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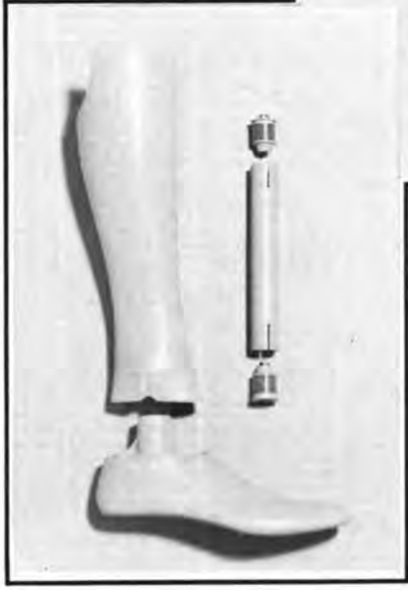

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Executive board of ISPO

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Editorial

Once more activity is building up in preparation for the next World Congress in London in 1983. Elsewhere in this issue a first announcement presents details of venue and date. This simple statement is the tip of an iceberg of committee work and planning. The selection of the site is followed by preparation of budgets and planning of the scientific programme, instructional courses, commercial and scientific exhibitions, film programme, social events, associated visits and the multitude of other details which combine to produce a successful event.

The World Congress is after all to many of the members one of the highlights of the triennium. It is the opportunity to learn and impart new ideas, to meet professionally and socially and to gather as a corporate body to review progress and plan for the future. The 1983 Congress is the first in which the Society will not be joined by another of our international or national collaborating societies as co-sponsor. No doubt we will still be joined by many of their members in enjoying London 1983.

The last meeting of the Executive Board was held in October in London in Imperial College, the site of the Congress. This was to permit Board Members to view the facilities and interact with the United Kingdom Congress Committee, offering comment and advice. The 1983 Congress was, however, only one of many matters which had to be discussed and acted upon. Planning for the Congresses in 1986 and 1989, was also considered. The Canadian National Member Society which made a bid for the 1986 event has now indicated that it wishes to withdraw its offer. Consequently the Board will now be approaching other national member societies inviting them to make a bid. 1986 seems a long time away, but in planning terms, and in the reservation of conference venues, it is not. The Board are most anxious to see the Congress moving to different areas so that the entire membership has from time to time the opportunity of taking part. It is hoped that there will be a good response to this invitation and that those of you who are interested will collaborate through your national member societies to make an offer. Although a great deal of hard work is involved, the return is enormous in terms of the enhanced opportunity for a large proportion of the national membership to communicate with professionals from all over the world.

Another major consideration at the October Board Meeting was the Society's interaction with, and contribution to the establishment of services in, the developing world. As many will have read, a Task Force was formed at the time of Bologna which is now actively fostering relations with the international agencies, such as United Nations and World Health Organisation, with national groups and with other involved professional societies like World Orthopaedic Concern. The major contribution which our Society can make is of course to channel the expertise of the membership to assist in planning, in training and in the establishment and operation of services in these areas. This requires the identification of our members who are willing and qualified to act in different capacities associated with the fulfilment of these aims. This is an exceedingly difficult task and to tackle it requires a systematic listing of members' qualifications and availability. So far we have been unable to fund the computerised professional register which would provide this facility. We have hopes that this is now in sight. In the meantime, however, we have designed a brief form which was published in the last issue of the Journal and which, in the absence of our register, will go some way to meeting our needs. The response to this appeal has so far been disappointing. Please take the time to complete and return the form so that the resources of the Society can be put to the most effective use in the development of our professional activities throughout the less privileged areas of the world.

John Hughes,
Honorary Secretary.

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Fourth World Congress—1983

TIME AND PLACE

The 4th Congress of the International Society for Prosthetics and Orthotics will be held in the Imperial College of Science and Technology from 5th to 9th September, 1983.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

The College is situated in a very pleasant area of London close to Hyde Park with a wide selection of hostels and hotels nearby. The venue offers excellent conference facilities combined with a large exhibition area for both the trade and scientific exhibits.

CONFERENCE AND EXHIBITION ADMINISTRATION

Conference Services Limited has been appointed to undertake the administration of the conference and exhibition.

PROGRAMME

The Congress programme will offer morning plenary and afternoon concurrent sessions covering prosthetics, orthotics and all other aspects of rehabilitation engineering. Amongst the main topics to be discussed are amputation surgery, neuro-muscular disorders relative to extremity orthotics, spinal disorders, spinal cord injury, multiple sclerosis, arthritis and the multiply handicapped person.

SOCIAL PROGRAMME

A programme of social events will be organized for all participants and will include a welcoming reception and a Friendship Evening encompassing the unique character of Imperial College itself and other Institutions within the city of London.

In addition one evening will be devoted to a cruise on the River Thames.

DELEGATE TOURS

Wednesday afternoon has been kept free of sessions so that all participants may have an opportunity to explore London. For those who are unfamiliar with the London scene there will be a selection of interesting tours to choose from covering both the City itself as well as some of the more easily reached sites.

ACCOMPANYING PERSONS PROGRAMME

In addition to the tours on Wednesday afternoon there will be a programme of tours and visits for accompanying persons to places of interest in and around London.

ACCOMMODATION

There is a wide range of hotels and University Halls of Residence costing upwards of £12 per night and within walking distance of Imperial College. Block bookings have been made for this Congress so that delegates may take advantage of favourable rates.

EXHIBITION

The College offers excellent facilities for the exhibition and displays and we anticipate a large number of companies and organizations will participate.

Exhibitors will be offered spaces with or without a shell scheme in two halls in very close proximity to each other. Continuous coffee and tea will be available within the exhibition area and pub-style lunches—sandwiches, beers and wines—will be available for purchase.

The Chairman of the Commercial Exhibition Committee is Michael Devas, and plans of the proposed layout will be available from May 1982, when bookings may be made.

For further information and details of advance bookings please contact:

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Prosthetics and Orthotics International, 1981, 5, 121–128

Modular seating for paralytic scoliosis: Design and initial experience

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Abstract

The conventional wheelchair sling seat provides little or no support to the spine of a child with myopathy or neurogenic muscular weakness. As the spinal muscles become weaker scoliosis may develop with associated deformity, pain and restriction of cardio-respiratory function. If muscle weakness is severe, the resultant fully developed deformity is virtually impossible to treat. Slowing the rate of increase of the deformity is, therefore, the most hopeful avenue of attack. This work addresses the hypothesis that custom moulded seating can increase sitting comfort and slow the rate of progression of spinal curvature in children with paralytic scoliosis, and further, that a range of standard or modular seats can achieve these goals at less cost.

Previous work on this problem has ranged from simply padding the armrest, in order to distribute force over the rib cage, through to custom moulded seating. Our initial experience with custom moulding, using the bean bag evacuation and consolidation technique, produced several comfortable seats although the technique was labour intensive and therefore costly. This led us to attempt to develop a method of providing comfortable seating that would help control spinal deformity at reasonable cost. This paper describes the design of a standardized seating system for school age children with myopathy or neurogenic muscular weakness. Preliminary results indicate that this technique may have advantages over alternative methods of treatment. The radiological study is continuing.

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Introduction

The Regency Park Centre for Physically Handicapped Children accepts educable school age children with significant physical handicaps whose parents reside in the State of South Australia.

It has been a common observation at the Centre that once a child with muscular dystrophy or spinal muscular atrophy becomes non-ambulant and confined to a wheelchair, his spine typically exhibits a progressively worsening scoliosis. Unlike the other large disability groups at the Centre (cerebral palsy and spina bifida), the children in these groups have a steadily progressive disease. Untreated cases with grotesque deformities provide ample anecdotal evidence that early intervention to provide postural support is desirable.

The conventional wheelchair does little to provide support to the spine. The sling seat and back provide neither a firm level position of the pelvis nor resistance to side ways curvature of the spine. In recent years a number of investigators have reported methods of providing improved support to the spine by modification of the wheelchair rather than by conventional spinal bracing. Wijkmans et al. (1978) described the use of the vacuum consolidation casting technique to make 180 custom moulded seats. Carlson and Winter (1978) reported using the technique to produce an unlined polypropylene shell with optional anterior attachments and headrest. Their "Sitting Support Orthosis" is mounted in a block of foam, sized to suit the individual's wheelchair. Strange et al. (1978) have also described a variation of the technique, eliminating plaster-of-Paris moulds, which enables an individual body support suitable for assessment to be made in two hours. The upholstery takes longer to complete. Ring et al. (1978) described the use of vacuum consolidation casting for 180 patients with favourable results.

An alternative approach has been used at the Hospital for Sick Children in Toronto (Gibson et al, 1978; Koreska et al, 1977) whereby blocks of polyethylene foam are cut and fitted into place to suit the patient's contours. They believe that the spine is more resistant to lateral curvature when placed in extension. They therefore incorporate a pad to hold the lumbar spine in lordosis.

Trefler et al. (1978) have developed moulded plastic inserts for cerebral palsied children. Their aim was to meet the specialized seating and mobility needs of this group of handicapped children with an economic modular system instead of expensive custom made seating for each child. We felt that this concept could be adapted to our seating programme for patients with paralytic scoliosis. It has the advantage of wider use of specialized seating, since less well equipped centres could buy the preformed modular components.

This paper outlines our early experience in the use of custom moulded wheelchair inserts initially and the later development and use of a modular seating system to control spinal deformity in children with paralytic spinal conditions.

Materials and Methods

Children attending the Regency Park Centre for Physically Handicapped Children include 24 with Duchenne muscular dystrophy and eight with spinal muscular atrophy.

Although Trefler et al. (1978) recommend that institutions commencing a seating programme should begin with the minimally involved child, we found that staff were more concerned with improving the seating of the severely involved muscular dystrophy children. It was therefore appropiate to begin our seating programme with custom moulded seats. The technique we used was as described by Ring et al. (1978).

In an effort to achieve the aims of comfort and postural control at lower cost, a range of standard (or "modular") seats was developed. In order to span the size range of school age children, and to provide accurate fitting with a reasonable number of seats and backs, it was decided to make four bases and four backs, corresponding to the anatomical data described by Diffrient et al. (1974) for normal 6, 9,12, and 15 year olds. These original dimensions have since been modified to provide increased lateral stability for the spine and to accommodate extra foam padding on the base. The current dimensions are shown in Figure 1 and Table 1.

The design of the bases incorporated a 10 degree recline with grooving to provide resistance to forward sliding and to aid circulation if extra padding was not used. Side supports were provided to encourage midline positioning of the pelvis and to prevent excessive abduction of the hips. The design of the back incorporated a curve in the plan view. The curvature is dependent on the age of the child. There is a recess for the spinous processes. Side wings extending into the subaxillary area prevent lateral bending. The base and the back meet at a circular surface which enables them to be joined at a desired hip flexion angle. The inferior surface of the base is flat enabling the seat to be used in a wheelchair, stroller, MacLaren buggy, car seat or other situations. A lap belt holds the pelvis back in the seat and a padded chest strap

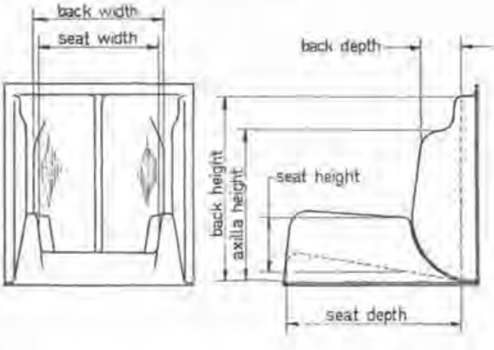


Fig. 1. Modular seat dimensions.

stops the trunk from leaning forward beyond the lateral trunk supports of the back.

The base and back are moulded from 5 mm acrylonitrile butadiene styrene (ABS). The sheet is heated by being placed 25 cm below a single infra-red heat bank with a heat output of approximately 1·1 kW per sq. foot. It is then vacuum-formed over the standard mould using a vacuum forming machine incorporating a reservoir of 0·3 cubic metres which is evacuated to 600 mm Hg vacuum.

Our initial experience has been evaluated in three ways.

1. *Questionnaires*

To obtain the views of the children, parents teachers, and physiotherapists, separate questionnaires were prepared and administered to each of these groups. The questionnaire for children is shown. Replies were received from all twelve members of each group, except for one parent.

2. *X-rays*

In order to evaluate the effectiveness of the modular seat in delaying the onset and slowing the progression of spinal curvature, sitting spinal X-rays were taken at approximately six monthly intervals of all children with muscular dystrophy or spinal muscular atrophy attending the centre. Patients who declined to use the posture support seating served as a control group. In order to reduce the variability of the results, the same attendant accompanies all the children to X-ray and the radiologist maintains a tube-to-film distance sufficient to eliminate magnification and distortion.

3. *Cost assessment*

The costs of the modular seating system and custom moulded seating were compared.

Results

Our results with the custom moulded seats were generally satisfactory in that patients accepted the seats and there appeared to be immediate improvements in posture. However, the manufacturing and fitting time remained high.

1. *Questionnaires on the modular seats*

(a) Children

The majority of children preferred their new seats to their old ones. Some commented they were held up straighter, could see more and could use their hands better. Two children whose seats were padded with 6 mm Plastazote commented that the seat was too hard. One child

Table 1. Dimensions of the modular seats

	Dimensions (mm)						
Seat Size	Back Height	Axilla Height	Back Width	Back Depth	Seat Width	Seat Depth	Seat Height
6 y-o	360	275	230	80	210	315	85
9 y-o	410	295	260	110	260	360	90
12 y-o	450	325	285	110	290	395	90
15 y-o	530	410	340	105	335	425	100

Back height— from the seat to the top of the backrest, excluding the connecting flange.

Axilla height—from the seat to the top of the lateral support, measured along the midline of the lateral support.

Back width— between lateral supports, measured at a point 50 mm below the axilla height, and 25 mm back from the front edge of the lateral support.

Back depth— from the lateral supports to the backrest, measured in the midline 50 mm below the axilla height.

Seat width— at mid-height of the side panels, below the lateral supports.

Seat depth— from the rounded front to the backrest, measured in the midline.

Seat height— from the seat to the top of the side panels, measured at the rear of the seat.

with no padding complained of sticking to the seat. The seats were provided in gloss white and the majority of children stated that they would prefer an alternative colour.

(b) Parents

Most parents preferred the new seats, and some commented that it kept their child sitting straighter. Most felt that the chair had a better appearance than the old seat and that it produced a better position for feeding, made the child more aware of his surroundings and that the more elevated position improved eye contact. Parents generally had experienced favourable comments from other people concerning their child's new seat.

(c) Teachers

This group was very much in favour of the new seats. They commented on the better posture and the resulting improved hand control and easier communication through better eye contact. Most teachers thought the modular seats more comfortable and more attractive than the child's former seating.

(d) Physiotherapists

Most therapists rated the modular seats as better than any previously available. In particular, they rated the child's sitting posture as improved. It was suggested that a lambswool lining would be better than hard plastic, that the chest strap was uncomfortable and that a less "clinical" colour would be an advantage.

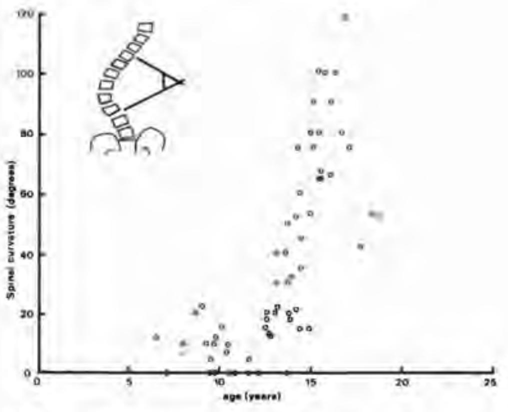


Fig. 2. Thoracolumbar spinal curvature measured from X-rays of the child sitting in his usual wheelchair.

2. *X-rays*

Figure 2 shows a consistent history for the thoracolumbar spinal curvature of children with Duchenne muscular dystrophy. Typically, curves of from 0° to 20° are seen on X-ray until thirteen years of age. Between the ages of 13 and 16 years the curve progresses at a rate of approximately 2·3°per month.

The application of a custom moulded seat to the children with Duchenne muscular dystrophy resulted in an immediate improvement (average 11° for 4 children) (Fig. 3), but subsequent progression at an average rate of 2·0° per month (Fig. 4).

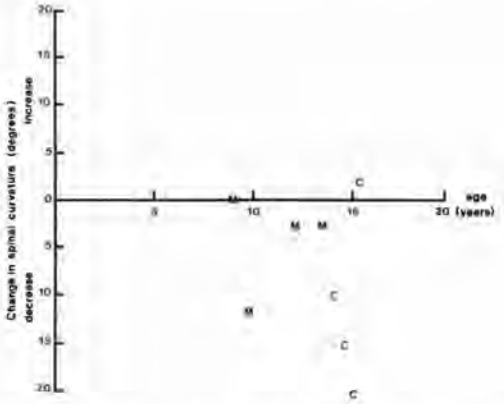


Fig. 3. Immediate effect of change from sling seat to custom moulded seat-C and modular seat-M.

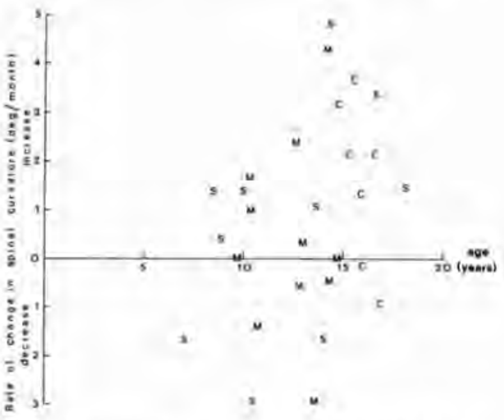


Fig. 4. Curve progression seen on six-monthly X-rays. Sling seat-S, custom moulded seat-C and modular seat-M.

The use of a modular seat for children with Duchenne muscular dystrophy resulted in an immediate improvement averaging 4° for 4 children (Fig. 3). Subsequently, their curve has actually lessened by 0·5°per month (Fig. 4), although this may be explained by the fact that their average age while they have been X-rayed using a modular seat has been only 12 years and 6 months. There are no figures for immediate improvement available for another 6 of the Duchenne muscular dystrophy children with modular seats. Their curves worsened an average of 8° between the last X-ray before receiving a modular seat and the first X-ray after receiving a modular seat, an average of 6 months later (Fig. 5). Subsequently, 3 of the children's curves have deteriorated at an average of 2·5°/month (Fig. 4).

Four of the five children at the Centre with spinal muscular atrophy appear to have worse curves than the children with Duchenne muscular dystrophy of the same age. One of the two people with autosomal recessive muscular dystrophy appears to have a significantly straighter curve than people with Duchenne muscular dystrophy of the same age.

3. *Cost assessment*

The cost of the modular seats has proved to be significantly less than the custom moulded seats. Our orthotist takes 30 hours to cast, fabricate, fit, finish and install a custom moulded seat and 17 hours to complete a modular seat. The cost of materials is similar for both types.

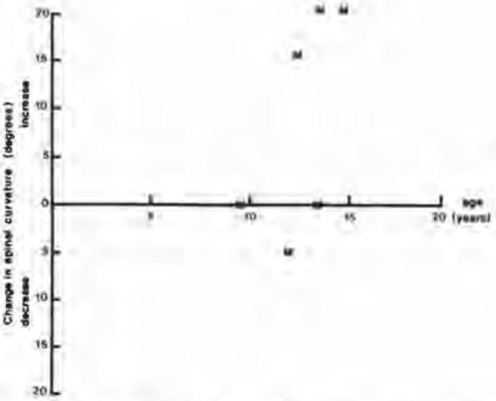


Fig. 5. Effect of change from sling seat to modular seat seen on six-monthly X-rays.

Discussion

The results of the questionnaires were very useful. This resulted in modification of our initial prototypes resulting in better patient acceptance. It was apparent that the 6 mm plastazote foam was an inadequate cushion, and we now use 50 mm of polyurethane foam (25 mm Dunlopillo HR2 and 25 mm Dunlopillo HR4). The lateral seat borders have been raised to accommodate the extra foam padding. While distortion of the foam cushion may not correct the pelvic obliquity, it is felt that comfort is a higher priority. The pressure under the ischial tuberosities and other pressure areas is measured using a Talley Skin Pressure Evaluator when the seat is issued. Extra padding may be used if the pressure is above 60 mm Hg or the patient complains of soreness.

Gloss white was generally rated as too clinical or "like a bathroom fitting". It was felt that a darker colour would be better. We have since found that a satin acrylic paint applied before the vacuum forming process gives a strong durable finish. The seats are now available in white, blue and brown.

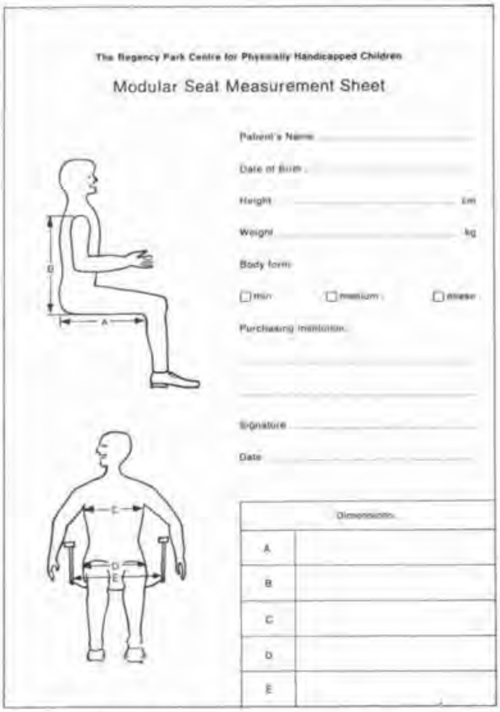
Fears were expressed concerning the seats becoming hot and sticky during the summer months, however this has not proved to be a real problem. The harnesses may need to have a larger chest pad. This will certainly be true for slim children.

The X-ray results are inconclusive at this stage, and it is expected to take another two years to determine whether statistically significant improvements in sitting posture or delay in development of spinal deformity have been achieved.

The cost of manufacture of modular seating is lower than that of custom moulded seating. However, this will have to be looked at in the light of the relative effectiveness of the two methods in delaying or slowing the rate of progression of paralytic scoliosis. We have demonstrated that the use of this seating technique provides initial improved posture with comfort at a cost considerably less than the custom moulded method. The continuing X-ray study will show whether our aims in regard to the spinal deformity have been achieved.

Our original dimensions taken from anthropometric data in the literature were not satisfactory for this group of patients. It appeared that the modular sets consistently

Fig. 6. Adjustable fitting chair used to establish the correct size and configuration of the modular seat. Seatbelts, footplates, armrests and trays are also positioned at this time.



The Regency Park Centre for Physically Handicapped Children

Modular Seat Measurement Sheet

Patient's Name ....

Date of Birth ....

Height .... cm

Weight .... kg

Body form

☐ thin ☐ medium ☐ obese

Purchasing institution ....

Signature ....

Date ....

Dimensions	
A	
B	
C	
D	
E	

Fig. 8. The modular seat measurement sheet may be used by other organizations to order a modular seat kit for a particular child.

differed from the dimensions of seats that were custom moulded for the same patients. We have therefore modified the measurements to provide increased lateral stability for the spine and to accommodate extra foam padding on the base. Our current modules cover our age group satisfactorily.

An adjustable fitting chair (Fig. 6) has recently been completed. This has allowed various combinations of modules to be used during a trial period to determine the best configuration for a particular patient.

We have made these modular seats available to other centres in kit form, with fabrication instructions (Fig. 7). The kit is ordered using a measurement sheet (Fig. 8). One of the advantages of this form of seating is that workshops with moderate equipment can assemble it.

Fig. 7. A complete modular seat "kit".

Our experience with our first modular seats has been reported in this paper. At the time of writing a total of 23 modular seats have been fitted.

Summary

This paper has described a modular seating technique that is being used with physically handicapped children and has compared it with custom moulding. It is being used with children suffering from muscular dystrophy of spinal muscular atrophy, which are paralytic conditions associated with a high risk of spinal deformity. It is also being for postural support of cerebral palsied children. Our aim was to develop a seating system that would provide postural support and comfort to a high percentage of children at reasonable cost. Our initial experience has been encouraging and it has

QUESTIONNAIRE TO CHILD

1. Name: ______________________

2. Do you like your old seat or your new white seat?
   Old New

3. (a) Do you find the new the seat to be:
   Much worse
   Worse
   The same
   Better
   Much better

   (b) Why? ______________________

   ____

4. Are you more comfortable?
   Very much
   Much
   The same
   Less
   Much less

5. How do you find the straps?
   (a) Very comfortable
   Comfortable
   Neither comfortable nor uncomfortable
   Uncomfortable
   Very uncomfortable

   (b) Location:
   Very good
   Good
   Neither good nor bad
   Bad
   Very bad

   (c) Effective holding:
   Very good
   Good
   Neither good nor bad
   Bad
   Very bad

   (d) How do you find the operation of the safety buckles?
   Very difficult
   Difficult
   Medium
   Easy
   Very easy

6. Can you use your hands:
   Worse than before?
   Same as before?
   Better than before?

   If electric, can you use controller:
   Worse than before?
   Same as before?
   Better than before?

   If manual, can you use wheelrim for pushing:
   Worse than before?
   Same as before?
   Better than before?

7. Would you prefer a colour other than gloss white?
   yes no
   If yes, what? ______________________

8. What have other people said about the seat? ____

   ____

9. Do you have any other comments or suggested changes? ______________________

   ____

   ____

Fig. 9. Completed modular seat for a patient with muscular dystrophy.

become standard practice in our centre to seat children with paralytic conditions in a modular seat when they first become wheelchair dependent (Fig. 9). The X-ray study is continuing, to determine whether this technique delays the onset of significant spinal curvature or slows its rate of progression.

Acknowledgements

The authors wish to thank Dr. L. M. Stern for reading the manuscript and making a number of suggestions, Mr. R. Bayly for making the moulds, Mr. E. Drew for his care and attention in making the seats, Mr. N. D. Ring for his help with the custom moulded seating, and Mr. D. A. Hobson for inspiring the modular seats.

REFERENCES

CARLSON, J. M. and WINTER, R. (1978). The "Gillette" sitting support orthosis. *Orth. and Pros.*, **32:4,** 35–45.

DIFFRIENT, N., Tilley, A. R. and BARDAGJH, J. C. (1974). Humanscale 1/2/3. Designed by Henry Dreyfuss Associates. MIT Press.

GIBSON, D. A., KORESKA, J., ROBERTSON, D., KAHN, A. and ALBISSER, A. M. (1978). Duchenne's muscular dystrophy. *Orthopaedic Clinics of North America,* **9:2,** 437–450.

KORESKA, J., ROBERTSON, D., MILLS, R. H., GIBSON, D. A. and ALBISSER, A. M. (1977). Biomechanics of the lumbar spine and its clinical significance. *Orthopaedic Clinics of North America,* **8:1,** 121–133.

RING, N, D., NELHAM, R. L. and PEARSON, F. A. (1978). Moulded supportive seating for the disabled. *Pros. and Orth. Int.* **2:1,** 30–34.

STRANGE, T. V., HARRIS, J. D. and NICHOLS, P. J. R. (1978). Individually contoured seating for the disabled. *Rheum. and Rehab.* **17:2,** 86–88.

TREFLER, E., TOOMS, R. E. and HOBSON, D. A. (1978) Seating for Cerebral-Palsied Children. *Inter-Clin. Inf. Bull.* **17:1,** 1–8.

WIJKMANS, D. W., GERMANS, F. H., VAN DER MEY, N., SOERJANTO, R. and DE SOETE, H. W. (1978). Individually Moulded Seats. Australian Association of Occupational Therapists, **25:3,** 15–20.

Prosthetics and Orthotics International, 1981, 5, 129–134

The TC double socket above-knee prosthesis

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Abstract

The conventional total contact suction AK prosthesis presents several disadvantages, such as difficulty in wearing the socket in a sitting position, difficulty in obtaining a favourable disposition of the stump soft tissues in the socket and difficulty in avoiding stump perspiration problems. In an attempt to solve these disadvantages, a new AK prosthesis with a thermoplastic double socket was developed at the Tokyo Metropolitan Rehabilitation Center for the Physically and Mentally Handicapped. The double socket is composed of an external socket attached to the lower parts and a detachable internal socket, and appears to solve all the disadvantages of the conventional prosthesis. This prosthesis is called the TC prosthesis, an abbreviation for the Tokyo Metropolitan Rehabilitation Center. The first model of this prosthesis, (TC-1) has a metal valve. A new rubber sheet valve was developed to solve several disadvantages of the metal valve in the TC-2 prosthesis. Since November 1978 the TC-1 has been fitted to 295 AK amputees, including 9 bilateral AK amputees, and since March 1980, 145 AK amputees have received the TC-2, including 6 bilateral amputees. Satisfactory results have been obtained with both prostheses.

Introduction

Since the suction socket AK prosthesis was first patented by Dubois Parmelee of New York in 1863, improvements have resulted from the contributions by specialists in various countries. A practical suction socket was developed in Germany at the beginning of World War II, however, use of this prosthesis was limited to Germany until the end of the war. Since 1945 use of the suction socket has spread throughout the world (Thorndike, 1949). Although the suction socket AK prosthesis did not need additional suspension aids, it led to stump oedema caused by the negative pressure in the interspace between the stump and the socket. To solve this problem, the total contact suction socket was developed by Kuhn in 1962.

The value of the modern total contact suction socket is well-known throughout the world. However, the total contact suction socket still has the following disadvantages:

1. difficulty in wearing the socket in a sitting position
2. difficulty in obtaining a favourable disposition of the stump soft tissues in the socket
3. difficulty in avoiding stump perspiration problems
4. difficulty in modifying the socket shape according to the changes of the stump circumference
5. difficulty in obtaining a comfortable fit
6. weight

Many improvements have been made to overcome these disadvantages. For instance, Sinclair (1969) devised a new double socket suction prosthesis which was composed of a rigid polyester socket with various cut-outs and a detachable flexible silicon liner socket. It was hoped that geriatric amputees with heart disease could wear this prosthesis in a sitting position, but it did not work as well as had been hoped. A thermoplastic double socket prosthesis for bathing is produced by the Otto Bock Company. The double socket cannot be separated and has no substantial changes from the ordinary prosthesis.

A transparent polycarbonate socket was introduced by Mooney (1972) and a lightweight adjustable socket was developed by Irons (1977). However, an improved prosthesis which

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solves all the disadvantages described above has yet to appear.

The TC-1 prosthesis

Since the disadvantages listed above are caused mainly by the properties of the socket itself, a new AK prosthesis was devised with a double socket. This new type of AK prosthesis is called the TC-1 (Fig. 1 left), an abbreviation for the Tokyo Metropolitan Rehabilitation Center Type-1 (Koike, 1979).

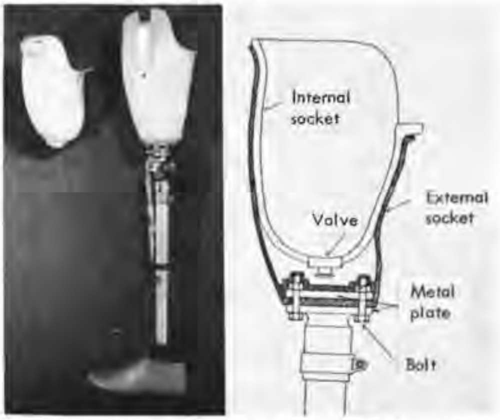

Fig. 1. Left, the TC-1 prosthesis. Right, section through the double socket.

Structure, materials and manufacturing procedures

The double socket is composed of both an internal and an external socket. The external socket is attached directly to the metal plate on top of the lower part of the prosthesis by four bolts without using a wooden block as is normally used in the conventional total contact suction prosthesis (Fig. 1 right). The external socket is constructed to have enough area to maintain sufficient contact with the internal socket and also to have enough space to hold the perspiration coming down through the valve of the internal socket.

The metal screw valve is attached at the bottom central portion of the internal socket (Fig. 2, top).

The two sockets (Fig. 2, bottom) can be attached and detached quite easily by means of a Velcro strap at the outer lateral wall of the external socket pulled through a "D" ring at the lateral upper edge of the internal socket. A low density polyethylene sheet is used for the internal socket and a low density polypropylene sheet is used for the external socket. To manufacture the internal socket a polyethylene sheet, 500 mm square and 10 mm thick, is softened in an oven and then draped over a prepared positive model. It is moulded over the cast by means of vacuum-forming (Wilson, 1974). To make the external socket a polypropylene sheet, 500 mm square 3 mm thick, is softened by heat and then placed cylindrically around the internal socket after an appropriate amount of plaster has been placed over its bottom part. It is welded at both ends (Donaldson, 1977). The thickness of the polypropylene sheet can be changed according to the amputee's weight. A middle density polyethylene sheet can also be used to simplify the welding process.

Fig. 2. Top, position of the valve. Bottom, internal socket with D ring and external socket with Velcro strap.

Advantages of the TC-1 prosthesis:

1. Because of the reduced weight and ease in handling the internal socket, donning is easy in a standing or sitting position (Fig. 3, left). The wearer can easily insert his stump into the internal socket and then into the external socket in one pushing motion (Fig. 3, right). Donning the TC-1 is completed by attaching both sockets together with the Velcro strap. Wearers of the conventional

Fig. 3. Left, donning the internal socket in a sitting position. Right, the internal socket in position prior to donning the complete prosthesis.

total contact AK prosthesis frequently experience the socket slipping off the stump while in a sitting position because the suction cannot be maintained. However, with the TC-1, flexibility of the internal socket allows the stump to maintain close contact with the socket at all times. The external socket can be shifted while sitting for long periods, hence sitting tolerance is markedly increased. The internal socket is also used as a stump shrinker while the wearer is sleeping.

2. Distortion of the remaining muscles and other soft tissues, which could be the cause of abnormal gait patterns, is prevented in the TC-1 because the valve is set at the bottom central portion of the internal socket. This provides a favourable disposition of all the soft tissues along the socket axis and ease in pulling out the cloth from the stump.
3. Slipping off during the swing phase, sweat stains on clothing, and problems hindering the proper functioning of the knee joint mechanism due to perspiration are solved to a great degree by the double socket system and the position of the valve with the TC-1.
4. Changes in contour and circumference of the stump are easily accommodated as the shapes of both sockets can be modified easily with heat application even in a training room. The same prosthesis can be used therefore, from the first day until the last day of the training programme.
5. Wearing the TC-1 is comfortable because pressure between the stump and the well-contoured and flexible sockets of the TC-1 is equally distributed.
6. Adequate contact area of the stump to the internal socket and adequate contact area between the two sockets can be observed through the semi-transparent materials of the sockets without an X-ray examination.
7. The cost of the prosthesis is reasonable because the manufacturing procedures are not complicated and mass production of the sockets is possible.

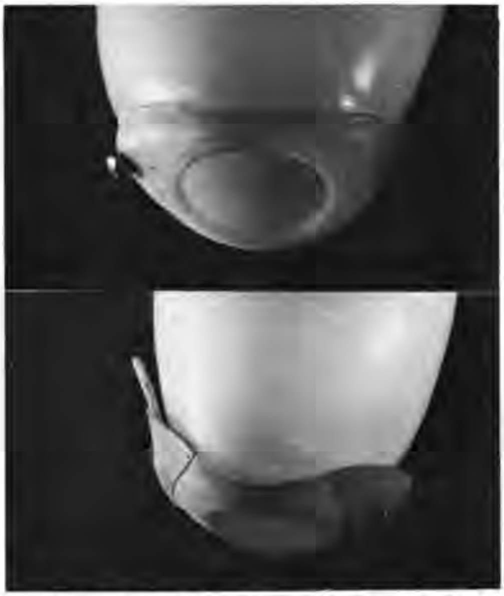

Fig. 4. Top thermoplastic base with valve hole of the TC-2 prosthesis. Bottom, the rubber sheet valve.

The TC-2 prosthesis

The metal valves of the TC-1 are not without some problems. Sometimes injury to the stump skin occurs while screwing the valve into the socket. At other times there is difficulty in maintaining total contact when a bony protrusion exists on the end of the stump. The valve's thickness can also create problems at times. In an attempt to solve these problems a new rubber sheet valve was developed. The thermoplastic base containing the valve hole is welded to the bottom central portion of the internal socket (Fig. 4, top). The valve hole is then covered by a thin sheet of rubber which is held in place by a screw on the posterior side and a hook on the anterior side (Fig. 4, bottom). The prosthesis using this new rubber sheet valve is known as the TC-2.

Advantages of the TC-2 prosthesis

1. As the rubber sheet valve does not have a metal base, the dimensions of the valve hole can be made larger than those of the metal valve (Fig. 5, top). Consequently, pulling out the cloth from the stump and allowing the perspiration to leave the internal socket become much easier.
2. The thickness of the rubber sheet valve is less than ⅓ of that of the metal valve (Fig. 5, bottom) so lowering the knee joint can be minimized in the case of knee disarticulation.
3. The shape of the valve hole can be changed according to the condition of each stump (Fig. 6, top).
4. Since this valve does not cause pain, total contact between the stump and the socket can be maintained even in cases with bony protrusions (Fig. 6, bottom).
5. The rubber sheet valve does not injure the stump skin and can be easily attached.
6. The TC-2 is much more comfortable to wear (Fig. 7).
7. The cost of the rubber sheet valve is far less than the metal valve.

Discussion

Various disadvantages of the conventional total contact suction prosthesis are caused mainly by the hard single socket made of thermosetting plastics or wood. Great efforts have been continuously made to solve the disadvantages by many in the medical profession.

A new total contact suction socket was devised by Sinclair (1969). This prosthesis was composed of a rigid socket with variously located cutouts and a detachable flexible liner socket. The liner socket was made of RTV silicon and the valve was located at the same position as the ordinary socket. Although this prosthesis was aimed at making it possible for geriatric AK amputees with heart disease to wear the suction socket in a sitting position, it resulted in failure. This failure might have been caused by the excessive flexibility of the detachable liner socket and the position of the valve.

A double socket AK prosthesis made of polymethylmethacrylate is produced for bathing by the Otto Bock Company. All components

Fig. 5. Top, the TC-2 valve hole can be made larger than that for the metal valve. Bottom, the rubber sheet valve is ⅓ the thickness of the metal valve.

Fig. 6. Top, the shape of the valve hole may be altered to accommodate the stump condition. Bottom, TC-2 internal socket shown on amputee.

Fig. 7. The prosthesis in use.

except the foot of this prosthesis, including the knee joint, are fabricated in polymethylmethacrylate. The internal socket cannot be removed from the prosthesis and is rigid. While the wearer of this prosthesis can stand in a pool or shower room, the prosthesis cannot withstand the heavy duty required for daily living. The socket can be modified partially with heat application but cannot be modified over the entire socket surface to accommodate a greatly changed circumference of the stump.

The TC prosthesis can be donned in a sitting position because the internal socket is detachable from the prosthesis and the valve is attached to the bottom central portion of the internal socket.

The internal socket of the TC prosthesis is not affected in any way while pulling out the cloth from the stump because the strength and flexibility of polyethylene socket are adequate. This is very convenient, especially for bilateral amputees and geriatric amputees.

A lightweight adjustable AK prosthesis made of polypropylene was developed for geriatric amputees by Irons (1977). This prosthesis cannot be used for heavy duty and its production is rather complex and requires considerable time. On the other hand, the TC prosthesis is simple to produce, requires little time and is very light.

The lightest TC prosthesis is 2·1 kg and is being worn with ease by a seventy-four year old man with a mid thigh amputation.

The transparent polycarbonate socket was introduced by Mooney (1972). Although the transparent polycarbonate socket is useful in checking socket fitting, it takes a long time to produce and is difficult to modify. The socket fitting of the polyethylene socket of the TC prosthesis can be observed through the semi-transparent material of the internal socket.

The TC prosthesis is lighter than the conventional prosthesis, because the thermoplastic sockets in themselves are lighter than the polyester socket and can be attached directly without a wooden block. Due to the reduced weight of the thigh part of the TC prosthesis and a favourable disposition of all the stump soft tissues in the socket because of the valve position at the bottom central portion, a functional pendulum motion of the shank is achieved and favourable gait patterns have been observed in many TC wearers from the first day of training.

The overcoming of the stump perspiration problems should be a boon to people living in warm environments.

The concept of socket fitting which requires exactness of the socket shape and dimensions to the stump should change by the development and use of the flexible socket.

The strength and durability of the TC prosthesis have been demonstrated by the fact that some of the younger amputees using it are able to play baseball and to ski.

Conclusion

Since November 1978, 295 AK amputees, including 9 bilateral AK amputees, have been fitted with TC-1 prostheses. The various advantages of the TC prostheses have been demonstrated as described above. The durability of the TC-1 prosthesis has been proved by the fact that none of the 295 TC-1's have been broken in use. Since March 1980, the TC-2 prosthesis has been applied to 145 amputees, including 6 bilateral amputees, and satisfactory results have been obtained.

REFERENCES

DONALDSON, N. R. (1977). Welding thermoplastics. *Orth. and Pros.*, **31 (1)**, 51–53.

IRONS, G., MOONEY, V., PUTNAM, S. and QUIGLEY, M. (1977). A lightweight above-knee prosthesis with an adjustable socket. *Orth. and Pros.*, **31 (1)**, 3–15.

KOIKE ET AL (1979). New double socket above-knee prosthesis TC-1. Bulletin of the Tokyo Metropolitan Rehabilitation Center for the Physically and Mentally Handicapped, 103–108.

MOONEY, V. ET AL (1972). Fabrication and application of transparent polycarbonate sockets. *Orth. and Pros.* **27 (3)**, 3–13.

SINCLAIR, W. F. (1969). A suction socket for the geriatric AK amputee. *Art. Limbs*, **13 (1)**, 69–71.

THORNDIKE, A. (1949). Suction socket prosthesis for above-knee amputees. *Amer. J. Surg.*, 603–613.

WILSON, A. B. (1974). Vacuum-forming of plastics in prosthetics and orthotics. *Orth. and Pros.*, **28 (1)**, 12–20.

Prosthetics and Orthotics International, 1981, 5, 135–140

Rehabilitation of the bilateral below-elbow amputee by the Krukenberg procedure

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Abstract

This paper describes the surgical technique of the Krukenberg procedure being applied in the Artificial Limb Centre, Pune, India. The results of 95 amputations on 56 patients are examined with respect to cause, age and sex distribution, and level of amputation. The benefits of this amputation to the bilateral amputee are discussed.

Introduction

The hand is one of the most important parts of the human body from both the cosmetic and the functional points of view. The hand has many functions, but perhaps its importance can be best appreciated when we think of it as a projection of the human brain. Through the use of the hand and the arm, man can exploit his brain to the fullest. Through the power of adaptation the hand has been able to assume the quality of a sense organ; in this regard it acts as a supplementary eye. In total darkness where the eyes fail, the hand gives a greater sense of security. Its highly sensitive skin provides the most important sense of touch. Since the hand performs most of the functions—ordinary or specialized—it contributes to the economic and social well-being of the individual.

Loss or impairment of its function therefore results in a great catastrophe, of even a greater magnitude if both the hands are lost (Fig. 1, top) because it results in total loss of functions. He is reduced to a state of total dependence, even for normal activities of daily living. Loss of vision in addition sometimes where it occurs in blast injuries, adds insult to the injury.

Over a number of years there has been a great improvement in the design and function of upper limb prostheses. These prostheses, though not comparable to the human hand and arm, provide a good functional substitute for them. However, no upper limb prosthesis has yet been devised which compensates for the loss of sensation and prehensile function caused by amputation of the hand. A bilateral amputee who is also blind

Fig 1. Top, bilateral through-wrist and below-elbow amputees. Bottom, Krukenberg stumps.

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wants to be able to feel, as he cannot manage a prosthesis because he cannot see.

The Krukenberg operation, a plastic procedure in which the forearm is phalangised into a radial and ulnar ray, is of inestimable value to the bilateral below-elbow amputee (Fig. 1, bottom) especially to those who are blind. The great advantage of this operation is that prehension and sense of touch are preserved, and he is spared the trouble of putting on prostheses for functional purposes.

This operation is very popular in India and is routinely performed in our centre. It is so popular that patients ask for it despite its unsightly appearance. Though the result is not cosmetic, the patients are pleased, because of the ability to feel, and also, if they desire, a prosthesis can always be worn for cosmesis. It is primarily due to its unsightly appearance that the operation is disliked by patients in the Western world.

Surgical technique

The object of this operation is to convert the fore-arm to forceps, in which the radial ray acts against the ulnar ray, with tactile sensibility. The technique followed in our centre is the standard one except for a few modifications.

The skin incisions are made in such a fashion that the radial ray is covered in its entirety with the available skin, and if needed, a small part of ulnar ray is covered with split thickness skin graft.

We make incisions keeping in mind the length of the below-elbow stump (Fig. 2). If the standard 7-8″ (175-200 mm) long stump or shorter stump is available, a U-shaped incision is made starting at a point 3″ (75 mm) distal to the flexor crease of the elbow passing longitudinally close to the ulna, turning around the end of the stump to a point at the same level on the dorsal surface.

In a longer stump (Fig. 3.) in the vicinity of the wrist joint or through-wrist disarticulation cases, it is always possible to cover both the rays with the available skin, by making suitable 7-shaped skin incisions. In such a case 4½″ (114 mm) long longitudinal incisions on the anterior and posterior aspect close to the ulna are made starting from a point 3″ (75 mm) from the flexor crease of the elbow. The ends of the two incisions are then joined by a transverse incision along the anterior, lateral and posterior aspect of the fore-

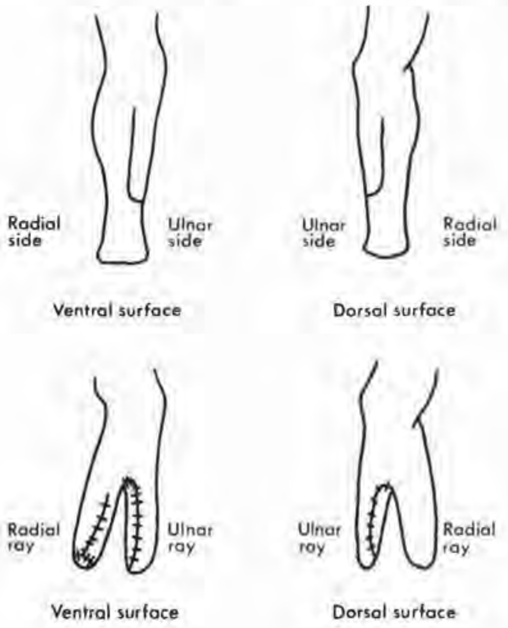

Fig 2. Incisions for the shorter stump.

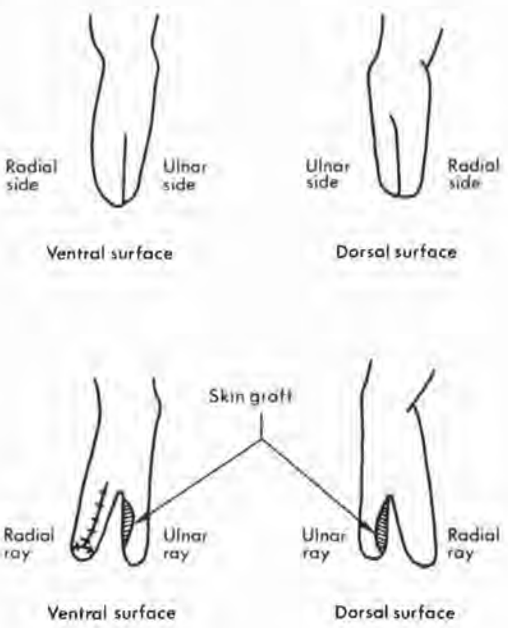

Fig 3. Incisions for the longer stump.

arm to give a 7-shaped incision. By making such an incision the skin distal to the level of the transverse incision can be utilized to cover the ulnar ray in its entire extent.

After raising the flaps the forearm is split into two parts by carefully separating the muscles and dividing the interosseous membrane. The radial half carries along with it the radial wrist flexors and extensors, the radial half of flexor digitorum sublimis and the radial half of extensor digitorum communis, brachioradialis, palmeris longus and the pronator teres, and on the ulnar side, ulnar wrist flexors and extensors, ulnar halves of flexor digitorum sublimis and extensor digitorum communis.

To reduce the bulk of the stump it is recommended by some to resect certain group of muscles. We do not advocate resection of muscles with a view to maintaining the vascularity of the stumps. Further it helps in providing adequate soft tissue cover to the stumps all around. Stumps in which too much muscle resection is carried out, are bony and therefore patients experience discomfort or even pain while holding objects.

After separating the muscles, the interosseous membrane is incised all along its ulnar attachment, so that interosseous vessels are not damaged

The radial and ulnar rays are then gently separated to achieve a separation of about 5″ (125 mm) at their tips. Thereafter both the bones are cut at a distance of 7″ (175 mm) from the flexor crease of the elbow joint. Before cutting the bones, we always raise a periosteal sleeve about ½″ (12·5 mm) long distal to the level of the bone sections. This important step helps in covering the exposed surface of the bone ends with its own periosteum and also prevents the cut end of the muscles from retracting. It is followed by stitching the cut ends of the muscles at the end of the bones, and also near the separated interosseous membrane sites, so that the rays are covered all round with muscles.

The nerves and vessels are treated in the usual manner. However, the median nerve, which is bared along its entire extent, is resected high up near the web of the rays.

Haemostasis is secured after releasing the tourniquet, and the radial stump is closed with available skin flaps. Part of the raw surface of the ulnar stump may need to be covered with a split thickness skin graft. In long below-elbow stumps or through-wrist stumps, however, the stump can always be covered in its entirety with locally available skin flaps. A drain is usually put in for 48 hours. After about three weeks, rehabilitation to develop abduction and adduction of the rays is begun.

Clinical material and results

Experience of 95 Krukenberg operations performed on 56 patients by the authors in this centre has been included in this series. The cause of injury leading to loss of hands is shown in Table 1.

Table I. Cause of amputation

Cause	Number	
Blast injury (bomb, mine or other explosives)	23	(41·1%)
Machine accidents	20	(35·7%)
Railway accidents	6	(10·7%)
Road accidents	4	(7·1%)
Electric burns	2	(3·6%)
Shell injuries	1	(1·8%)
Total	56	

Blast injury followed by machinery accidents accounted for loss of limbs in the majority of cases. The blast injuries (41·1%) which include bomb explosion, mine-blast and other explosives resulted in injuries to men whose job involved handling such dangerous explosives. Machine accidents in which the hand accidentally gets caught accounted for 35·7% of cases.

The majority of cases (39) occurred in young people between 16 and 30 years of age, since it is the young ones who are more exposed to hazardous work. The youngest patient in the series was aged 10 years and the oldest 60 years. In the series of 56 cases there was only one female patient who had sustained bilateral below-elbow amputation as a result of a railway accident. Such a great disparity in the incidence of trauma in females is obviously because they are less exposed to a hostile or dangerous environment.

Table 2 shows the level of amputations in various patients before they were subjected to Krukenberg operation.

Table 2. Level of amputation

	Number of patients
Bilateral—below-elbow	34
Bilateral—through-wrist	6
Bilateral—above-elbow and below-elbow	9
Bilateral—above-elbow and through-wrist	3
Bilateral—partially mutilated hand and through-wrist	2
Unilateral—below-elbow	2
Total	56

The various patients who underwent bilateral or unilateral Krukenberg operations are shown in Table 3. In all, 95 Krukenberg operations have been performed

Table 3. Krukenberg operations

	Number of patients	Number of operations
Bilateral Krukenberg	39	78
Unilateral Krukenberg-		
on bilateral amputees	15	15
on unilateral amputees	2	2
Totals	56	95

Seventy-eight bilateral Krukenberg operations were performed on 39 bilateral below-elbow and bilateral through-wrist cases. Fifteen unilateral Krukenberg operations were done on bilateral upper limb amputees, as they had above-elbow amputations on the contralateral side in 12 cases, and partially mutilated hands in 2 cases. In one case, though he was a bilateral below-elbow amputee, this procedure could not be carried out on one side due to a very short stump. In this series we had two unilateral below-elbow amputees on whom this procedure was done on demand, because they felt that they would be better off functionally with such a stump. Normally in a unilateral case this procedure is not essential.

The operation has been successful in all cases, and each patient has benefited immensely by it. It has been a pleasure to watch bilateral Krukenberg cases having achieved total independence not only in activities of daily living but also settled in jobs. After adequate training they were able to attend to their personal hygiene, dress, eat (Fig. 4), smoke, write (Fig. 5), cycle and attend to their jobs most satisfactorily. However, they find it too difficult to button up their shirts and are unable to perform heavy manual work. Those patients whose jobs entailed heavy manual work, were fitted with conventional working prostheses with terminal devices. The majority of the patients do not mind about their appearances. They are more concerned about the function and usefulness of these stumps rather than cosmesis as their very existence depends upon their ability to use their Krukenberg stumps. The majority of the patients have always accepted this operation willingly and take pride in the demonstration of their functional capabilities following this reconstructive procedure. However, they have all been fitted with suitable prostheses for cosmetic purposes. It has been our experience that quite a number of patients, though initially wanting such a cosmetic prosthesis, ultimately give them up altogether, either because they do

Fig 4. Eating with the Krukenberg stump.

Fig 5. Top, patients with Krukenberg stumps drinking and writing. Bottom, smoking and combing hair.

not find them so useful, have overcome their earlier shyness or are unable to buy another one.

In bilateral amputees on whom unilateral Krukenberg procedure was carried out, because the contralateral limb either had too short a below-elbow stump or had amputations above-elbow, the functional results were not so good as compared to bilateral Krukenberg cases. These patients had to depend on a prosthesis for function on the contralateral side. However, with adequate training in the use of the Krukenberg stump with a prosthesis on the opposite side, they could manage fairly well.

Discussion

The Krukenberg procedure, though not good to look at, is extremely popular in India and is routinely performed in our centre. The majority of the patients ask for it, or rather demand it to be more precise, because their very existence depends upon their ability to use these Krukenberg stumps. Its popularity is primarily due to the patient's reactions towards the plastic procedure. They find it so useful that they do not care about its appearance. The majority of such severely disabled patients with total loss of function are more concerned about regaining their lost functions rather than their appearance. However, the appearance of a bilateral below-elbow amputee with or without a prosthesis with a hook, is not a very pleasant sight either. Such patients may hide their disability by wearing cosmetic hands, but it becomes apparent when they wear hooks and other terminal devices for working purposes. Krukenberg stumps can also be hidden in a similar fashion if so desired. Therefore the correct solution to the problem in our mind is in its acceptance by the patient and the society in a fashion similar to congenitally deformed limbs. Such patients in our society are quite acceptable, and the patients themselves take pride in demonstrating their functional capabilities with such stumps.

The greatest advantage of this operation is in the retention of the tactile sensations, which no prosthesis can substitute, a factor of inestimable value in the case of the blind. Because of retention of sensation and muscle power they are able to have very effective control over the activities being performed by these stumps. They can hold objects very firmly or softly without crushing if the object is soft or fragile. They are able to lead an absolutely independent life and are spared the trouble of putting on a prosthesis, a factor of great importance to those who cannot afford a prosthesis. In fact, quite a number of patients discard their prostheses after a little while due to freedom of activities attained by the Krukenberg stumps.

Though this procedure is usually indicated for bilateral below-elbow amputees, it is sometimes applicable to a unilateral amputee. Unilateral Krukenberg operation is indicated for those who are also blind, those who cannot afford a prosthesis, and for those in whom loss of function of the dominant hand has not been taken over by the supporting hand either due to lack of interest on the part of the patient or due to disease or disability.

In children the bones should not be shortened while performing Krukenberg operation, so that distal epiphyses are retained and there is normal growth. This is possible only if at the time of initial injury a through-wrist disarticulation was performed. However, in those cases where the distal epiphyses have already been sacrificed, no further shortening of the bones should be done while performing the Krukenberg procedure.

The success of this procedure is largely dependent upon the patient's motivation and the post-operative care in training the forearm muscles in performing adduction and abduction movements of the radial ray over the ulnar ray. Normally it takes about 3–4 months from the time of operation for the patient to develop sufficient power and co-ordination to perform these movements. As time passes, the power and co-ordination of movements improves, and so does the freedom of activities.

Conclusion

In this series, results of 95 Krukenberg operations performed have been presented. The operations have been successful in all cases and the patients immensely benefited, as they could achieve complete independence from a state of total helplessness and dependence on others.

The merits of this plastic procedure outweigh the sole objection of its appearance, which can be compensated for by wearing a cosmetic prosthesis for social occasions.

*BIBLIOGRAPHY

BAUER, K. H. (1949). Zum Problem der Ohnhänderversorgung und zur Frage der operativen Behandlung, insbesondere des Krukenberg-Armes. *Verhandlungen der Deutschen Orthopädischen Gesellschaft,* Band 36, Seite 51–53, F. Enke–Verlag, Stuttgart.

BIESALSKI, K. (1917). Der Arbeitsarm und der Armstrumpf, *Zeitschrift für Orthopädische Chirurgie,* Band 36, Seite 233ff. (Der bakannte Ausspruch Biesalski's "Der Stumpf ist die Beste Prothese" steht auf seite 236).

BIESALSKI, K. (1918). Die Kunstglieder des Oskar-Helene-Heims, *Zeitschrift für Orthopädische Chirurgie, "Der Prothesenbau".* Band 37, Seite 174–278.

BOOS, O. (1960). Die Versorgung von Ohnhändern, Friedrich K. Schattauer Verlag, Stuttgart.

HOSSFELD, G. (1949) mitgeteilt von H. Stobe in dessen Vortrag über "Ein Beitrag zur Muskelphysiologie des Krukenberg-Greifarmes", *Verhandlungen der Deutschen Orthopädischen Gesellschaft,* Band 36, Seite 65ff, Enke-Verlag, Stuttgart.

KALLIO, K. E. (1948). Recent advances in Krukenberg's operation, *Acta Chir. Scand,* **97,** 165.

KEYL, R. (1949). Erfahrungen mit der Krukenberg Operation und deren Nach behandlung. *Verhandlungen der Deutschen Orthopädischen Gesellschaft,* Band 36. Seite 61–64.

KIESSELBACH, (1951). mitgeteilt von R. von Volkmann in Zur arbeitsweise des Muskulus Supinator und Muskulus Biceps Brachii, Verhandlungen der Anatomischen Gesellschaft auf der 48. Versammlung in Kiel vom 22. bis 25. August 1950. Seite 213, bis 221. Verlag Gustav Fischer in Jena.

KREUZ, L. (1944). Die Herrichtung des Unterarmstumpfes zum natürlichen Greifarm nach dem Verfahren von Krukenberg. *Zentralblatt für Chirurgie,* Band 37–38, Seite 1170–1175.

KRUKENBERG, H. (1917). Uber die plastische Umwertung von Armamputationsstümpfen. Ferdinand Enke Verlag, Stuttgart.

NATHAN, P. A. and NGUYEN, B. T. (1977). The Krukenberg operation; a modified technique avoiding skin grafts. *J. Hand Surg.* **2:2,** 127–130.

SPITZY, H. u FELDSCHAREK. (1966). Die Vorsorgung beiderseits Armamputierter. *Münchener Medizinische Wochenzeitschrift,* Nr. 33.

SWANSON, A. B. (1964). The Krukenberg procedure in the juvenile amputee. *J. Bone Jt. Surg.* **46A,** 1540

THOMSON, W. (1949). Diskussionsbeitrag zum Thema Krukenberg Plastik. *Verhandlungen der Deutschen Orthopädischen Gesellschaft,* Band 36, Seite 60–61.

VOLKMANN, R. VON (1951). Die Muskelfunktion im Krukenberg Armsowie einige operative Folgerungen. *Verhandlungen der Deutschen Orthopädischen Gesellschaft,* Band 38, Seite 293 bis 297f. Enke Verlag Stuttgart.

*Added by the Editors

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Early referral to limb deficiency clinics

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Abstract

Immediate support is needed by parents when a limb deficient child has been delivered, a time when parents' fears and problems are greatest. This support involves special skills not readily available in the community. Thus it is important that these children and their parents are referred to Specialist Clinics by their local doctor immediately after birth. Experienced therapists and medical social workers attached to these clinics are not normally available to obstetric specialists and general practitioners. The doctor-in-charge of the Clinic, the social worker and the therapist visit the parents and child in hospital. This early counselling facilitates the bonding of the parents and child. It also reduces the parents feelings of guilt and distress over having a deformed baby. Appropriate counselling given at this stage on prostheses, daily living activities, parent group discussions and the future prospects for these children, helps ensure a satisfactory life.

Love, indifference and hate experienced in infancy, profoundly affects our development and relationships. Love gives security, warmth and the ability to make close relationships; indifference leads to insecurity and isolation; hate generates guilt or hostility. For most of us there is a delicate balance, in our favour or against us, depending on social pressures and environmental influences. In all but the most exceptional circumstances, to be born with a deformity will swing the balance adversely. Restoration of the balance requires understanding, family support and encouragement, and professional help.

For all of us, birth is a critical period. The outcome depends largely on the acceptance, warmth and care we receive, which in turn is closely related to the expectations the parents have for the child. A child born with a limb deficiency will be responded to in a variety of ways depending on his parents' background and stability. If these have not been optimal then the presence of disability will place an extra burden on the child. If the parents are not helped to sort out their feelings at the time, then damage will be lasting. The stress resulting from a deficient child can lead to minor differences between parents developing into a major rift.

The presence of a serious handicap in a young infant precipitates a crisis for the whole family. Intervention programmes are essential to save life or to ameliorate the long term effects of the handicapping condition. These programmes require careful and extensive planning if they are to be accepted by the child and his family, rather than being perceived as unacceptable intrusions.

Bettleheim (Klaus & Kennell, 1976) states that "Children can learn to live with a disability but they cannot live well without the conviction that their parents find them utterly loveable . . . If the parents, knowing about his (the child's) defect, love him now, he can believe that others will love him in the future".

The effect of early skin-to-skin contact of infant and mother, following birth, plus the father's presence, helps to bond the infant to both parents. It has been shown (De Chateau, 1976) that mothers having this early contact, give more love, the infants cry less and laugh more, have significantly higher I.Q.'s and develop more advanced scores in language tests. Attachment is crucial to the survival and optimal development of the infant and to the child's bonds with other individuals in the future.

It is now known that the baby sees, hears and moves in rhythm to his mother's voice in the first minutes and hours of life, the linking of the reactions of the two results in a synchronised 'dance' between the mother and baby which is an essential part of the process of attachment. Bonding of the father to his newborn baby

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depends on his attraction to the infant, his perception of the newborn as 'perfect', his elation and increased sense of esteem. Extensive early exposure of the father to the infant in hospital is essential.

Turbulent emotional reactions replace joy and delight where a mother has just given birth to a child with a limb deficiency. The blight of a malformation, particularly where it is visible and hence embarrassing, is a crushing blow to the parents and to everyone else who has shared in the event. What is visually apparent, e.g. a missing limb, is far more distressing to parents than hidden congenital defects or internal disorders—even though these conditions may be far more disabling. The parents' efforts to keep secret the information of the birth of an abnormal child, contrasts strikingly with the usual wish to spread the happy news.

The reactions of parents to the birth will be influenced to a large extent by how effectively their questions are answered and their doubts and problems ameliorated. Sympathetic, realistic advice at the earliest opportunity, from the doctor or therapist experienced in this area, can reduce the long term problems they will have to face. Where no secrets are kept from either one, neither parent has to interpret to the other or feel that he or she has to buffer the shock. Lack of bonding with the child, or rejection by one or both parents is greater when they are not together when they first learn of the birth abnormality.

Mothers, having been told that their baby has a limb deficiency, find that the most traumatic time is when waiting to see the infant. The shock of producing a baby with a visible defect is stunning and overwhelming, but attachment can be facilitated by showing parents their new baby as soon as possible and accentuating the attractions.

Parents also attach great importance in the early stages to the general attitude of the medical and nursing staff, more than to words. Adverse attitudes are never forgotten so that it is important for all staff having contact with the parents to be aware of their own feelings and to guard against over-reaction.

Unresolved guilt, denial, or less than adequate resolutions may cause the child or the family to suffer. Many parents search at length to find a specific cause for the deformity in order to be rid of feelings of guilt, and in some cases the grandparents may aggravate the feelings of shock, grief, guilt, denial or resentment experienced by the parents.

At the Limb Deficiency Clinic at the Royal Children's Hospital, Melbourne, Australia, when there is a referral after the birth of a limb deficient child, the doctor in charge of the Clinic visits the parents to counsel and to arrange a visit with the medical social worker and occupational therapist, who will give appropriate help and realistic understanding of the future. While visits may be impracticable for a remote country area, as much information as possible is given over the telephone to suffice until such time as the parents and child can travel to the Clinic.

Our best efforts to encourage appropriate referral to local doctors, obstetricians and nursing staff at women's or midwifery hospitals, are often met with apathy and reluctance. This failure highlights the need for appropriate training in the curriculum of the undergraduate medical practitioner. The importance of education being directed to this area cannot be over emphasized.

The security felt by the parents through the knowledge that there is someone who cares and who is readily available for support when needed, helps reduce uncertainties as they arise. It is preferable that the parents develop a rapport and have trust and support with *one* person, one who can handle all situations and be available for the parents' and child's needs as they arise as well as throughout the child's developmental stages, both physical, social and emotional. An occupational therapist may be the ideal person for this role. The occupational therapist is more likely to be experienced in treating and working with limb deficient children and their parents, in dealing with the emotional and physical needs of the child including the training programmes required for a prosthesis, and with activities of daily living should a prosthesis not be worn. It is realised that the emotional responses are more important than anything else. If these are dealt with satisfactorily then the fitting of a prosthesis will be a natural step.

Usually parents welcome the opportunity to meet with another family where there is a child with a similar deficiency. At the Royal Children's Hospital, Melbourne, parents' group discussions are held with the medical social worker and therapist attached to the Clinic. These groups provide the opportunity for

Fig. 1 Help and appropriate early training result in a satisfactory quality of life for a person born with a limb deficiency.

parents to realise that there are other children in the community with similar problems to those of their child. These groups also bring reassurance and an appreciation that the stress of the parents and their disturbed thoughts are not unusual. At the same time emotional support is gained and suggestions for solving physical problems are exchanged.

Not all limb deficient patients attain an optimal result. Some children with a minimum deficiency have difficulty with various skills or in accepting themselves, or in achieving independence. Surprisingly, it seems that these difficulties are largely due to factors within the family rather than to physical limitations of the child. Most girls will discard an upper limb prosthesis with a split hook on reaching adolescence due to its appearance, on the other hand boys tend to continue wearing such a prosthesis, because they depend upon it for function and accept it without hesitation.

The major problems to be overcome are:

1. To ensure that bonding takes place between parents and child.
2. To alert the medical profession and midwifery nurses to the importance of early referral to the Limb Deficiency or Specialist Clinics.
3. To have a named person accept full responsibility for the continuing professional management of the patient.
4. To make the appearance of the prosthesis acceptable to the child and family concerned, without reducing function.
5. To educate professionals working with patients in the prosthetic field to the realization that the amputee child is not a scaled down adult, that for successful rehabilitation it is necessary to know the basic emotional needs of the young child, his physical make-up and the differences between him and an adult.

Help, and appropriate early training result in a satisfactory quality of life for a person born with a limb deficiency (Fig. 1). Successful use of a prosthesis depends on the child seeing himself as loved and accepted as a person in his own right and as he is, rather than as his parents may have wished him to be.

REFERENCES

De Chateau, P. (1976). Neonatal care routines: Influences on maternal and infant behaviour and on breast feeding. UMEA University medical dissertations N.S. no. 20.

Klaus, M. H. and Kennel, J. H. (1977). Impact of early separation or loss on family development: Maternal-infant bonding. C. V. Mosby Co., St. Louis.

BIBLIOGRAPHY

Blakeslee, B. (1963). The Limb-Deficient Child. University of California Press, Berkeley, California.

Condon, W. S. and Sander, L. W. (1974). Neonate movement is synchronised with adult speech: International participation and language. *Science*, **183,** 99–101.

Daniells, L. L. and Berg, G. M. (1968). The crisis of birth and adoptive patterns of amputee children. Clinical Proceedings, Children's Hospital, Washington D.C., **24,** 108–117.

Talbot, D. and Solomon, C. (1978). The function of a parent group in the adaptation of the birth of a limb deficient child. *Int. Clin. Inf. Bull.* **XVII (1)** 9–10, 16–17.

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Indigenous substitutes for modern prostheses and orthoses

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Abstract

In most developing countries, the physically handicapped often have rehabilitation setbacks such as unavailability of modern rehabilitative aids which may result in non-achievement of the desired goals in activities of daily living. Children with poliomyelitis, hemiplegics, amputees and paraplegics top the list of patients requiring rehabilitation at University College Hospital, Ibadan. The amputees depend on wooden peg legs or pylons made by the occupational therapy department since modular and P.T.B. prostheses are presently not available in this hospital. Physiotherapists, therefore, encounter problems in teaching correct patterns of walking and other functional activities to the above-knee amputee because knee joints are absent. Rural amputee farmers use pylons as they can wade through water and mud with them.

Calipers, toe raising devices, knee cages and spinal supports are required by 75% of the 300 children with poliomyelitis and some of the paraplegics receiving physiotherapy in this hospital.

Due to lack of imported parts, materials and experienced personnel, it has not been possible to meet the required demands. The occupational therapy department, as well as indigenous shoe makers and iron welders, rescue the situation as much as possible. Similarly, cervical collars are made from PVC buckets.

It is therefore necessary that research on the use of local materials for prostheses and orthoses be carried out. Difficulties encountered with imported parts and materials will be removed to the advantage of patients.

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Introduction

In most developing countries the physically handicapped suffer a lot of setbacks during and after the period of rehabilitation.

One setback is the unavailability of sufficient assistive aids which could help to hasten recovery and the achievement of activities of daily living.

The physically disabled commonly treated at the University College Hospital, Ibadan, are amputees, hemiplegics, and children with poliomyelitis and cerebral palsy.

The amputees were dependent for ambulation on peg legs and wooden prostheses (Fig. 1, left) made by the occupational therapy department. Patellar tendon bearing and modular types of prostheses are presently not available. The government-owned workshop in Ibadan made some of these prostheses a few years ago until this became impossible due to shortage of

Fig. 1. Left, above-knee prosthesis manufactured from local materials. Right, long leg caliper.

equipment and experienced personnel. Imported willow wood was used extensively for making both the above and below-knee artificial limbs in the workshop.

In the case of above-knee amputees, physiotherapists found it difficult to teach the correct pattern of walking, climbing and descending stairs and other functional activities which involved the lower extremities because the prostheses made by the occupational therapists had no knee joint. When one exists, the heavy artificial limb (made of local wood) together with improper alignment makes rehabilitation difficult. However, the efforts of the occupational therapists are commendable in the absence of other means of ambulation.

Supportive aids

About 225 (75%) of the 300 children with poliomyelitis and cerebral palsy who attend the outpatient department for physiotherapy require some form of walking aid depending on the degree of muscle imbalance and deformities of the affected limbs.

In order to avert contractures which may lead to gross deformities, the supportive aids applied were : 1. Plaster of Paris back and night splints to prevent hamstrings and tendo Achilles contractures respectively; 2. Plaster of Paris cylinder to correct genu recurvatum; 3. Plaster of Paris hip spica to prevent or correct tensor fasciae latae contractures; 4. Spinal jacket to arrest paralytic scoliosis.

All of the above are currently made by both the physiotherapists and the plaster technicians and are regarded as temporary measures. Rubber shoes made from old inner tubes and worn out motor tyres protect the plaster from wear at the soles.

Permanent rehabilitative aids

Permanent rehabilitative aids which may not require frequent changes were made by prosthetists and orthotists where possible.

These aids were a. Long and short leg calipers with ring or cuff top and posterior or anterior stops; b. Toe raising devices (with springs or rubber attachments); c. Knee cages; d. Spinal supports made with block leather or in the form of simulated Milwaukee brace. In the case of upper extremities, cock-up splints were made of plaster of Paris, Orthoplast and aluminium when the latter is available.

Patients from the University College Hospital, Ibadan were often referred to the government-owned orthopaedic workshop in Ibadan until 1976 when materials and manpower resources became inadequate. Both the occupational therapy department and indigenous ironmongers and shoemakers came to the rescue.

Iron rods and flat iron bars used in building industries were substituted for the acceptable lightweight and jointed aluminium bars. Tanned goat and cowhide were used as leather components of calipers and knee cages.

Long leg calipers (Fig. 1, right) have no knee joint and are not adjustable for length in order to accommodate the growth of the children. These were rather expensive for some poor parents who had to pay for the appliances so frequently.

Fig. 2. Left, plastic bucket showing patterns for cervical collar. Right, cervical collar applied.

Cervical collars

Patients suffering from osteoarthritis of the cervical vertebrae, whiplash injuries and others are requested to wear cervical collars for the purpose of temporarily restricting the movements of the neck, gaining relaxation of the muscles of the neck which may be in spasm and to relieve neck pain.

The cervical collars issued to patients in most hospitals in Nigeria were imported and made of plastic materials or foam rubber. Nevertheless, in some teaching hospitals and orthopaedic workshops, cervical collars were made to measure by using Plastazote, Molefoam or Zoplafoam and Orthoplast.

Quite lately, restrictions have been applied to imported goods by the federal government; these necessitated improvisation and indigenous "manufacture" of cervical collars by the author from pliable plastic containers e.g. buckets and large bowls which are readily available in the markets.

Varying sizes and patterns were cut from the plastic buckets (Fig. 2, left). The edges were rounded off and padded with rubber tubing. The collars were applied with the aid of stockinette (Fig. 2, right); perforations were made on the collars for ventilation.

Discussion

Hundreds of children suffering from poliomyelitis require the appropriate rehabilitation aids in Ibadan and in fact in Nigeria as a whole if they are not to be severely crippled for life and perhaps resort to begging.

There are very few (about 5) workshops in the whole of Nigeria (population 80 million) where the infrastructure, machinery and materials required for the manufacture of prostheses exist. The major constraints have been non-availability of materials (which are mostly imported) as well as experienced manpower. Unless these shortcomings are recognised and remedied, local shoemakers, ironmongers and welders will continue to come to the aid of the disabled no matter how primitive or lacking in functional restoration their products may be.

In Nigeria, it is socially necessary for a woman to wear a jointed above-knee prosthesis. Custom demands that she should genuflect when greeting an elderly person. Local fabrication of parts is therefore essential in order to meet the requirements of the local taboos demanded of some amputees.

Conclusion

In conclusion it is of paramount importance that import restrictions should be relaxed and custom duties abolished completely on major appliances used by the disabled in developing countries. This should continue until the components of rehabilitation aids can be manufactured at local level as a form of appropriate technology.

Training of manpower should be intensified at all levels including prosthetists, orthotists, physiotherapists, occupational therapists and others who, by working as a team, contribute to the functional restoration of the disabled and their return to normal activities of daily living.

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BIBLIOGRAPHY

Bain, A. M. (1964). Experience in rehabilitation in Uganda. In; Proc. First Symposium on Rehabilitation in Africa, The National Fund for Research into Poliomyelitis and other Crippling Diseases, London, 88–95.

Golding, J. S. R. (1976). Health care delivery for the disabled. The Commonwealth Foundation—Occasional Paper XLI, 40–43.

Kirman, S. R. A. (1966). Prosthetics in Pakistan. *Pros. Int.*, **2:6**, 4.

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Videotape recording—a complementary aid for the walking training of lower limb amputees

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Abstract

Videotape recording was used as an additional aid in the walking training of lower limb amputees. Fifty patients were interviewed about their reaction to watching themselves on a TV monitor, especially with respect to any negative or depressive feelings resulting from the TV sessions. No such reactions could be elicited among the examined patients.

Introduction

Lower limb amputee training aims at teaching the patient a technique of walking and moving which will minimize abnormalities in the pattern of movement. If the patient is to increase the distance he is able to walk, and thereby improve his ability to cope with the functions of daily life and his chances of returning to paid employment, he will have to be taught a gait pattern that is as little energy consuming as possible and simulates normal walking (Waters et al. 1976).

The physiotherapist training the patient will have to rely largely on verbal and tactile information. As an additional aid a mirror can be used to make it easier for the patient to recognize and correct errors in gait or movement pattern (Fig 1). In many cases, however, these sources of information fail to make the patient understand what errors he is making and, even less, how he is to correct them.

For many years now TV cameras, videotape recorders, and TV monitors have been widely used for educational purposes. The instructive value of this medium has been substantiated for numerous different target groups, among them sportsmen and athletes Hirsch, 1968; De Bacy, 1970; van Gestel, 1971. Learning the technique of walking with an artificial limb must be comparable to learning specific patterns of movement in athletic performance (Alexander and Goodrich, 1978).

The aim of our study was to find out whether

Fig 1. The use of a mirror at the end of the walking area to aid the patient in recognizing errors. The patient had to divide his attention between walking performance and studying his mirror image.

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patients who were recorded on videotape during walking training had any negative feelings about the recordings or about viewing themselves and having their gait pattern commented upon.

Material and Method

Fifty patients were recorded during the years 1979–1980. Table 1 shows the levels of amputation.

Table 1. Amputation levels

Below-knee	15
Above-knee	28
Hip disarticulation and hemipelvectomy	7

The Department's profile, with a special interest in oncologic diseases, results in a high incidence of patients amputated for tumours in comparison with the rest of the country (Table 2). This also means that many of the amputees are young people with a mean age of 43 years (Table 3).

Table 2. Causes of amputation

Vascular disease	17
Tumour	19
Trauma	9
Congenital deformities	5

Patients with complicating diseases such as hemiplegia or Parkinsonism were excluded, as it was felt that this might cause negative emotions in them. Some patients objected strongly to being recorded and if attempts at persuading them failed to change their attitude, no recordings were made.

The recording equipment consists of a TV monitor (Salora Boston 24 B, Salora Oy, Finland), a videotape recorder (Sony AV–3670 OE, Sony Corp., Japan) and a TV camera (Nivico, TK 220, Victor Co of Japan Ltd).

The videotape recordings are made in a large hall during the patient's regular walking training session (Fig 2). The equipment is always kept ready for use and the large room permits the patient to be filmed from the front, rear and side, after which patient and physiotherapist discuss the recorded session in front of the TV monitor. Abnormalities, errors and positive attributes are pointed out and the patient is advised about the best way to correct his errors (Fig 3).

All videotapes are stored and can at any time be shown and discussed again, which permits comparison with earlier training sessions. Videotape recordings were made at varying stages of training, but not during training in parallel bars. Following the discussion in front of the TV monitor, the 50 patients in this series were asked to answer a simple questionnaire.

Fig 2. The television is kept ready for use in the large training hall.

Results

Forty four out of fifty patients reported that they had noticed details of which they had not been conscious before. All fifty patients felt that the videotape recording and discussion had been useful to them and no patient rated the experience as unsatisfactory or poor.

When asked what they had particularly liked, many patients said that they had experienced a sense of sudden recognition and become aware of defects in their gait pattern which they had

Table 3. Age* and sex distribution

	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89
Male	0	7	5	1	2	3	6	5	0
Female	1	5	2	2	1	5	1	3	1

**at time of recording*

Fig 3. Patients and physiotherapists can at any time discuss progress and performance as shown by the video recording

failed to understand before. Many patients reported that they "walked better than they had thought".

The patients uniformly replied that the videotape recording had helped them to achieve a better gait performance than would have been possible with the aid of a mirror only. They ascribed this to the fact that they had been able to view themselves from different angles and did not have to divide their attention between walking performance and studying their mirror image. No negative reactions emerged with respect to how the patients had experienced their performance on TV. None of the them showed any depressive tendencies and those who had been hesitant before the videotape recording, afterwards became positive or even very positive in their attitude.

Discussion

Videotape playback has for many years been used for a variety of therapeutical and educational purposes (Alger 1969; Bishop 1970). Only one report dealing with videotape playback and lower limb amputee training (Alexander and Goodrich, 1978). This report shows an improved gait pattern in a group of patients who were given an opportunity to view their performance on videotape, in comparison with a group of patients who were recorded but not allowed to view the videotape recordings.

Relatively simple TV equipment was used for lower limb amputee training. Each patient was recorded during walking training on a videotape recorder and immediate playback after each session made it possible for the patient together with the physiotherapist to analyze his own gait and movement pattern. The method allows the patient to view his own movements from all sides and the physiotherapist to give concrete advice about the patient's errors immediately following the training session.

It is quite striking how easy it has been for the patients to understand what errors they make. For weakly motivated patients earlier recordings can act as a spur since they can be used to make the patient aware of his progress or (in some cases) regress. Many of our young amputees are very anxious to leave the hospital and therefore reluctant to see the need of a correct walking pattern. A training session with video-playback has in many cases motivated them for further training. Many patients reported that they "walked better than they had thought", which is entirely in accordance with the experience of Alexander and Goodrich (1978).

The physiotherapists who train the amputees have experienced the videotape recordings as decidedly positive. It has been easier for them to teach the patients correct weight-bearing technique and equal stride length at an early stage.

The fact that the method allows the patient to view himself from all aspects and does not force him to divide his attention between the effort required to walk correctly and studying the effect in the mirror must be regarded as positive. The only thing which could prevent the method from being used would therefore be possible negative reactions of the patient.

The study based on patient interviews did not show any negative or depressive reactions among the fifty patients who were filmed and immediately after their gait performance viewed themselves on a TV monitor. Videotape playback is in our opinion a valuable complement to conventional walking training of lower limb amputees.

REFERENCES

ALEXANDER, J. and GOODRICH, R. (1978). Video-tape immediate playback: A tool in rehabilitation of persons with amputations. *Arch. Phys. Med. Rehab.* **59,** 141–144.

ALGER, L. (1969). Therapeutic use of video-tape playback. *J. Nerv. Ment. Dis.* **148,** 430–436.

BISHOP, B. (1970). Innovation in teaching. *Phys. Ther.* **50,** 46–52.

DE BACY, D. (1970). Effect of viewing video-tapes of sport skill performed by self and others on self assessment. *Research Quart.* **41,** 27–31.

HIRSCH, C. (1968). Effectiveness of television instant replay as an instructional aid to learning the full golf swing. Thesis, Kent State University, Kent, OH.

VAN GESTEL, A.P.M. (1971). Television and video recorder in therapeutic exercise. *Scand. J. Rehab. Med.* **3,** 79–84.

WATERS, R. L., PERRY, J., ANTONELLI, D. and HISLOP, H. (1976). Energy costs of walking of amputees: The influence of level of amputation. *J. Bone & Jt. Surg.* **58A,** 42–46.

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A case study of reaching by a user of a manually-operated artificial hand

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Abstract

Reaching involves both transport of the hand toward an object and opening of the hand by an appropriate amount before arrival at the object. Movements of a manually-controlled artificial left-hand are compared with movements of the natural right-hand of a proficient user of an artificial hand. Although picking up of objects was slower with the artificial hand, similarities in opening and transport movements were observed in the two hands. Despite major mechanical differences in the systems subserving movement in the artificial and natural hands, the similarities extended to the separate movements of the thumb and finger. The strategy of artificial hand control employed by this subject is discussed and related to training new users of artificial hands.

Introduction

Recently there has been considerable interest in the myoelectric hand including its evaluation in practical, everyday use (Northmore-Ball, et al, 1980). However, the majority of fittings in the U.K. still involve prostheses operated by a control cable attached to a harness on the opposite shoulder. As well as being cheaper and more reliable in use than the present generation of myoelectric hands, users commonly report that the manually-operated artificial hand provides better feedback during use (Sensky, 1980). However, there is little behavioural data on the coordination of movement in artificial hand control. This paper summarizes new findings from a project intended to improve this situation. The basic question asked was whether coordination achieved by a proficient user of an artificial hand is similar to coordination in the natural hand? The answer to this question would be an important first step in the identification of the nature of the skill to be trained in a person newly fitted with an artificial hand.

A major function of the hand is reaching for objects. An important component of coordination in normal reaching is the opening of the hand before the hand reaches the object. Transport may then proceed without pause until the hand encompasses the object. Surprisingly, despite the classic studies of the development of infants' grasp patterns by Halverson (1937), there is little published data on coordination in reaching. However, a series of film studies of reaching movements by adults without disability has recently been carried out by Jeannerod (1981). The main findings were that the degree of hand opening varies for objects of different sizes and the hand begins to close before contact is made with the object, (maximum opening was observed at the same time as the hand began to slow down in its approach to the object). The experiment described below set out to determine whether these findings would apply to a manually-controlled artificial hand.

Subject

A 13-year old girl with congenital absence of her left arm below the elbow was chosen for the study. From the age of two, she had been fitted with a standard below-elbow prosthesis and a juvenile split hook operated by a shoulder harness. One year prior to the study she changed to a functional artificial hand with a good cosmetic appearance (Otto Bock, voluntary opening, catalogue number 8K8). For both types of artificial hand, forward flexion (protraction) of the shoulder girdle is used to tension a cable running from the harness to the hand. This causes the hand to open against the action of a spring that keeps the hand normally closed.

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However, the hook and the Otto Bock hand differ in the way they open. Opening of the hook is single-sided, the "finger" staying in fixed alignment with the forearm while the "thumb" moves to open or close the hand. The Otto Bock hand opens in a double-sided fashion, the thumb and the index with middle fingers moving equal and opposite amounts in opening and closing the hand.

The subject's right hand was her natural hand. Its function was perfectly normal and so the data for the right hand presented below may be treated as control data.

Method

Standing at a waist-high table, the subject was asked on each trial to pick up a 7·5 cm length of wooden dowel placed upright approximately 35 cm from the edge of the table. Two different dowels, of 12 mm and 22 mm diameter, were used alternately on successive trials. With the artificial hand locked in mid-position (as if the radio-ulnar wrist axis were vertical), this task required that the dowel be picked up with the thumb on the side nearer the body opposing the index and middle fingers on the other side of the dowel. When picking up the dowel with the right hand, the subject was instructed to use thumb, index and middle fingers also. Movements were made "at a comfortable speed without knocking the dowel over".

The data reported in this paper are from the third of a series of six consecutive blocks of four trials each. In each block, the first two reaching movements were made with the natural right hand, the second two with the artificial left hand.

Recording of movements was made using a 16 mm Bolex camera with a 35 mm lens mounted 1690 mm above the surface of the table. The camera was run at a nominal speed of 64 frames per second with Kodak Tri-X reversal film. Overhead lighting by two 275 watt photoflood lamps was employed. On every trial the clockwork drive of the camera was rewound and set running before the subject was told to start the reaching movement. The camera was stopped after the object was seen to be grasped and the return movement of the arm had commenced. An electronic counter triggered by the onset of hand movement was included in the field of view of the camera. This showed that trial to trial variations in the running speed of the camera only amounted to some 5% for an average sample period of 15·5 msec.

As an aid to calibration of distance in the evaluation of the film records a sheet of card with a 2 cm lined grid was kept on the surface of the table. To improve the accuracy of digitizing the position and opening of the hand on the film records, three markers were placed on each of the subject's hands (Fig. 1).

Fig 1. Photograph of the subject showing the placement of markers for digitizing position of wrist, thumb and finger on the natural (right) hand and artificial (left) hand.

One was placed on the radial side of the forearm just distal to the wrist. A second was placed over the interphalangeal joint of the thumb and a third was placed on the proximal interphalangeal joint of the index finger. In determining the aperture of the natural hand, a better position for the markers might have been on the tips of the thumb and finger. Unfortunately, it was found that the thumb and finger tips became obscured from camera view by the dowel in the final stages of the movement. However, visual inspection showed that opening of the natural hand was accomplished almost entirely at the metacarpophalangeal joints. (In the artificial hand, this was the case by virtue of its construction.) The movement of the markers may therefore be taken as an accurate representation of aperture. Markers were also placed on the ends of the dowels.

Results

A computer-based system for digitization of film was used to measure the distances between the dowel and the three markers on the hand for each frame of the filmed record of the reaching movements. These distances were then analyzed in various ways as described below. It should be noted that for clarity only a sub-set of the data is presented. These data are from the third of the six blocks of four trials and may be considered typical of the other five blocks.

Reaching with the artificial hand was slower than with the natural hand. Figure 2 shows a plot of the distance of the wrist from the dowel in relation to the time taken for the left and right hands to pick up the wide and narrow dowels. The

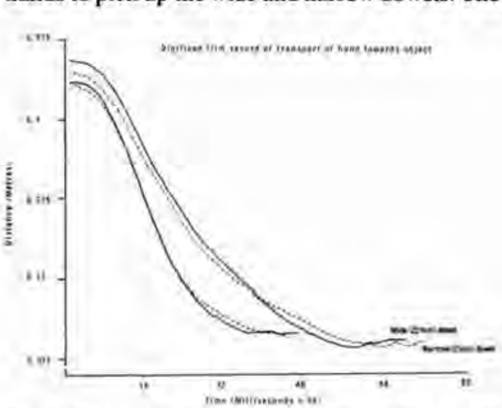

Fig 2. Distance of the wrist marker from the wide (solid lines) and narrow (dashed lines) dowels as a function of time for natural and artificial hands. The two trajectories for the artificial hand are on the right (i.e. they are the slower ones).

digitized data extend 5 frames past the point at which the finger and/or thumb first made contact with the dowel. Both pairs of curves show a similar period of initial acceleration up to about frame 10 followed by a period of roughly constant velocity. However, the artificial hand movements show an earlier deceleration at about frame 16 whereas there is no discernible slowing of the right hand until about frame 22. Contact is made by the artificial hand some 25 frames, or about 50% later than the natural hand.

Data on hand opening for the wide and narrow dowels are given in Figure 3. The distance between the interphalangeal joints of thumb and finger is plotted as a function of time normalized by the time to contact. The fourth division on the horizontal axis (relative time 100) is the time of contact. The first three divisions on the

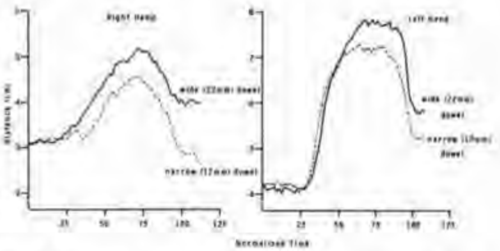

Fig 3. Distance between finger and thumb for the wide (solid lines) and narrow (dashed lines) dowels as a percentage of the time to contact for natural (left panel) and artificial (right panel) hands.

horizontal axis thus represent 25%, 50%, and 75% of time to contact. It will be observed that the vertical axes for left and right hand cover slightly different ranges, although they are to the same scale. This reflects differences in the physical dimensions of the natural and artificial hands. It should also be noted that the subject started the artificial hand movements with the tension off the shoulder harness cable so that the thumb and finger tips were touching. In contrast, movements with the natural hand were started with the hand relaxed giving a thumb-finger tip gap of about 15 mm. Thus the change in hand opening from the start and end of each record is different for the left and right hands.

The figure clearly shows two major points of similarity in the opening of the two hands. Firstly, opening of the hand achieves a maximum in the course of transport which exceeds the final degree of opening required to grasp the dowel. In both hands the difference between the maxima for wide and narrow dowels is of the same order as the difference in dowel diameters. Secondly, from about 25% up to about 75% of the time to contact, both hands show a steady opening. But there is a striking difference in the last 25% of the time course. Whereas the right hand closes at approximately the same rate as it opened, closing of the left hand is apparently delayed—the hand opening shows a plateau rather than a peak—and in consequence the rate of closing of the artificial hand is considerably faster than its rate of opening.

The picture presented so far is thus one in which differences between the hands appear in the later parts of the movement as the object is approached. The psychological literature on motor skills often distinguishes between two types of control; (a) movement made without reference to its relation to the environment (open-loop), (b) movement that is corrected as it progresses on the basis of feedback about its relation to the environment (feedback-regulated). In skilled performance it is usually found that the early part of a movement is launched in open-loop fashion (often ballistically with the agonist muscles providing a large, impulsive force at the very beginning of the movement). Corrections on the basis of feedback are only made in the later stages depending on how well the target for the movement is approached, (Keele, 1968; Beggs and Howarth, 1972). We may therefore suppose that the start of the transport movement in reaching is open-loop. Moreover, the similarity of the early of the part of the trajectories for the left and right hands suggests the underlying commands to the muscles (motor programme) in the two cases are equivalent.

What could underly the differences between the reaching movements of the two hands in the later stages of the movements, when feedback regulation of the movement might be expected to be important? Our analysis of the data so far shows the approach velocity of the artificial hand is slower and it is held open for relatively longer. We now present a further analysis aimed at a better appreciation of the problems involved in artificial relative to normal hand control in the later, approach stages.

In Figure 4, as a function of time relative to contact, we have plotted the perpendicular distance of the thumb and the index finger from an imaginary axis joining the wrist and the centre of the dowel. Positions to body left of this axis are represented as positive. Thus, for example, with the axis aligned straight forward with respect to the body the right hand thumb is given as positive and the right hand index finger distance is given as negative. For the left hand in a similar position the positive and negative signs are, of course, reversed.

Consider first the left panel of Figure 4 which shows the data for the natural right hand. For about the first third of the time to contact there is parallel movement of thumb and finger relative to the wrist-dowel axis. This is because the hand starts by swinging round as it is transported toward the dowel until the gap between the thumb and finger tips spans the wrist-dowel axis.

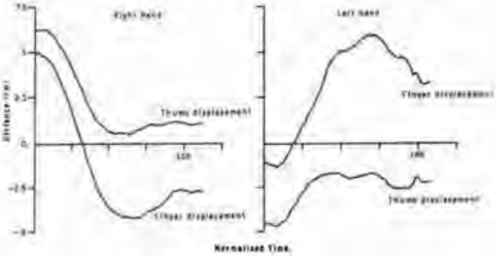

Fig 4. Distance of the finger and thumb from an axis joining the wrist marker to the wide dowel for natural (left panel) and artificial (right panel) hands. In both panels, the curve for the finger is the one nearer the horizontal axis at time zero.

The more interesting aspect of the data is they show that, while the thumb holds a more or less fixed position relative to the axis, the index finger is largely responsible for the opening and closing of the hand. This possibly reflects differences in the ease of controlling fine movements at the metacarpophalangeal joints of the finger and the thumb. But it may also be seen to confer a simpler visual relationship between the object and the approaching hand assuming attention is focussed on the relation between thumb and dowel. This presumably simplifies processing of visual feedback so making any adjustments to the approach movement easier and quicker.

Turning to the right panel in Figure 4 the data on the artificial hand show an almost identical pattern of movement of the thumb and finger relative to the wrist-dowel axis. Moreover, the similarity of the artificial and natural hands is also seen in Figure 5 when reaching for the narrow dowel. This correspondence is all the more remarkable when one considers the nature of finger and thumb movement in the artificial hand. The mechanical system is such that tensioning the cable against the spring holding the hand closed leads to simultaneous movement of the thumb and finger in opposite directions. The amount of movement is equal for thumb and finger. Given the mechanical functioning of the

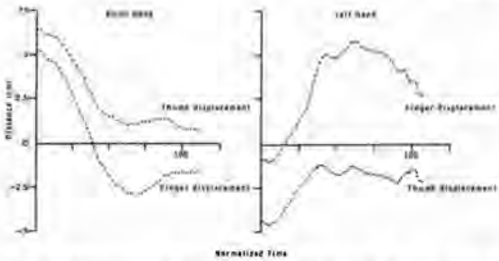

Fig 5. Distance of the finger and thumb from an axis joining the wrist marker to the narrow for natural (left panel) and artificial (right panel) hands. In both cases, the curve for the finger is the one nearer the horizontal axis at time zero.

hand, it is thus very surprising that the subject is able to operate her artificial hand during reaching in such a way that the use of thumb and finger appears normal.

Further examination of the film showed that the subject achieved the invariance between the thumb and wrist-dowel axis in at least two ways. On some trials the direction of movement of the artificial hand was reversed before the object was contacted. The speed reversal matched the speed with which the thumb would otherwise have approached the dowel. Such reverse transportation can be seen in both curves for the artificial hand in Figure 2. It is not present in the natural hand transport curves. Rotation of the arm about the wrist was also observed on some trials as a result of abduction of the arm at the left shoulder joint combined with internal rotation. This manouevre maintained a relatively fixed distance of the thumb from the axis as the hand closed, without any overall transportation movement observed at the wrist.

Conclusions

Analysis of the film records of reaching indicates that the proficient user of an artificial hand uses the thumb as the basis for aligning the grasp as the hand approaches the object. This parallels natural hand usage and it is reasonable to suppose that it simplifies processing of visual feedback about the relation of the hand to the object. This feedback is needed in making adjustments to the approach trajectory of the hand. However, this strategy (which did not appear to be conscious on the part of the subject) required manoeuvres of the artificial hand that presumably interact with the problems of control due to the shoulder-based movements. In future research in this area there would seem to be a strong argument for taking the methodological approach of Soede (1980) who has developed objective indices for the ease of control of different types of artificial hands.

For example, we observed a number of similarities between normal hand function and the functioning of the artificial hand, but the movements of the artificial hand were much slower. An important question in contemplating possible changes in artificial hand design, is to what extent the slowness is due to the need to employ muscles, normally used in gross movement, for fine movements. Or, does the slowness result from an added dependence on vision due to lack of sensory feedback from the extremity? With reference to the last possibility, a quick test showed that the subject was only able to grasp the dowel with eyes shut one out of five times when she was asked to pick it up from a known position using her artificial hand. Using the natural hand, with her eyes shut, she picked up the dowel five out of five times. But, whether the slowness arises from the employment of gross muscles, from an added dependence on visual feedback or a combination of both factors, the real issue is how much more difficult is it to use the artificial hand? Techniques, such as those suggested by Soede (1980), should be most useful in assessing the attention demands of various manouevres of an artificial hand.

The present study has treated the performance of a single user of an artificial hand. The subject was a "good" user in that she wore her prosthesis regularly and was proficient in its operation in activities of daily living. It would be interesting to know whether other users would exhibit similar patterns of control. In particular, what is the nature of movements used by people who are less proficient, who have only recently been fitted with an artificial hand? And how do consistent patterns of movement, such as those seen in this study, develop?

The answers to these questions are obviously central to evolving an efficient training programme for new wearers of artificial limbs. But even at this stage certain implications for the goals of training by therapists may be drawn. We will consider these in order of their occurrence in the reaching movement, although this may not be the most appropriate learning sequence. So that the first part of the transport movement can be open-loop, the learner should have a clear spatial target in mind before starting to move the hand. Training at this stage might be based on a game where the hand is used (without opening) to knock over a target placed at various positions. After several trials, the learner could be encouraged to close his or her eyes just before starting the movement.

The second component, hand opening, might be introduced as a static task, with the hand immediately in front of the object. The goal would be to open the hand just wider than the perceived object size and hold it at that width. In this exercise it would probably be useful to have a set of standard objects with clear size gradations. Again, in later trials, the learner could be encouraged to close the eyes just before starting to open the hand. This would emphasize the need to relate the degree of hand opening to a clear mental image of the object.

The two components, transport and hand opening, might be most easily put together into a reaching action by having the learner initiate both elements together. Then, as skill develops, opening of the hand may be allowed to occur later, subject to the constraint that a maximum aperture exceeding the object size be attained by about three-quarters of the way through the action. The learner should be directed to focus attention on the thumb relative to the object from about halfway through movement. To discourage the learner from monitoring the hand too early in the movement, it would probably be best to start the movement looking at the object. A helpful exercise might be to ask the learner to keep the hand open at the maximum and simply bring the hand up to the object, stopping with the thumb just touching the object.

Finally, strategies to cope with simultaneous closure of thumb and finger would have to be outlined. There might be a problem explaining these to younger children, although static practice with the hand opened and closed to keep the thumb in fixed alignment with a simple target might help.

Throughout training, and particularly on trials performed with the eyes shut, video feedback showing performance of the artificial hand could be very useful to the learner as well as the therapist. Moreover, the use of video records to show the learner his or her improvement in performance over a number of sessions would provide strong positive reinforcement. If video were used to demonstrate similarities between artificial and natural hands, acceptance of the prosthesis might be improved by emphasizing the similarities between artificial and natural hand function. This might become a criterion for the wearer accepting the hand as "a part of him-or herself".

Acknowledgements

This research was supported by the East Anglian Regional Health Authority. We are grateful for assistance provided by Derek Simmonds of the MRC Applied Psychology Unit in shooting the film and to David Kerwin and Derek Maynard of the School of Human Movement Studies, Bedford College of Education in taking measurements from it. We are indebted to our subject for her cooperation.

REFERENCES

Beggs W. D. A. and Howarth, C. I. (1972). The movement of the hand towards a target. *Quart. J. Exp. Psych.* **24,** 448–453.

Halverson, H. M. (1937). Studies of the grasping responses of early infancy. *J. Gen. Psych.* **51,** 371–449.

Jeannerod, M. (1981). Intersegmental coordination during reaching at natural visual objects. In: Baddeley, A.D. and Long, J. (eds) *Attention and Performance IX,* Erlbaum, Hillsdale, New Jersey.

Keele, S. W. (1968). Movement control in skilled motor performance. *Psych. Bull.* **70,** 387–404.

Northmore-Ball, M. D., Heger, H. and Hunter, G. A. (1980). The below-elbow myo-electric prosthesis. *J. Bone and Jt. Surg.* **62,** 363–367.

Sensky, T. (1980). A consumer's guide to "bionic arms". *Brit. Med. J.* July, 126–127.

Soede, M. (1980). On the mental load in arm prosthesis control. PhD Thesis, Leiden, Netherlands.

Obituary

Marian Weiss

We have received the sad news that Professor Marian Weiss died on July 17th 1981 in Warsaw.

Marian Weiss was an unusual personality and a pioneer within orthopaedic rehabilitation and prosthetics.

In Konstancin near Warsaw he developed with vision, skill and enthusiasm a comprehensive centre encompassing surgery, rehabilitation, prosthetics and teaching facilities. He was allocated the first chair of rehabilitation in Poland.

To the world Marian Weiss is known for significant scientific contributions. He introduced "immediate fitting and ambulation" in prosthetic practice. His research in neuromuscular patho-physiology and in spinal surgery is also among his important work.

Through his services to WHO, ISPO and Rehabilitation International he made a major contribution in the international field.

His charming and distinguished spirit and appearance provided friendships in East and West.

His passing is a loss to the international programme and leaves a void in his native country.

KNUD JANSEN

Prosthetics and Orthotics International
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Deutsch

Vergleichende Untersuchung der Funktion einer myoelektrischen und einer aktiven Greifzangenprothese

P. J. Agnew
Pros. Orth. Int. **5:2,** *92–96*

Zusammenfassung
Bei einem Patienten, der sowohl mit einer myoelektrischen Vorderarmprothese mit sensorischer Rückmeldung als auch mit einem aktiven Hook versorgt war, wurden dreissig verschiedene Funktionen getestet. Ein Vergleich der Ergebnisse ergab eine deutliche funktionelle Ueberlegenheit ($p<0.001$) der Greifzange über die myoelektrische Prothese. Die Bewertung erfolgte nach dem Minnesota Rate of Manipulation Placing Test und dem Smith Test of Hand Function. Die Indikationsstellung für die eine oder andere Art Prothese hat sich als unmöglich erwiesen. Für einige Belange scheint die myoelektrische Prothese mit sensorischer Rückmeldung überlegen zu sein.

Teamwork im Kampf gegen die Kinderlähmung
S. A. Ajao und G. A. A. Oyemade
Pros. Orth. Int. **5:2,** *68–74*

Zusammenfassung
In Nigeria bildet die Kinderlähmung nach wie vor ein grosses Problem mit zahlreichen Patienten, die alle der Behandlung bedürfen. 1120 Patienten mit Kinderlähmung aus der Polio-Sprechstunde der Abteilung für Physikalische Therapie des Universitätsspitals in Ibadan wurden untersucht. Die multidisziplinäre Behandlung des Problems setzt sich die Rehabilitation der Polio-Patienten zum Ziel, damit sie nicht der Wirtschaft zur Last fallen. Anhand eines Falles werden die Probleme und Möglichkeiten aufgezeigt. Besonders wichtig ist jedoch die Durchimpfung als Vorbeugungsmassnahme.

Verstellbare Kurzprothesen
A. Balakrishnan
Pros. Orth. Int. **5:2,** *85, 86*

Zusammenfassung
Doppelseitige Beinamputierte, die mit Prothesen von normaler Länge versorgt werden, haben jeweils Mühe, sich rasch fortzubewegen oder Treppen zu überwinden. Besonders für geriatrische Patienten eignen sich kurze Stummelprothesen mit festen Kufen. Es besteht die Möglichkeit, die Kurzprothese mit einer solchen normaler Länge am gleichen Schaft zu befestigen und umgekehrt. Ein Gelenk zwischen Unterschenkel und Kufe ermöglicht dem Patienten die Benützung der Toiletten in Indien mit Hilfe eines niedrigen zusammenklappbaren Gestelles. Ausserdem erleichtert das Gelenk dem Patienten die Feldarbeit. Die Konstruktion hat sich vor allem für Doppelamputierte in Entwicklungsländern als nützlich erwiesen.

Bemerkungen zum Beitrag von N. C. McCollough über die Forschung in der Amputationschirurgie und der technischen Orthopädie
Pros. Orth. Int. **5:2,** *97–102*

Dieser Beitrag erschien im Heft Nr. 1, Band 5. Wir haben folgende Fachleute um Stellungnahme gebeten: James Foort, A. Bennett Wilson Jr. und Joseph H. Zettl.

Die operative Behandlung angeborener Missbildungen der Gliedmassen—III, Teil
E. Marquardt
Pros. Orth. Int. **5:2,** *61–67*

Zusammenfassung
Der III. Teil behandelt die unteren Extremitäten anhand ausgewählter Beispiele. Folgende Gebiete werden behandelt: Vollständige oder teilweise Defektbildung der Tibia, der Fibula und schliesslich des Femurs.

Vorläufige klinische Ergebnisse mit dem hydraulisch gesteuerten Sprunggelenk nach Mauch
T. T. Sowell
Pros. Orth. Int. **5:2,** *87–91*

Zusammenfassung
Eine vorläufige klinische Erprobung von acht Prototypen der hydraulischen Sprunggelenkssteuerung nach Mauch erfolgte durch die US Veterans Administration während zwei Jahren (Juni 1977—Oktober 1979). Versorgt wurden ein Oberschenkel, drei Unterschenkel— und ein doppelseitig Ober-/Unterschenkel amputierter. Beide Oberschenkelamputierte wurden ferner mit dem hydraulischen gesteuerten S-N-S Knie von Mauch ausge rüstet. Die Untersuchung verfolgte folgende Ziele:

1. Abklärung der Frage, ob dieses Sprunggelenk die anatomischen Bewegungen in der frontalen, sagittalen und transversalen Ebene nachvollzieht.
2. Prüfung der Verwendbarkeit in bezug auf die Amputations höhe, seine Vorteile für doppelseitig Amputierte und die Verwendbarkeit mit den herkömmlichen konventionellen und Modularpassteilen.
3. Untersuchung des Schwierigkeitsgrades bei Einbau, Auslotung und Anpassung und allfälliger neuer Gesichtspunkte bei der Gehschulung.

Die Ergebnisse der Untersuchung zeigten, dass das Sprunggelenk dem natürlichen sehr ähnlich ist beim Gehen auf unebenem Gelände, schrittweise treppab steigen, beim Laufen, beim Ueberwinden von Steigungen auf—und abwärts und bei einer Reihe von Sportarten, u.a. Ski fahren. Fünfzig Gelenke sind nun in der klinischen Erprobung unter der Leitung des VA Rehabilitation Engineering Center (ehemals V.A.P.C.)

Prüfung von handbetriebenen Rollstühlen, Die Notwendigkeit internationaler Standardisierung
A. Staros
Pros. Orth. Int. **5:2,** *75–84*

Zusammenfassung
Das Zentrum für Rehabilitationstechnik der Veteran's Administration und andere zuständige Stellen in den Vereinigten Staaten bemühen sich seit den frühen 60er Jahren, die Rollstühle zu verbessern. Unsere Anforderungen für den Transport Rollstuhl sind das Ergebnis einer Reihe von teils einfachen, teils recht komplizierten Untersuchungen. Auch für elektrisch angetriebene Rollstühle haben wir versuchsweise Richtlinien herausgegeben. Leider wurden diese Anstrengungen mit gleichen Bestrebungen in andern Ländern nicht koordiniert, was in Zukunft unbedingt nachzuholen ist.

Español

Resultados funcionales de las protesis mioelectricas comparadas con las protesis con gancho de prehension.
P. J. Agnew
Pros. Orth. Int. **5:2,** *92–96*

Resumen
Se describe la funcionalidad de una prótesis mioeléctrica, con información sensorial, comparada con un gancho de prehensión. Se hicieron treinta comprobaciones en un solo sujeto, con amputación por debajo del codo, usando una prótesis mioeléctrica y una con gancho de prehensión. Usando un modelo autoregresivo para comparación de los datos, el gancho resultó mejor funcionalmente que la prótesis mioeléctrica ($p < 0.001$). La efectividad fué comprobada con el aparato de manipulación de Minnesota y el de Smith de función de la mano. No se comenta las posibilidades de las dos prótesis en otros amputados. Sin embargo, los resultados clínicos sugieren la conveniencia de las prótesis mioeléctricas con información sensorial para algunos trabajos.

El equipo lucha contra la plaga de la poliomielitis
S. A. Ajao y G. A. A. Oyemade
Pros. Orth. Int. **5:2** *68–74*

Resumen
La poliomielitis es todavía un problema médico en Nigeria, que la mayoría de las veces deja al paciente con parálisis, contracturas y anormalidades que requieren un tratamiento complejo. Se han estudiado mil ciento veinte pacientes diferentes con poliomielitis y tratados en el Departamento de Fisioterapia en la Clínica de Polio del Hospital Universitario en Ibadan. Se ha usado un equipo con un punto de vista multidisciplinario, para integrar a las víctimas de la polio en la comunidad, de manera que no constituyan una responsabilidad económica. Se describe un caso en el que una víctima de la poliomielitis que, como máximo, consigue gatear, con un tratamiento efectivo dado por el equipo dió como resultado su posibilidad de mantenerse en la comunidad. Tambien se ha insistido en la importancia de la inmunización profiláctica para evitar la extensión de la enfermedad en la comunidad.

Nota tecnica—Pilon de apoyo inclinado
A. Balakrishnan
Pros. Orth. Int. **5:2,** *85–86*

Resumen
Los amputados bilaterales a los que se les adapta una prótesis normal tienen dificultades para andar deprisa o subir y bajar escaleras. Muchas veces se les suministra pilones o prótesis cortas, con apoyo no articulado, especialmente para amputados geriátricos. Se ha desarrollado un sistema intercambiable, que permite que la misma prótesis sea usada con toda su longitud o en un pilón corto.

Las prótesis por encima de la rodilla se convierten en un pilón corto, removiendo la pantorrilla y el pie de la pieza de rodillaencaje, reemplazándolos con un balancín hueco articulado.

La inclinación de las piezas de rodilla y encaje, que es posible por la articulación en la unión del balancín y el encaje, permite al amputado bajar su cuerpo para usar el inodoro de tipo indio, con ayuda del andador portatil plegable y además la inclinación ayuda al amputada trabajar en el jardín y en el campo.

El sistema intercambiable es especialmente conveniente para los amputados bilaterales en paises en desarrollo.

Comentarios sobre investigacion ortopedica en cirugia de amputacion, protesica y ortesica por N. C. McCollough
Pros. Orth. Int. **5:2,** *97–102*

Este artículo fué publicado en el Vol. 5, no. 1 de la Revista. Se colicitaron comentarios a varias distinguidas personas y se han recibido de: James Foort, A. Bennett Wilson Jr., and Joseph H. Zettl.

Tratamiento operatorio de las malformaciones congenitas de la pierna—III Parte.
E. Marquardt
Pros. Orth. Int. **5:2,** *61–67*

Resumen
La Parte III está dedicada a experiencias en la extremidad inferior, ilustradas con ejemplos muy seleccionados. Los casos fueron; deficiencia tibial longitudinal, total o parcial; deficiencia peronea longitudinal, total o parcial; deficiencia longitudinal femoral, total o parcial.

Evaluacion clinica preliminar del sistema hidraulico mauch para pie y tobillo.
T. T. Sowell
Pros. Orth. Int. **5:2,** *87–91*

Resumen
Se ha llevado a cabo una evaluación clínica de este sistema hidráulico en la Administración de Veteranos de USA en ocho prototipos, durante un periodo de dos años (Junio 1977—Octubre 1979). Uno encima de la rodilla, tres debajo de rodilla, uno bilateral encima y debajo rodilla. Los dos de encima de la rodilla usaban la rodilla hidráulica Mauch S-N-S. El propósito de este estudio fué:

1. Determinar si este sistema da la misma funcion que el tobillo anatómico en los tres ejes: mediolateral, antero-posterior y vertical.
2. Ver sus posibilidades, en relación con el

nível de la amputación, sus ventajas en los dobles amputados y el posible uso con los mecanismos de rodilla en las prótesis normales o de pilón.

3. Ver la facilidad de instalación, alineamiento y ajuste por un protésico y las nuevas técnicas de entrenamiento de la marcha por un fisioterapeuta. El resultado del estudio revela que este sistema iguala al tobillo anatómico en actividades tales como andando en un terreno irregular, descendiendo escaleras paso por paso, corriendo, descendiendo y ascendiendo en planos inclinados paso por paso, y una variedad de otras actividades deportivas, incluyendo el esquiar. Se han fabricado cincuenta unidades y están siendo evaluadas en un estudio clínico en toda la nación dirigido por el Centro de Ingenieros de Rehabilitación de la Administración de Veteranos (antes V.A.P.C.)

Analisis de sillas de ruedas movidas manualmente Necesidad de normas internacionales

A. Staros

Pros. Orth Int. **5:2,** *75–84*

Resumen

El Centro de Rehabilitación de Ingeniería de la Administración de Vetaranos (VAREC) y otros en Estados Unidos han trabajado conjuntamente para mejorar las sillas de ruedas, desde el principio de los 60. Las normas de la U.S. Veteran Administrarion para las sillas de ruedas fueron perfectamente promulgadas, basadas en una serie de pruebas, algunas sencillas y otras que necesitaron un equipo muy complejo. VAREC ha adaptado tambien unas normas para las sillas de ruedas eléctricas. Sin embargo, dichos esfuerzos y aquellos que se han realizado en Estados Unidos, tanto para las sillas movidas a mano como para las eléctricas, no han tenido relación con el trabajo en otras naciones; en el desarrollo de normas internacionales empezado recientemente, debe incluirse el trabajo de todos.

Français

Comparaison de l'efficacité fonctionnelle d'une prothèse myo-électrique et de celle d'une prothèse à crochet actif.

P. J. Agnew

Pros. Orth. Int. **5:2,** *92–96*

Résumé

Description de l'efficacité fonctionnelle d'une prothèse myo-électrique avec feed back sensitif et de celle d'une prothèse avec crochet actif. 30 observations ont été faites chez le même patient ayant subi une amputation de l'avant-bras droit au-dessous de coude, utilisant l'une ou l'autre des prothèses. Une comparaison des résultats par régression simple montra une nette supériorité fonctionnelle ($p < 0.001$) de la prothèse à crochet. L'efficacité fonctionnelle a été jugée selon les scores du test du Minnesota rate of manipulation placing et du test de fonction selon Schmith. Aucun pronostic n'est fait concernant l'utilisation de l'une ou l'autre prothèse par d'autres amputés. Cependant l'expérience clinique suggère que la prothèse myo-électrique avec feed back sensitif se prête bien à certaines autres fonctions.

Travail de groupe dans la lutte contre la polioyelite

S. A. Ajao et G. A. A. Oyemade

Pros. Orth. Int. **5:2,** *68–74*

Résumé

Au Nigeria, la polio représente encore un problème médical important, ses séquelles laissant des patients aux muscles paralysés, contracturés et déformés nécessitant un traitement élaboré. Nous avons étudié 1120 patients souffrant de polio et traités à la clinique pour polio du département de physiothérapie de l'hôpital universitaire à Ibadan. L'approche pluri-disciplinaire du groupe avait pur but de réintégrer les victimes dans la communauté sans charges économiques pour la société. Le traitement effectif est illustré par un cas pris en exemple montrant comment maintenir les capacités de ce patient à vivre dans la communauté.

L'importance de la vaccination à large échelle est également soulignée.

Note technique—prothèses courtes modifiables.
A. Balakrishnan
Pros. Orth. Int. **5:2,** *85–86*

Résumé
Les amputés bilatéraux appareillés de prothèses standard de longueur normale trouvent difficile de marcher rapidement ou de monter ou descendre les escaliers. Habituellement nous utilisons des pilons ou courtes prothèses non-articulées à semelle arondie, spécialement en gériatrie. Un système interchangeable a été dévelloppé qui permet à la même prothèse d'être utilisée soit normalement soit comme pilon court.

Une prothèse de cuisse se transforme en pilon en enlevant la pièce de jambe et de pied et en la remplaçant par un pilon évidé et articulé à semelle arondie, fixé à l'unité soquette/genou. Cette transformation à la hauteur du genou permet à l'amputé d'avoir son corps plus près du sol pour aller auxtoilettes selon les habitudes indiennes et pour travailler à la terre. Ce système interchangeable convient particulièrement bien aux amputés bilatéraux dans les pays en voie de développement.

Commentaires concernant l'article de N. C. McCollough sur la recherche dans la chirurgie d'amputation et dans l'appareillage.
Pros. Orth. Int. **5:2,** *97–102*

Cet article est paru dans le volume 5, numéro 1 du journal. Nombreuses furent les remarques commentées par James Foort, A. Bennett Wilson jr. et Joseph H. Zettl.

Traitement opératoire de malformations congénitales des membres, 3ème partie.
E. Marquardt
Pros. Orth. Int. **5:2,** *61–67*

Résumé
La troisième partie traite des membres inférieurs; elle est illustrée de quelques exemples choisis. Les domaines sont les suivants: aplasie complète ou partielle du tibia, aplasie complèteou partielle du péroné, aplasie totale ou partielle du fémur.

Evaluation clinique préliminaire du système hydraulique selon Mauch à une prothèse cheville-pied.
T. T. Sowell
Pros. Orth. Int. **5:2,** *87–91*

Résumé
Pendant 2 ans (je juin 1977 à octobre 1979), l'administration U.S. des Vétérans a procédé à une évaluation clinique provisoire de 8 prototypes du système hydraulique de Mauch cheville-pied. Les patients étaient amputés 1, un au-dessus du genou, trois en-dessous du genou et un bilatéral en-dessus et en-dessous de genou. Les 2 amputés à la cuisse utilisaient déjà le système hydraulique S-N-S selon Mauch de genou.

Le but de cette étude était:

1. De déterminer si ce système permettait une fonction de la cheville selon les 3 axes naturels médiolatéral, antéro-postérieur et vertical.
2. De déterminer son application selon la hauteur de l'amputation, son avantage pour les amputés bilatéraux et sa compatibilité avec des prothèses en fût ou à armature centrale et leurs pièces standart de genou.
3. De déterminer les difficultés de montage, d'allignement et d'ajustement par letéchnicien ainsi que d'éventuelles adaptations de la kinésithérapie pour l'apprentissage de la marche.

Les résultats de l'étude montrent que ce système reproduit les fonctions anatomiques de la cheville telles que la mar che sur un terrain irrégulier, la descente ou montée d'un escalier, la descente ou montée d'une côte et diverses activités sportives y compris le ski. 50 modèles ont été produits et sont testés sur le plan clinique à travers tout le pays pour le VA Rehabilitation Engineering Centre (anc. V.A.P.C.).

Etude des chaises roulantes à main. Nécessité de standard internationaux.
A. Staros
Pros. Orth. Int. **5:2,** *75–84*

Résumé
Le centre téchnique de réadaptation de la Veteran's Administration (VAREC) et d'autres services ont été conduits à analyser les chaises

roulantes dès le début des années 1960. Ils ont défini une chaise à main standard en se basant sur différents tests, certains simples, certains plus complexes. La VAREC a aussi développé une ligne directrice concernant les chaises roulantes électriques. Cependant ces études sur les 2 types de chaise ont eu lieu aux Etats-Unis et n'ont pas été mis en relation avec les travaux dans d'autres pays. Un travail de développement de la standardisation internationale a débuté récemment et devraient inclure les travaux de tous.

Italiano

L'efficacia funzionale di una protesi mioelettrica nei confronti ad una protesi cinematica con gancio un esperimento su singolo soggetto.
P. J. Agnew
Pros. Orth. Int. **5:2,** *92–96*

Riassunto
Viene descritto l'efficacia funzionale di una protesi mioelettrica provvista di retroreazione sensoria nei confronti di una protesi cinematica con gancio. Trenta osservazioni sono state effettuate su una singola persona con un'amputazione di avambraccio che usava alternativamente la protesi mioelettrica e quella cinematica con gancio. Usando un modello autoregressivo di prim'ordine onde trarre conclusioni circa le due serie di dati, risultava che la protesi cinematica era meglio dal punto di vista funzionale ($p < 0.001$) della protesi mioelettrica.

L'efficacia funzionale è stata definita operativamente come punti sul Test di Minnesota del Tasso di Collocamento Manipolativo e il Test di Smith delle Funzioni della Mano. Non si fa predizione riguarante la utilizzazione sia dell'una che dell'altra protesi per altri amputati. Tuttavia dati clinici hanno suggerito l'idoneità della protesi mioelettrica con retroreazione sensoria per alcuni altri compiti funzionali.

L'equipe combatte il flagello della poliomielite
S. A. Ajao e G. A. A. Oyemade
Pros. Orth. Int. **5:2,** *68–74*

Riassunto
La poliomielite rappresenta ancora un problema sanitario nella Nigeria, le conseguenze della quale lasciano i pazienti con la paralisi muscolare, contratture e anormalità che richiedono un trattamento elaborato. Sono stati studiati 1120 pazienti affetti da poliomielite e trattati presso il Centro per la polio del Dipartimento di Fisioterapia della Clinica Universitaria di Ibadan. Il risultato dell'attività multidisciplinare di una equipe sanitaria professionale viene utilizzato per reinserire le vittime della poliomielite nella comunità affinchè non costituiscano un peso economico.

Viene illustrato il caso di una vittima della polio incapace di reggersi in piedi che, grazie al trattamento efficace applicato dalla equipe ha ottenuto un recupero funzionale tale da consentirgli di vivere e mantenersi nella comunità.

Viene anche sottolineata l'importanza della immunizzazione profilattica per impedire la diffusione della malattia nella comunità.

Nota tecnica "Gli sutbbies inclinabili" (Protesi corte inclinabjli)
A. Balakrishnan
Pros. Orth. Int. **5:2,** *85–86*

Riassunto
Amputati bilaterali che vengono forniti con protesi di lunghezza naturale possono incontrare difficoltà a camminare con un passo veloce o salire e scendere le scale. Di solito gli Stubbies o protesi corte con fondo oscillante non articolato, vengono anche fornite, specialmente per gli amputati geriatrici. E' stato sviluppato un sistema che permette l'uso della protesi sia con lunghezza naturale sia con una protesi corta.

La protesi con lunghezza naturale viene trasformata in una protesi corta togliendo il piede e la caviglia sostituendolo con la base di appoggio inclinata. L'inclinazion e del componente invasatura-ginocchio è possibile attraverso l'articolazione fra la base di appoggio della protesi corta e i rimanenti componenti; questa articolazione permette all'amputato di abbassare il corpo onde utilizzare una toeletta tipo indiano, con l'aiuto di una sedia portatile pieghevole ha anche la possibilità di svolgere piccoli lavori fuori casa, nei giardini e nei campi.

Questo sistema intercambiabile è particolarmente idoeno per gli amputati bilaterali nei paesi in via di sviluppo.

Osservazioni sulle ricerche nel campo della tecnica chirurgica nell'amputazione, nella protetica e nell'ortotica
N. C. McCollough
Pros. Orth. Int. **5:2,** *97–102*

La relazione surriferita è stata pubblicata nel Vol. 5 No 1 del Journal. Osservazioni sono state richieste da diversi medici e sono state ricevute da: James Foort, A. Bennett Wilson Jr. e Joseph H. Zettl.

Il trattamento chirurgico delle malformazioni congenite agli arti—Parte III
E. Marquardt
Pros. Orth. Int. **5:2,** *61–67*

Riassunto
La parte III è dedicata all'esperienza con l'arto inferiore e viene illustrato con esempi scelti. I temi trattati sono: difetti longitudinali della tibia, totali o parziali; difetti longitudinali della fibula, totali o parziali; difetti longitudinali del femore totali o parziale.

Una valutazione preliminare nell 'utilizzo dell' articolazione tibiotarsica idraulica di mauch
T. T. Sowell
Pros. Orth. Int. **5:2,** *87–91*

Riassunto
Una valutazione preliminare è stata effettuata dall'Amministrazione dei Veterani negli S.U. su diversi amputati con l'articolazione Tibiotarsica idraulica di MAUCH in un periodo di due anni. E'stata inserita l'articolazione Tibiotarsica idraulica in un amputato di coscia, in tre amputati di gamba e in amputati bilaterali di coscia e di gamba. Inoltre nelle protesi di coscia è stato utilizzato anche il ginocchio idraulico S-N-S di MAUCH. Lo scopo di questo studio è stato quello di:

1. Determinare se l'articolazione della Tibiotarsica idraulica MAUCH ha funzioni simili alla articolazione naturale sui tre assi principali della stessa—mediolaterale, anteposteriore e verticale.
2. Determinare la sua applicabilità per quanto riguarda il livello di amputazione, i benefici che reca agli amputati bilaterali e la sua compatibilità con le protesi tipo standard.
3. Determinare la facilità di installazione di allineamento e le procedure di regolazione dal tecnico e di fissare eventualmente nuove tecniche per rieducazione deambulatoria che possano risultare necessarie. I risultati dello studio su amputati rivelano che questo sistema riproduce le funzioni della articolazione della tibiotarsica naturale nella deambulazione con la protesi in terreno irregolare, nello scendere e nel salire le scale, pendenze e in attività sportive compreso lo sciare. Cinquanta unità sono state prodotte e vengono sottoposte a prove su amputati scelti in tutti i territori degli Stati Uniti. Le prove vengono effettuate dalla VA Rehabilitation Engineering Centre (V.A.P.C.)

Le prove sulle carrozzelle per handicappati—spinte a mano
A. Staros
Pros. Orth. Int. **5:2,** *75–84*

Riassunto
Il Centro di Ingegneria dell'Associazione dei Veterani (VAREC) ed altri Centri negli Stati Uniti sono stati coinvolti nei lavori connessi con il miglioramento delle carrozzelle con spinta a mano dei primi anni Sessanta. Gli standards della VAREC per le carrozzelle spinte a mano sono stati emessi in base a numerose prove, alcune semplici, altre richiedenti attrezzature complesse. La VAREC ha anche redatto una proposta per uno standard per carrozzelle elettriche. Nondimeno, gli sforzi come quelli fatti negli Stati Uniti sia per carrozzelle spinte a mano sia per carrozzelle a propulsione elettrica non sono stati messi in rapporto con i lavori compiuti in altre nazioni. Certamente l'azione definitiva verso lo sviluppo degli standards internazionali recentemente avviata dovrebbe impiegare meccanismi per comprendere il lavoro di tutti.

Medizinisch–Orthopädische–Technik, 5/81
A. W. Gentner Publishers, Stuttgart

Experiences with hand-operated, folding wheelchairs in a spinal cord injury centre

Von A. Witzenrath

Abstract
The construction of seatback, arm and leg-rests, wheels and brakes in folding indoor wheelchairs with handrims are discussed. Based on practical experience in a spinal cord injury centre, some improvements are suggested here. A special chart would be useful in individual wheelchair prescription.

The influence of technical wheelchair specifications upon the energy consumption of the wheelchair driver

Von P. Engel and W. Henze

Abstract
For comparative studies of different technical influences (tyre air pressure, wheelchair weight and design) on work load and physical strain measurements of spiroergometric data and heart frequency were performed on ten non-disabled wheelchair test drivers during active wheelchair propelling on a treadmill ergometer with 2 km/hrs speed at different gradient slopes (0-3 degrees). Too little tyre air pressure (0.5 bar) resulted, as expected, in significantly higher physical strain at all tested steps of work load than driving with 3.0 bar tyre pressure. A wheelchair of 3.6 kg more weight than normal by imposing a solid seat and back, increases energy consumption and heartbeat only when propelling at 2–3 degrees inclination. In comparison to the standard model of nearly the same weight driving a sportive wheelchair model led to little reduction of physical strain. The results indicate that even minor technical variations in wheelchairs can be identified by physiological measurements, which can be used for evaluation of technical developments.

Suggestions for improving hand-propelled wheelchairs

Von H. Klosner, K. Seeliger und K.-L. Tondera

Abstract
After presentation of the actual state of wheelchair design possible improvements are evaluated with regard to:
— seating by solid cushioned seat, back, and adjustable footrests
— diminishing friction and replacing the handrim by a hand driven lever to a central gearbox with integrated brakes
— easier transportation by diminishing the volume when folded, easier folding and less weight due to design and lightweight material
— cosmetics and acceptance of better design, making it less conspicuous and by interchangeable seat-covers.
These improvements may not deteriorate the features of the wheelchair.

Ergometric evaluation of wheelchairs with handrim propulsion

Von W. Lesser

Abstract
Wheelchair drivers were tested under different stress conditions with regard to pulse rate, increase of muscle activity and maximum driving time. Reasons for the low grade efficiency of wheelchair are discussed.

A new wheelchair concept

Von B. E. Bürdek

Abstract
For more than 30 years there was practically no development in the field of wheelchairs in West Germany.
This project shows a comprehensive design approach, technical and functional aspects, problems of handling, ergonomical and aesthetical aspects have been considered and transferred to versatile solutions.

In the development of the new wheelchair concept three important parameters have been considered: different, individual forms of disability, different kinds of manipulation and characteristic problems of target groups.
The concept of an "indoor"-wheelchair with slight limitation of outdoor functions is of modular construction (seat and chassis). The wheelchair has a solid, upholstered seat. The backrest is adjustable through a gas loaded spring and allows two seating positions (working position and resting position). The seat can be folded together and taken off the chassis in one move. The chassis collapses easily through a well integrated folding mechanism. The armrest can be raised or lowered individually.

Book Review

Hand Splinting, Principles and Methods. Fess, E. E., Gettle, K. S. and Strickland, J. W. The C. V. Mosby Company, St. Louis, Toronto, London, 1981, 317p. £23.50p.

Hand splinting is a subject which traditionally attracts proportionally less attention in orthotic literature than, for instance, the orthotic management of the lower extremity. Nevertheless, its importance and value command increasing attention as an essential part of the rehabilitation of the functionally impaired hand.

"Hand Splinting—Principles and Methods" has been written by two hand therapists and an orthopaedic surgeon. It describes the anatomy and kinesiology of the hand in relation to hand function, outlines the mechanical properties required of splints, describes the categories of existing splints and introduces a proposed new method classification. Further chapters deal broadly with the design, fit and construction of splints before describing the various types which can be applied to the wrist, fingers and thumb. Readers who are not hand therapists will be attracted to the chapter relating to exercise and splinting for specific problems. Finally the book analyses examples of patients with typical clinical problems and describes suitable solutions.

Readers will find this book easy to read and well illustrated. It is based on the experiences of the writers in the Hand Rehabilitation Center of Indiana and concentrates on basic principles relating to the design and application of splints. This is in contrast to much contemporary literature which frequently tends to list particular types of orthoses for specific conditions. The writers' approach is to emphasize the need to maintain flexible attitudes to splinting techniques and not to be drawn to "set" solutions.

Little information is forwarded regarding materials which are most suited to hand splintage. Whilst low temperature thermoplastics have generally reduced fabrication times and allow modification to be accomplished in the clinic, stronger materials are required particularly for the fabrication of durable splints. In spite of this small omission, readers will find this a well constructed and comprehensive book and a valuable guide to splinting techniques.

D. A. Carus.
Tayside Rehabilitation Engineering Services.
Limb Fitting Centre.
Dundee, Scotland.

Prosthetics and Orthotics International, 1981, 5, 167–171

Calendar of events

National Centre for Training and Education in Prosthetics and Orthotics

Short Term Courses 1982
Course for Physicians and Surgeons

NC102 Lower Limb Orthotics; 8–12 February, 1982.

Course for Physicians, Surgeons and Therapists

NC502 Upper Limb Prosthetics; 1–5 March, 1982.

Courses for Prosthetists

NC210 Above-Knee Modular Prosthetics; 11–15 January, 1982.
NC212 Hip Disarticulation Prosthetics; 15–26 February, 1982.

Courses for Orthotists

NC203 Knee-Ankle-Foot and Hip-Knee-Ankle Foot Orthotics; 18–29 January, 1982.
NC207 Spinal Orthotics; 8–19 March, 1982.

Course for Occupational and Physiotherapists

NC302 Lower Limb Prosthetics; 1–5 February, 1982.

Course for Prosthetic and Orthotic Technicians

NC603 Modular Above-Knee and Hip Disarticulation Prosthetic Construction; 22 March—2 April, 1982.

Further information may be obtained by contacting Professor J. Hughes, Director, National Centre for Training and Education in Prosthetics and Orthotics, University of Strathclyde, 73 Rottenrow East, Glasgow G4 0NG, Scotland. Telephone 041–552 4400, extension 3298.

New York University Medical Center
Prosthetics and Orthotics

Short-Term Courses
Courses for Physicians and Surgeons

741C Lower Limb Prosthetics; 22–26 February, 1982.
751B Lower Limb and Spinal Orthotics; 22–27 March, 1982.
741D Lower Limb Prosthetics; 19–23 April, 1982.
751C Lower Limb and Spinal Orthotics; 26 April–1 May, 1982.
744B Upper Limb Prosthetics and Orthotics; 21–25 June, 1982.

Courses for Therapists

742B Lower Limb Prosthetics; 1–12 March, 1982.
752B Lower Limb and Spinal Orthotics; 22–27 March, 1982.
752C Lower Limb and Spinal Orthotics; 26 April–1 May, 1982.
742C Lower Limb Prosthetics; 10–21 May, 1982.
757 Upper Limb Orthotics; 7–11 June, 1982.
745 Upper Limb Prosthetics; 14–18 June, 1982.

Courses for Orthotists

756 Spinal Orthotics; 4–15 January, 1982.
758 Upper Limb Orthotics; 1–11 June, 1982.
753 Lower Limb Orthotics; 6–23 July, 1982.

Courses for Prosthetists

746 Upper Limb Prosthetics; 18–29 January, 1982.
743 Above-Knee Prosthetics; 14 June–2 July, 1982.

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

North Western University Medical School

Short Term Courses
Courses for Physicians, Surgeons and Therapists

602C, 603C Lower and Upper Limb Prosthetics; 8–12 February, 1982.
702B, 703B Spinal, Lower and Upper Limb Orthotics; 15–19 March, 1982.
602D, 603D Lower and Upper Limb Prosthetics; 29 March–2 April, 1982.
602E, 603E Lower and Upper Limb Prosthetics; 19–23 April, 1982.
702C, 703C Spinal, Lower and Upper Limb Orthotics; 24–28 May, 1982.
602G, 603G Lower and Upper Limb Prosthetics; 7–11 June, 1982.

Course for Physicians and Surgeons

603F Lower and Upper Limb Prosthetics; 3–7 May, 1982.

Courses for Physical Therapists

622A Lower Limb Prosthetics; 11–15 January, 1982.
622B Lower Limb Prosthetics; 17–21 May, 1982.

Course for Orthotists

731 Review Course in Orthotics; 24–26 March, 1982.

Course for Prosthetists

641 Review Course in Prosthetics; 22–24 March, 1982.

Course for Rehabilitation Personnel

640 Orientation in Prosthetics and Orthotics; 5–7 April, 1982.

841 Two Semester Programme in Orthotics and Prosthetics (Prosthetic portion); 4 January, 1982.
761 Certificate Programme in Orthotics; 1 February–15 June, 1982.
631, 632, 633 Management of the Juvenile Amputee for Physicians, Surgeons, Therapists and Prosthetists; 10–13 May, 1982.
801 Pedorthic Management of the Foot; 14–18 June, 1982.

Further information may be obtained by contacting Mr. C. M. Fryer, Director, Prosthetic-Orthotic Centre, North Western University Medical School, 345 East Superior St., Room 1723, Chicago, Illinois 60611, U.S.A.

1982
Eighth International Congress of the World Federation of Occupational Therapists.
Information: World Federation of Occupational Therapists. P.O. Box 26445, Arcadia, Pretoria, S.A.

8 January, 1982
Biomechanical aspects of seating for the disabled (BES Annual Day Conference), Leeds U.K.
Information: Prof. V. Wright, Rheumatism Research, 36 Clarendon Road, Leeds, U.K., LS2 9PJ.

11 January, 1982
Foot pressure problems and benefits of gait analysis, Whitechapel, London E1.
Information: Mr. John Florence, F.B.I.S.T., Orthotic Workshop, New Heritage, Chailey, Sussex.

20 January, 1982
Electric and Electromagnetic stimulation of bone growth (one day symposium), Nijmegen, The Netherlands.
Information: Prof. Th. J. G. van Rens, Dept. of Orthopaedics, University of Nijmegen, 6500 HB, Nijmegen, Netherlands.

21–23 January, 1982
Third 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.

1 February, 1982
Prevention of hand deformities and maintenance of function, Whitechapel, London.
Information: Mr. John Florence, F.B.I.S.T., Orthotic Workshop, New Heritage, Chailey, Sussex.

18 February, 1982
Splint making, Devonshire Royal Hospital, U.K.
Information: Course Secretary, Rehabilitation Centre, Wythenshaw Hospital, Southmoor Road, Manchester.

1 March, 1982
Amputations and alternatives to amputation, Whitechapel, London
Information: Mr. John Florence F.B.I.S.T., Orthotic Workshop, New Heritage, Chailey, Sussex.

15–19 March, 1982
The Hand, Norwich, U.K.
Information: Mrs. M. West, course administrator, Physiotherapy Department, Norfolk and Norwich Hospital, Brunswick Road, Norwich, NR1 3SR.

8–9 April, 1982
First Southern Biomedical Engineering Conference, Louisiana, U.S.A.
Information: Dr. S. Saha, Dept of Orthopaedic Surgery, Louisiana State University Medical Centre, P.O. Box 33932, Shreveport, LO7 1130

16–17 April, 1982
International Seminar and Working Meeting of the Medical Commission of Rehabilitation International, Puerto Rico (immediately preceding IV World Congress of the International Rehabilitation Medicine Association)
Information: Dr. Karlheinz Renker, Gesellschaft fur Rehabilitation in der D.D.R., Harg 42-44, D.D.R.-40 Halle (Saale), German Democratic Republic.

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.

24–27 April, 1982
8th Annual Meeting of the Society for Biomaterials and 14th International Biomaterials Symposium, Florida, U.S.A.
Information: Myron Spector, Biological and Physical Sciences, Medical University of South Carolina, Charleston, S.C. 29425, U.S.A.

27–30 April, 1982
International Conference on "Communications and Disability: A Global Perspective," Washington D.C.
Information: President's Committee on Employment of the Handicapped, Washington, D.C. 20210, U.S.A.

7 May, 1982
Fracture Symposium, Stoke on Trent, U.K.
Information: Dr. G. W. Hastings, Biomedical Engineering Unit, Medical Institute, Hartshill, Stoke on Trent, U.K.

12–14 May, 1982
Biomedical Polymers PIMS IV (joint with PRI), Durham, U.K.
Information: Dr. P. Braiden, Dept. Engineering Sciences, University of Durham, Durham, U.K.

23–28 May, 1982
Ninth International Congress of the World Confederation for Physical Therapy on the theme "Man in Action" Stockholm, Sweden.
Information: L.S.R. Birgerjarlsgatan 13, III, 45 Stockholm, Sweden or the WCPT, 16/19 Eastcastle Street, London W1, England.

13–18 June, 1982
Eighth International Congress of the World Federation of Occupational Therapists on theme "Occupational Therapy and Rehabilitation: Help for the Handicapped", Hamburg, Federal Republic of Germany.

10–13 July, 1982
Third International Conference on Mechanics in Medicine and Biology, Compiègne, France.
Information: Prof. M. Jaffrin, Universite de Compiègne, Génie Biologique, BP 233, 60206 Compiègne Cedex, France.

1–3 September, 1982
Human Locomoter II, Kingston, Ontario.
Information: Canadian Society Biomechanics, c/o Dept. Kinanthropology, University of Ottawa, Ottawa, Ontario KN 6NS.

5–11 September, 1982
World Congress on Medical Physics in Biomedical Engineering (combines 13th International Conference on Medical and Biological Engineering and the 6th International Conference on Medical Physics), Hamburg, Germany.
Information:The Secretariat, Medical Physics and Biomedical Engineering 82, c/o Hamburg Messe und Congress GmbH, P.O. Box 302360 D-2000 Hamburg 36, Federal Republic of Germany.

8–10 September, 1982
Second Annual Advanced Course on Lower Extremity 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.

March or April 1983
7th Asia and Pacific Conference of Rehabilitation International, Kuala Lumpur, Malaysia.
Information: Malaysian Council for Rehabilitation, 12 Long Kongan Jenjarom, Off Jalan Klang, Kuala Lumpur, Selangor, Malaysia.

4–9 September, 1983
I.S.P.O. Fourth World Congress, London.
Information: Conference Services Ltd., 3 Bute Street, London.

1984
IV World Congress of Rehabilitation International.
Information: Rehabilitation International, 432 Park Ave. South, New York, New York 10016, U.S.A.

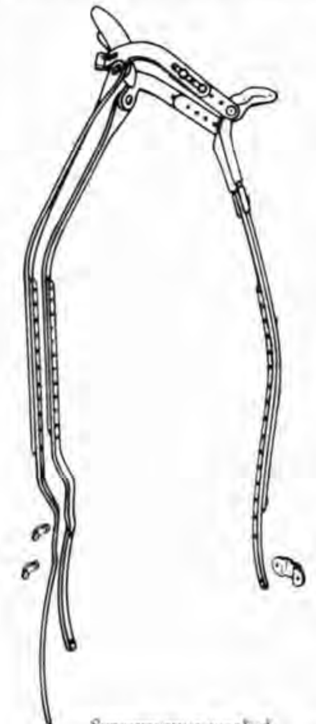
Prosthetics and Orthotics International, 1981, 5, 172–176

Prosthetics and Orthotics International Index to Volume 5, 1981

Author Index

Subject Index

Milwaukee Kits



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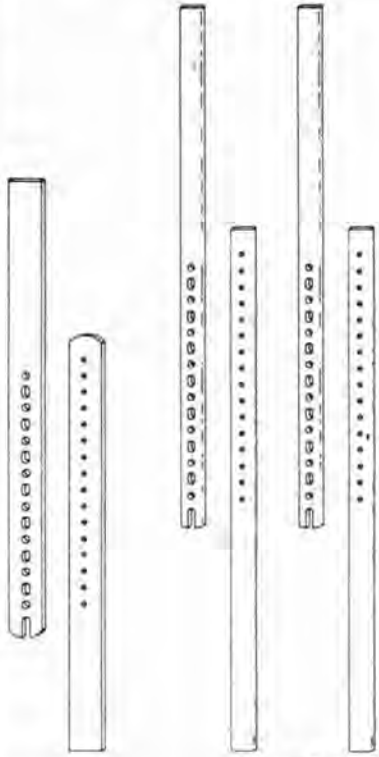

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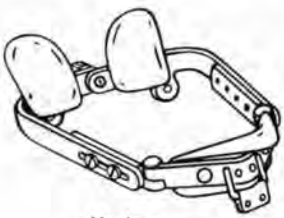

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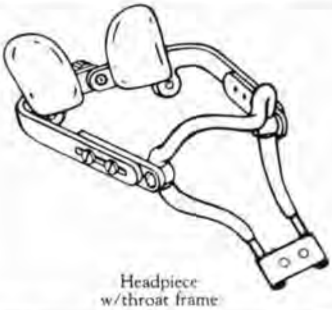

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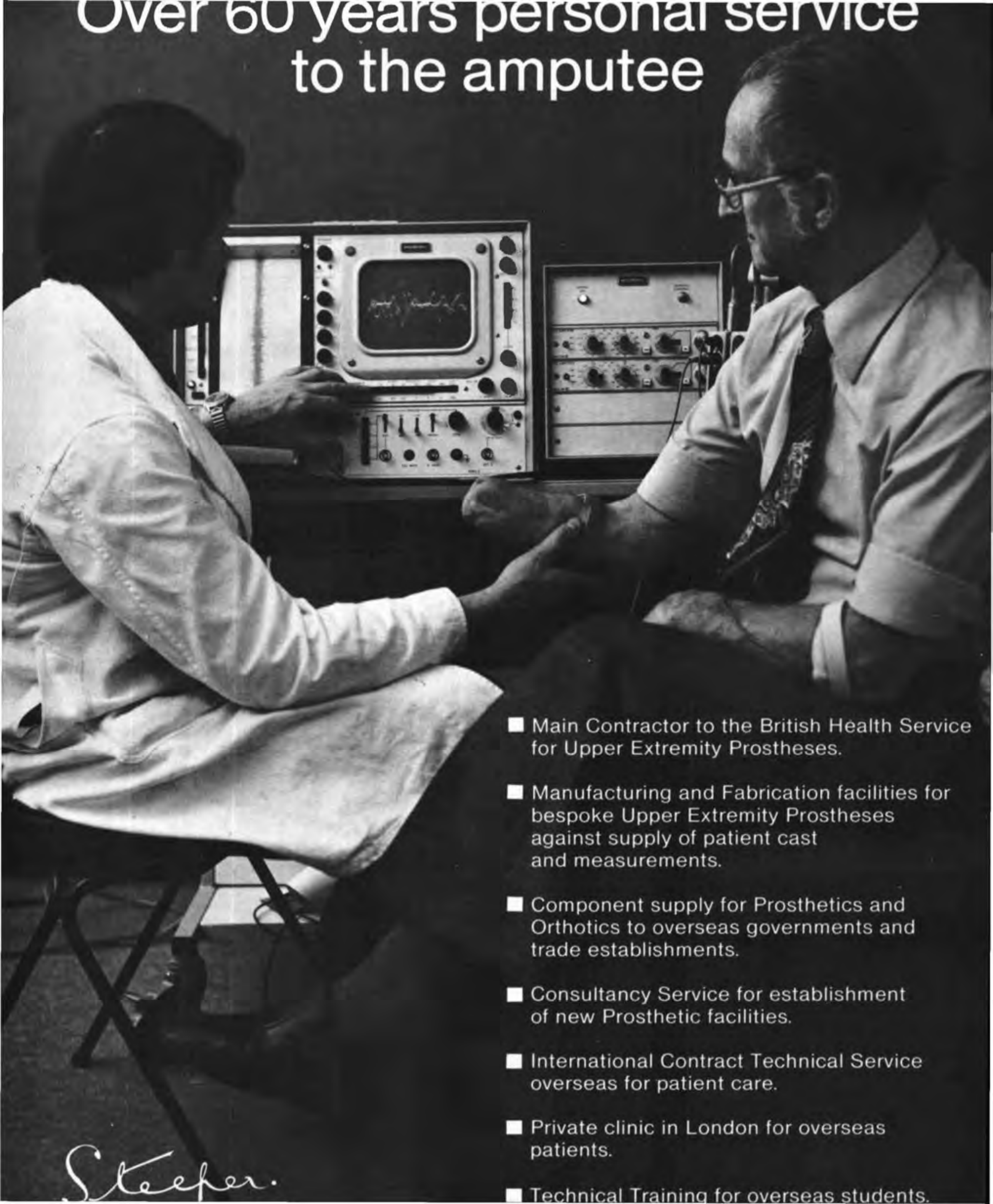
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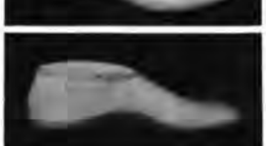

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