulding.

(iv) The heated material is placed over the cast, after which the lid of the drape former is closed and clamped and a vacuum is applied to form the foam around the cast. The material is left in the drape former until cool and then removed and roughly trimmed, leaving excess material to allow for final trimming after the second stage of moulding.

Fig. 3. Vacuum forming of low density polyethylene sheet.

A slightly different technique is used to produce the rigid polyethylene backing for the seat (Fig. 3).

(i) The material is clamped in an aluminium frame and heated to a temperature of 140°–160°C until soft.

(ii) With the lid open, an aluminium box is placed on the drape former and connected to the vacuum supply. This box, which can be made in different sizes to suit large or small seats, can be used as a conventional vacuum forming chamber.

(iii) The moulded polyethylene foam shell is placed on the original cast standing within the vacuum chamber covered with stockinette. The heated polyethylene still held in the frame is placed over the top of the box and the vacuum applied to form the outer skin around the shell.

*PLASTAZOTE—Trade name of Bakelite, Xylonite Ltd.
*VITRATHENE—Trade name of Stanley Smith & Co. Ltd.

(iv) The outer skin and the shell are then removed from the machine and the seat is checked with the patient to determine the position of trim lines and the angle of fixation. Finally, the foam and outer shell are bonded together using contact adhesive and then trimmed.

Fabrication and fitting of tubular frame

Following a survey of possible methods of producing a supporting structure for the moulded seat, it was decided to adopt a tubular frame on account of the ready availability of both tube fittings in a large number of sizes, materials and finishes.

The frame is constructed in the following manner:

(i) The frame is bent to shape and assembled using available fastenings from the tube in use.
(ii) By drilling through the tube and seat, a nickel plated steel pin, together with a 25 mm washer, is positioned through the hole and a snap-on cap hammered into position. Four are usually fitted to hold the frame securely to the seat in the required position. Where the pins pass through the foam lining a 25 mm disc is trepanned out and a different coloured plug inserted. If the seat is only required as a wheelchair insert, the frame work is ideal for stabilization of the seat.
(iii) If required the frame can be specifically tailored to interface with some other piece of equipment. One example of this is the baby buggy adaptation for which a standard list of parts has been produced enabling the modifications to be carried out.

Finishing operations
Fitting of straps

Nylon webbing, together with the necessary buckles etc, is fitted into the optimum positions determined during the trial fitting with the patient. If a full harness is required this is bought in from a commercial supplier as a ready made item. Where straps must pass through the seat, injection moulded inserts are pressed into slots in the polyethylene outer skin to act as guides for the webbing.

Finishing of edges

It is important that the standard of overall finish should be as high as possible and, therefore, to improve the appearance of the edges and to cover any sharp corners, a strip of the type of beading used in the automotive industry is fitted around the edge of the outer shell and the polyethylene foam liner is buffed to give a uniform smooth finish.

Conclusions

It has been shown that it is possible to produce a well fitting moulded seat using readily available materials and easily manufactured vacuum forming equipment. Particular emphasis has been placed on two aspects of the design.

Appearance

Probably the most influential feature of any merchandise is its appearance. Indeed it is likely that a patient will reject a seat on grounds of appearance even though it may serve a useful purpose in terms of posture, etc. Earlier work with moulded seating has proved this statement to be true, especially in the case of small children where the mother has objected to the appearance of the seat. Considerable effort has been given to improving the seat in this way and much has been achieved by utilizing readily available manufactured items of high quality.

Cost

There is evidence in the United Kingdom that the potential demand for moulded seating is high. It is essential, therefore, that any equipment supplied to meet this demand is economically viable, in particular labour costs should be kept to a minimum. In the case of the Derby Seat the approximate materials costs are £20–£40 ($45–$90 U.S.) and the approximate time, including casting etc, is between 4 and 6 hours depending on the size and complexity of the final item. These costs could be reduced even further by utilizing to a greater extent items already available which could be purchased for less cost than they could be produced internally. Various possibilities are under consideration as alternatives to present methods.

The design principles described in this paper are equally applicable to other orthotic equipment. It seems likely that a number of

traditional orthoses could be "value engineered" in this manner to produce an article which is more acceptable to the patient and produced at a lower cost.

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Obituaries

Victor Manuel Santana Carlos

On September 14, 1980 Doctor Victor Manuel Santana Carlos died as a result of a sudden heart attack. Dr. Carlos would have been 73 years old on January 20 1981.

Born in Setubal, just south of Lisbon, he studied at the Coimbra University Medical School. Soon after receiving his medical degree he became Director of an Institute dedicated to the rehabilitation of mentally sub-normal children which stimulated an interest in the disabled. He was a physiatrist at the Rheumatologic Institute in Lisbon when the Portuguese governmental authorities invited him to plan the first Medical Rehabilitation Center in Portugal.

He went to the U.S.A. where Dr. Howard Rusk offered him a residency in Physical Medicine and Rehabilitation at the New York University Medical Center. After his return he started the first training school for physiotherapists, occupational therapists and speech therapists in the country and on April 20th, 1966 the Rehabilitation Center at Alcoitao-Estoril opened its doors. He served as Clinical Director until his retirement in 1978.

During the same period he was appointed professor of Physical Medicine at the Institute of Hydrology (Lisbon) and nominated President of the Portuguese Society of Physical Medicine and Rehabilitation. Invited to become National Secretary of Rehabilitation International he became a member of its Council.

He was also a Council Member of the International Medical Society of Paraplegia and Member of the European Academy of Rehabilitation Medicine and the International Committee of Human Relations in Rehabilitation. Furthermore he was invited to serve on the Education Committees of the International Society for Prosthetics and Orthotics and the International Federation of Physical Medicine and Rehabilitation.

He was elected President of the Ibero-American Association for Rehabilitation of the Disabled and as such presided over the organizing committees of the first Ibero-American Congress on Rehabilitation held in Alcoitao Portugal in 1970. He held the same position at the 1st European Conference on Rehabilitation—Rehabilitation International also held in Portugal in 1974.

He was a Consultant for the Portuguese Ministry of Overseas Territories, planning the Medical Rehabilitation Centers in Luanda—Angola and Lourenco Marques (Maputo)—Mozambique.

Over the years he played an active part in many international meetings, presiding over congress sessions, presenting papers regarding both the rehabilitation of the disabled and the training of medical and paramedical staff in rehabilitation.

In 1978 he was honoured by the Portuguese Ministry of Social Affairs receiving the Gold Medal of the year for his services to the disabled in his home country.

JOSE ALBERTO FARIA
SIDNEY FISHMAN

Gunnar Holmgren

On the 11th of November 1980 Gunnar Holmgren CPO and MD honoris causa and managing director of the Een-Holmgren Orthopaedic Company, Uppsala, Sweden, died from a cardiac infarct.

Gunnar Holmgren was born in the north of Sweden in 1918. He began his professional training in the orthopaedic workshop of Vanföreanstalten, Stockholm, in 1934.

At the age of 26 years he was appointed chief prosthetist in Gothenburg. He made numerous visits to orthopaedic and prosthetic centres abroad and worked periodically in Habermanns factory in Frankfurt am Main, in the Roehampton Limb Fitting Centre and in several orthopaedic work shops in U.S.A., run by Veterans Administration, the naval Hospital, Oakland, and University of California, Los Angeles and San Francisco.

He returned several times to these and other centres for his own prosthetic studies and later—by invitation—as an admired specialist and teacher.

In 1957 he founded, together with his colleague Helge Een, COP, a private company for orthopaedic technical service to the University Hospital, Uppsala, and later to the City and County Hospitals of Stockholm. The success of the "Walking School" in Uppsala—primarily founded as a Folksam-donation to the University for a research project—owed a great deal to Gunnar Holmgren.

When it came to the extremely difficult task of helping the thalidomide crippled children in Sweden there was only one choice: Gunnar Holmgren.

His goal was to do the very best for his patients.

His efforts to improve the education of the members of his own profession was successful when a school for orthopaedic mechanics (in 1972) and for prosthetists (in 1977) was started in the "Munksjö-skolan", Jönköping. He generously spread his deep knowledge and profound experience to orthopaedic surgeons, physiotherapists and others involved in prosthetic and orthotic rehabilitation.

He became famous for his technical skill, inspiring enthusiasm and a deep sense of responsibility in all situations. The key to his success was his firm character and sound judgement combined with excellent craftsmanship. He always had a positive approach to life and had made friends all over the world. With the death of Gunnar Holmgren, orthopaedics in the Scandinavian countries and many other countries as well, have lost a great man. We who have been fortunate enough to collaborate with Gunnar have no words that adequately express the loss.

TOR HIERTON
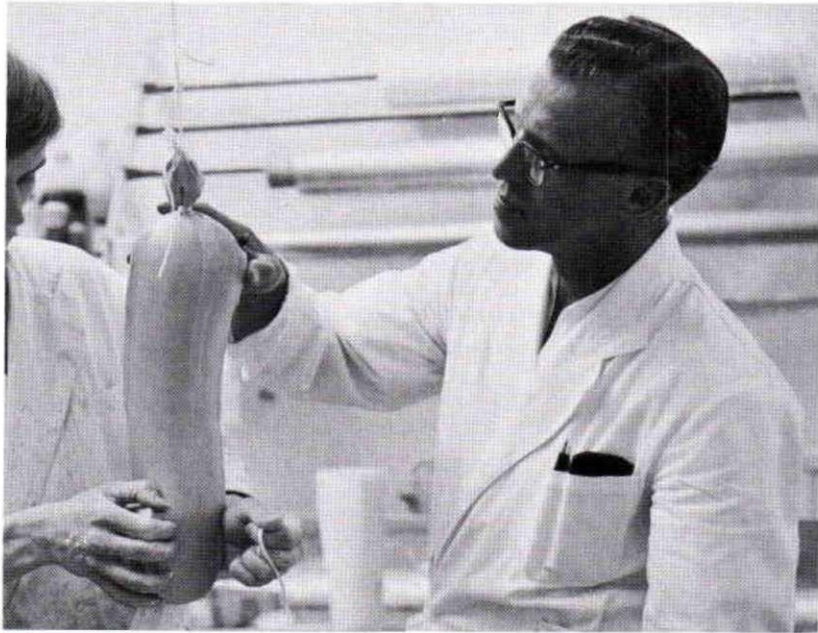
In order to honour the memory of Gunnar Holmgren it has been suggested that a fund be created called *"Gunnar Holmgren's Memory"*, administered by Uppsala University. The aim of this fund is to promote education in prosthetics and orthotics by scholarships for special training and by inviting guest lecturers.

Contributions to this fund will gratefully be received at the following address:

Gunnar Holmgren's Memory
Postal cheque account No. 12 22 93-4
Uppsala, Sweden.

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Deutsch

Klinische Ergebnisse von Beinamputationen
A. K. Agarwal, M. K. Goel, R. K. Srivastava and S. Rastogi
Pros. Orth. Int. **4:3,** *162–164*

Zusammenfassung

Nachkontrolle von 525 Beinamputierten aus der Ambulanz des Prothesen- und Rehabilitations- zentrums Lucknow, Indien, vom Januar 1976 bis März 1978. Die Statistik enthält Angaben über die Geschlechts- und Altersverteilung, Ursache und Höhe der Amputation sowie die Länge und Zustand des Stumpfes. Die Ergebnisse werden an- schliessend besprochen.

Die Reproduzierbarkeit von Messungen des Gangbildes mit dem Goniometer nach Lamoreux
E. Jansen and H. Ørbaek
Pros. Orth. Int. **4:3,** *159–161*

Zusammenfassung

Das Winkelmessersystem nach Lamoreux wurde zehn Mal an der gleichen normalen Versuchsperson am Skelett befestigt zur Messung der Hüft- und Knieflexion und - extension. Es ergab sich eine Standardabweichung innerhalb des gesamten Messbereiches von ungefähr 5% für die Hüfte und 10% für das Knie. Diese Abweichungen hielten sich konstant während der ganzen Versuchsreihe. Der Winkelmesser ist damit für klinische Untersuchungen des Gangbildes gut geeignet.

Die operative Behandlung angeborener Missbildungen der Gliedmassen-1. Teil
E. Marquardt
Pros. Orth. Int. **4:3,** *135–144*

Zusammenfassung

Angeborene Missbildungen der Gliedmassen lassen sich mit neuen operativen Methoden und mit Hilfe ausgeklügelter Instrumente besser behandeln denn je. Damit lässt sich schon im frühen Alter die psychische Belastung des Kindes durch seine Missbildung beheben oder mindestens stark verringern.

Im 1. Teil wird die obere Extremität abgehandelt. Die Methoden werden mit einigen Verlaufsbeispielen dokumentiert. Besprochen werden die Akrosyndaktylie, die endogene Syndaktylie, longitudinal und transversale Defektmissbildungen.

Becken Oberschenkel Orthese zur Frühmobili- sation proximaler Oberschenkelschaftfrakturen
B. F. Meggitt and T. Vaughan-Lane
Pros. Orth. Int. **4:3,** *150–155*

Zusammenfassung

Eine neuartige bewegliche Hüft- Oberschenkel- Orthese wurde entwickelt zur problemlosen Frühmobilisation von Patienten mit Schaftfrakturen des Femurs in der proximalen Hälfte. Wirkungsweise, Verordnung, Anwendung und klinische Frühergebnisse werden dargelegt. Die Qualität der Orthese lässt sich verbessern durch Verwendung des neuartigen Kunststoffgipses Crystona anstelle der üblichen Gipsbinden.

Ein Fall von Versorgung einer Chopart- Amputation durch eine Prothese mit kombinierter End- und PTB-Belastung
N. M. Mustapha, F. McCard and A. T. Brand
Pros. Orth. Int. **4:3,** *156–158*

Zusammenfassung

Die Exartikulation zwischen Talus und Calcaneus einerseits und Naviculare und Cuboid andererseits nach Chopart wurde sehr wahrscheinlich zuerst in Schottland durch Syme 1829 in Edinburgh ausgeführt. Nach guten Anfangsergebnissen verschlechterte sich ihr Ruf wegen der sekundären Klumpfussfehlstellung infolge des gestörten Muskelgleichgewichtes, da die Antagonisten der Achillessehne zu stark geschwächt werden. Dies führte zu Schwielen und Hornhaut an der Spitze der Sohle mit entsprechenden Schmerzen und Schwieri- gkeiten.

Trotzdem wird der Eingriff gelegentlich noch immer durchgeführt und gehört zu den

Möglichkeiten der Rückfussamputationen. Der Orthopädie-techniker kann sich daher durchaus vor die Aufgabe gestellt sehen, einen solchen Fuss zu versorgen. Dazu gibt es verschiedene Möglichkeiten. Unsere Prothese hatte die Aufgabe, funktionell und kosmetisch ein Maximum zu bieten mit einer auf das Stumpfende und auf das Ligamentum patellae aufgeteilten Belastung.

Verbesserte Orthese aus einem neuartigen Gips zur Behandlung distaler Femurfrakturen
T. Vaughan-Lane and B. F. Meggitt
Pros. Orth. Int. **4:3**, *145–149*

Zusammenfassung
Ein neuartiger Kunststoffgips namens Crystona, der im Wasser abbindet, wird vorgestellt und seine Eigenschaften werden mit dem herkömmlichen Gipsverband verglichen. Dabei ist der übliche Gips überlegen zur notfallmässigen Behandlung auf einer Unfallstation. Crystona dagegen besitzt grosse Vorteile zur Herstellung von dynamischen Orthesen zur Frakturbehandlung nach Ablauf der akuten Phase. Dies wird am Beispiel der Oberschenkelschaftfrakturen gezeigt.

Vorgestellt wird eine Oberschenkelschiene mit Kniescharnier zur Behandlung distaler Femurschaftfrakturen. Die Schiene wird mit einem einfachen Gürtel am Rumpf befestigt. Dieses Modell, mit Crystona hergestellt, verringert das Gewicht solcher Schienen um die Hälfte und erlaubt ausserdem die funktionelle Nachbehandlung der frei beweglichen Gelenke des Knies, Sprunggelenkes und Fusses. Verordnung, Anwendung und frühe klinische Ergebnisse schliessen den Beitrag ab.

Español

Estudio clinico de las amputaciones de extremidad inferior—
A. K. Agarwal, M. K. Goel, R. K. Srivastava and S. Rastogi
Pros. Orth. Int. **4:3**, *162–164*

Abstracto
Se presenta un estudio retrospectivo de 525 amputados de extremidad inferior, atendidos en el Centro de Rehabilitación y de Miembros Artificiales en Lucknow, India; desde enero 1976 y marzo 1978. Se discuten las estadísticas sobre edad, sexo, causa de las amputaciones, nivel, longitud y condiciones del muñón.

Estudio de los movimientos en la marcha por medio del goniometro de Lamoreux—
E. Jansen and H. Ørbaek
Pros. Orth. Int. **4:3**, *159–161*

Abstracto
El sistema de goniómetro de Lamoreux, montado—sobre el esqueleto, se aplicó diez veces en la misma— persona normal para medir la extensión de los movimientos de rodilla y cadera. Se ha encontrado que las desviaciones standard son de un 5% en cadera y 10% en el movimiento de rodilla. Esta cifras son las que resultan del estudio de las series como de cada caso en particular.

Tratamiento operatorio de las malformaciones congenitas de las piernas—1ª parte
E. Marquardt
Pros. Orth. Int. **4:3**, *135–144*

Abstracto
Las nuevas técnicas, junto con las instrumentaciones sofisticadas de hoy, han mejorado substancialmente las posibilidades operatorias de las malformaciones congénitas de las extremidades, de tal forma que pueden eliminar ó aliviar el estigma que sufren los niños.

El apartado 1 está dedicado a la experiencia en las extremidades superiores con algunos ejemplos. Los temas tratados son la acrosindactília, la sindactília endógena, deficiencias longitudinales y transversas.

Vendaje de muslo con articulacion de cadera para movilizacion inmediata de las fracturas de tercio superior de femur
B. F. Meggitt and T. Vaughan-Lane
Pros. Orth. Int. **4:3**, *150–155*

Abstracto
Se presenta un nuevo modelo para una pronta y segura movilización funcional de los pacientes con fracturas del tercio proximal del fémur, el "Vendaje de muslo con articulación de cadera". Se informa sobre la mecánica, la prescripción, la técnica de su aplicación y las primeras experiencias clínicas. Se muestra el uso del nuevo vendaje plástico "Crystona" que produce

un vendaje más funcional que la escayola (yeso de París).

Protesis para amputacion de chopart combinada de apoyo en el extremo y en el tendon rotuliano
N. M. Mustapha, F. McCard and A. T. Brand
Pros. Orth. Int. **4:3**, *156–158*

Abstracto
La desarticulación entre astrágalo y calcáneo y el cuboides y escafoides (desarticulación de Chopart) se hizo por primera vez en G. Bretaña por Lyme en Edimburgo en 1829.

Aunque inicialmente fué un éxito, perdió confianza porque se produce una deformación en equino como resultado de la falta de oposición en la contracción del sóleo y gastrocnemio y el tendón de Aquiles. En la parte anterior se producen callosidades que pueden ser muy molestas.

Sin embargo, es una operación que todavía se hace y que tiene sus indicaciones en las amputaciones distales conservadoras de la extremidad inferior. Los protésicos pueden encontrarse con el hecho consumado al que le tienen que aplicar una prótesis. Hay varios modelos pero describimos una prótesis cosmética, funcional y con un apoyo combinado en el extremo del miembro y el apoyo rotuliano.

Nuevo material para vendaje y nuevo diseño funcional de vendaje para fracturas de tercio inferior de femur
T. Vaughan-Lane and B. F. Meggitt
Pros. Orth. Int. **4:3**, *145–149*

Abstracto
Se presenta un nuevo material, plástico, ligero "Crystona" y sus características técnicas comparada con el yeso de París. El yeso de París se considera mejor para el vendaje inmediato de las fracturas en los Servicios de urgencia. La "Crystona" tiene muchas ventajas como vendaje dinámico después del periodo agudo y se demuestra en el vendaje funcional de las fracturas de la diáfisis del fémur.

Se presenta un método mejorado de vendaje rígido "Vendaje Cilíndrico Articulado en Rodilla", con un cinturón de suspensión de un vendaje tubular articulado, sin el pie, en el tratamiento de las fracturas del tercio inferior de fémur. Usando Crystona y el vendaje cilíndrico se ha reducido el peso a la mitad, mejorándo el vendaje con la movilidad de rodilla, tobillo y pie. Se presenta la aplicación técnica y las primeras experiencias.

Français

Etude clinique concernant les amputations du membre inférieur
A. K. Agarwal, M. K. Goel, R. K. Srivastava and S. Rastogi
Pros. Orth. Int. **4:3**, *162–164*

Résumé
Il s'agit d'une étude rétrospective concernant 525 amputés du membre inférieur provenant du centre de prothèse et rééducation de Lucknow, Inde, entre janvier 1976 et mars 1978. La statistique contient des données sur l'âge, le sexe, l'indication et la hauteur de l'amputation ainsi que la longueur et l'état du moignon. Les résultats sont discutés.

Reproductibilité de la mesure de la marche avec un goniomètre de Lamoreux
E. Jansen and H. Ørbaek
Pros. Orth. Int. **4:3**, *159–161*

Résumé
Le système de mesure goniométrique de type Lamoreux a été fixé 10 fois sur un sujet normal pour mesurer les mouvements de flexion et d'extension de la hanche et du genou.

La déviation-standard du total des mesures était approximativement de 5% pour les mouvements de la hanche et de 10% pour ceux du genou. Ces valeurs étaient les mêmes autant pour toutes les séries que pour chacune des séries du test. Le goniomètre est considéré utile à l'analyse clinique de la marche.

Traitment chirurgical des malformations congénitales des membres—première partie
E. Marquardt
Pros. Orth. Int. **4:3**, *135 144*

Résumé
De nouvelles techniques alliées à un instrumentarium sophistiqué ont permis de telles possibilités et chances de succès dans le traitement des malformations congénitales que les troubles psychologiques des enfants traités

ont disparu ou en tout cas se sont bien améliorés.

La première partie est surtout consacrée au membre supérieur et illustrée de quelques exemples. La discussion porte sur l'acrosyndactylie, le syndactylisme endogène, les aplasies longitudinales et transverses.

Une orthèse du bassin et de la cuisse dans la mobilisation précoce des fractures diaphysaires hautes
B. F. Meggitt and T. Vaughan-Lane
Pros. Orth. Int. **4:3,** *150–155*

Résumé
Une nouvelle contention de la cuisse et du bassin a été développée pour permettre une mobilisation précoce facile des patients avec fracture fémorale diaphysaire proximale. Les forces mécaniques en jeu, les indications, les applications techniques et les résultats cliniques à court terme sont présentés. Les avantages d'une utilisation du Crystona-nouveau plâtre plastifié par rapport au plâtre habituel sont démontrés.

Un cas d'appareillage après amputation selon Chopart avec une prothèse prenant appui sur le moignon et le tendon rotulien
N. M. Mustapha, F. McCard and A. T. Brand
Pros. Orth. Int. **4:3,** *156–158*

Résumé
La désarticulation entre d'une part l'astragale et le calcaneus et d'autre par le scaphoide et le cuboide selon Chopart a probablement été entreprise la première fois en Ecosse (Edinburgh) par Syme en 1829. Malgré des résultats à court terme encourageants, cette méthode eût mauvaise réputation à cause d'une déformation secondaire en équinisme, suite à un déséquilibre

musculaire entre les fléchisseurs et les extenseurs. Des callosités et une hyperkératose se développaient au bout du moignon provoquant douleurs et difficultés.

Pourtant ce type d'amputation se fait encore de temps en temps et a sa place dans l'arsenal des possibilités concernant l'arrière-pied. Quelle que soit l'opinion de l'orthopédiste, il peut se trouver devant le fait accompli d'une telle amputation et donc le devoir de construire une prothèse convenable. Il existe diverses possibilités. Nous décrivons une prothèse répondant à des exigences cosmétiques, fonctionnelles et combinant un appui distal ainsi qu'un appui sur le tendon rotulien.

Nouveau matériel de contention plâtrée et améliorations fonctionnelles dans le traitement des fractures distales du fémur
T. Vaughan-Lane and B. F. Meggitt
Pros. Orth. Int. **4:3,** *145–149*

Résumé
Un nouveau genre de plâtre plastifié á mouiller, le Crystona, est présenté, ses qualités sont comparées au plâtre usuel. Ce dernier convient mieux au traitement immédiat dans un service d'urgences. En revanche le Crystona a de grands avantages fonctionnels pour la confection d'une contention dynamique après la phase aiguë qui sont démontrés en prenant l'exemple des fractures distales du fémur.

Une gouttière articulée au genou est présentée, elle est fixée à la taille par une simple ceinture. Fait en Crystona, le poids en est réduit de moitié et permet la rééducation fonctionnelle puisque le genou, la cheville et le pied sont libres. Les indications, l'utilisation et les premiers résultats cliniques sont discutés.

Prosthetics and Orthotics International
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Author Index

Subject Index

Change of Address

Would members please note that changes in address should be notified to the secretariat
in Copenhagen
or,
in the case of members belonging to a National Member Society, to the secretary of that
Society.

Calendar of events

New York University Medical School
Short Term Courses 1981
Courses for Physicians and Surgeons

741 D Lower Limb Prosthetics, 20–24 April, 1981.
751 C Lower Limb and Spinal Orthotics, 27 April–2 May, 1981.
744 B Upper Limb Prosthetics and Orthotics, 15–19 June, 1981.

Courses for Therapists

752 C Lower Limb and Spinal Orthotics, 27 April–2 May, 1981.
757 Upper Limb Orthotics, 1–5 June, 1981.
745 Upper Limb Prosthetics, 8–12 June, 1981.

Courses for Orthotists

753 Lower Limb Orthotics, 15 June–3 July, 1981.

Courses for Rehabilitation Counsellors

750 B Prosthetics and Orthotics, 22–26 June, 1981.

Requests for further information should be addressed to Ms. Sandy Kern, Registrar, Prosthetics and Orthotics, New York University Post-Graduate Medical School, 317 East 34th Street, New York, N.Y. 10016

Northwestern University Medical School
Short Term Courses 1981
Courses for Physicians and Surgeons

703 C Spinal, Lower and Upper Limb Orthotics, 6–10 April, 1981.
603 E Lower and Upper Limb Prosthetics, 20–24 April, 1981.
603 F Lower and Upper Limb Prosthetics, 11–16 May, 1981.
603 G Lower and Upper Limb Prosthetics, 1–5 June, 1981.
633 A Management of the Juvenile Amputee, 22–25 June, 1981.

Courses for Prosthetists

641 Review Course in Prosthetics, 13–15 April, 1981.
631 A Management of the Juvenile Amputee, 22–25 June, 1981.
700 U.C.B.L. and Pedorthic Management of the foot. For specific dates please call 312/649 8006.
800 Pedorthic Management of the foot. For specific dates please call 312/649 8006.

Courses for Orthotists

700 U.C.B.L. and Pedorthic Management of the foot. For specific dates please call 312/649 8006.
751 C.T.L.S.O. For specific dates please call 312/649 8006.
771 Plastic K.A.F.O. For specific dates please call 312/649 8006.
781 U.C.B.L. For specific dates please call 312/649 8006.
800 Pedorthic Management of the foot. For specific dates please call 312/649 8006.

Courses for Therapists

702 C Spinal, Lower and Upper Limb Orthotics, 6–10 April, 1981.
602 E Lower and Upper Limb Prosthetics, 20–24 April, 1981.
752 A Upper Limb Orthotics, 27–29 April, 1981.
622 B Lower Limb Prosthetics, 4–7 May, 1981.
602 G Lower and Upper Limb Prosthetics, 1–5 June, 1981.
632 A Management of the Juvenile Amputee, 22–25 June, 1981.

Courses for Pedorthists

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801 Pedorthic Management, 8–12 June, 1981.
Requests for further information should be addressed to Charles M. Fryer, Director, Prosthetic-Orthotic Centre, Northwestern University Medical School, 345 East Superior Street, Room 1723, Chicago, Illinois 60611.

Continuing Education
Prosthetics, Orthotics and Rehabilitation Engineering at
West Park Hospital

Commencing in June of 1981 West Park Hospital in Toronto, Canada will be offering the following courses:

1.	Below-knee Prosthetic Course	June 15—June 26, 1981
2.	Above-knee Prosthetic Course	June 29—July 10, 1981
3.	Lower Limb Orthotic Course	July 13—July 24, 1981
4.	Upper Limb Orthotic Course	Aug. 3—Aug. 14, 1981
5.	Upper Limb Prosthetic Course	Aug. 17—Aug. 28, 1981

The intention is to offer an additional Spinal Orthotic Course later in 1981 thereby establishing the three key fundamental courses in each discipline.

This programme will be ongoing offering speciality courses in addition to the basic key courses each year, with our goal of providing current up-dated procedural techniques thereby representing continuing education in its correct sense. There will be heavy emphasis placed on clinical management for the Prosthetic and Orthotic participant, also a more comprehensive element in the understanding of Biomechanics and its important role when dealing with Physiology as related to Pathomechanics.

Courses designed to provide information to Allied Services that have contact with P/O through their own roles within the medical field will be offered.

Orthopaedic Surgeons
Pediatricians/Surgeons
General Practitioners
Physiotherapists
Occupational Therapists
Social Workers
3rd Party Paying Agencies—Insurance Personnel

Requests for further information should be addressed to: Mrs. Barbara Mintz, Secretary
Continuing Education,
Prosthetics, Orthotics and
Rehabilitation Engineering at
West Park Hospital,
Toronto, Ontario
Canada. M6M 2J5   Tel. (416) 243–3731.

25–29 August, 1981
Physical Medicine and Rehabilitation, Disability Prevention and Medical Rehabilitation, Stockholm.
Information: Stockholm Convention Bureau, Jacobs Torg 3, 111 52 Stockholm, Sweden.

30 August–3 September, 1981
Rehabilitation Engineering Society of North America (RESNA), Annual Conference on Rehabilitation Engineering. Theme "Technology That Enables". To be held in Sheraton Washington Hotel, Washington D.C.
Information: Convention Management Consultants (CMC), 5401 Kirkman Road, Suite 550, Orlando, Florida 32805, U.S.A.

31 August–4 September, 1981
15th Congress of the International Society of Orthopaedic & Surgery & Traumatology (SICOT), Rio de Janeiro.
Information: Sec. Gen.: Dr. R. De Marneffe, SICOT, 4 rue des Champs Elysées, B-1050, Bruxelles, Belgique.

7–12 September, 1981
The Seventh International Symposium on External Control of Human Extremities
Information: Yugoslav Committee for Electronics and Automation, P.O. Box 356 11001, Beograd, Yugoslavia.

9–11 September, 1981
1st Annual Advanced Course in Lower Limb Prosthetics, New York.
Information: Dr. L. W. Friedmann, Chairman, Department of Physical Medicine and Rehabilitation, Nassau County Medical Centre, 2201 Hempstead Turnpike, East Meadow, New York 11554, U.S.A.

9–11 September, 1981
Medizin–Technik 81. Congress on Medical Technology, University of Stuttgart, Germany.
Information: Tagungsgeschäftsstelle, Medizin-Technik 81, Universität Stuttgart, Postfach 560, D7000 Stuttgart 1, Germany.

16–20 September, 1981
Mediterranean Conference on Medical and Biological Engineering Marseilles.
Information: Prof. G. Kapham, Faculté de Médecine (Nord) Boulevard P. Drummard, 13326, Marseilles, Cedex III, France.

15–20 November, 1981
International Symposium on Design for the Disabled, in co-operation with Israel Design Centre and International Council of Industrial Design. Tel Aviv, Israel.
Information: Israel Society for Rehabilitation of the Disabled, 10 Ibn Gvirol St., Tel Aviv, Israel.

21–23 January, 1982
3rd Meeting European Society of Biomechanics, Nijmegen, Netherlands.
Information: Ton de Hange, Conference Secretary, c/o Miss Cora Rooker, Dept. of Orthopaedics, 6500 HB Nijmegen, The Netherlands.

18–24 April, 1982
Fourth World Congress of The International Rehabilitation Medicine Association, San Juan, Puerto Rico.
Information: Herman J. Flax , M.D., Chairman IRMA IV, P.O. Box 11696, Caparra Station, Puerto Rico 00922, U.S.A.