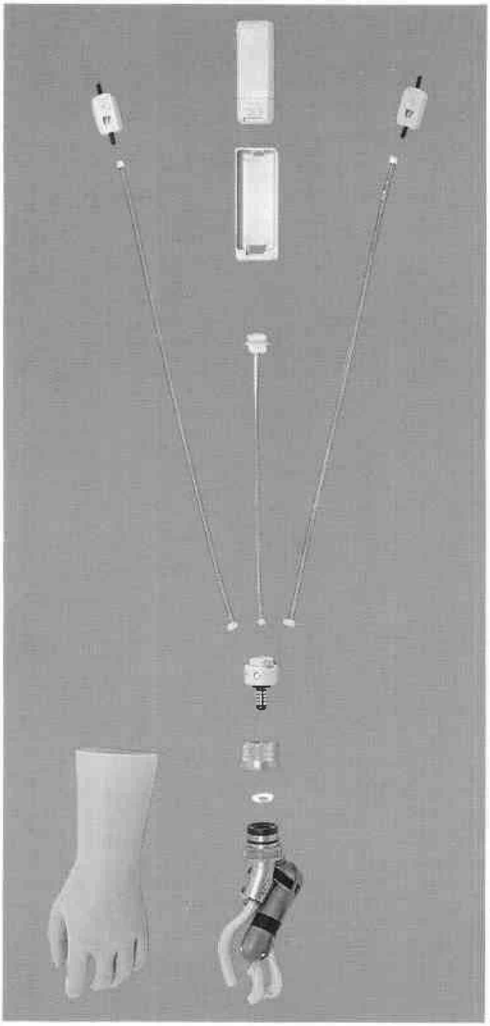
The Journal of the International Society for Prosthetics and Orthotics

Prosthetics and Orthotics International

December 1989, Vol. 13, No. 3



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Prosthetics and Orthotics International

Prosthetics and Orthotics International is published three times yearly by the International Society for Prosthetics and Orthotics (ISPO), Borgervaenget 5,2100 Copenhagen Ø, Denmark, (Tel. (01) 20 72 60). Subscription rate is £45 per annum, single numbers £16. The journal is provided free to Members of ISPO. Remittances should be made payable to ISPO.

Editorial correspondence, advertisement bookings and enquiries should be directed to Prosthetics and Orthotics International, National Centre for Training and Education in Prosthetics and Orthotics, University of Strathclyde, Curran Building, 131 St. James' Road, Glasgow G4 0LS, Scotland (Tel. 041-552 4049).

ISSN 0309–3646

Produced by the National Centre for Training and Education in Prosthetics and Orthotics, University of Strathclyde, Glasgow

Printed by David J. Clark Limited, Glasgow

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ISPO

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W. H. Eisma (President)	Netherlands
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S. Heim (Vice President)	FRG
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E. Lyquist (Past President)	Denmark
G. Murdoch (Past President)	UK
J. Steen Jensen (Hon. Treasurer)	Denmark
N. A. Jacobs (Hon. Secretary)	UK

Standing Committee Chairmen and Task Officers

A full list of Standing Committee Chairmen, Task Officers and Consultants will appear in the next issue.

Chairmen of National Member Societies

Australia	A. van der Borch
Austria	W. Ott
Belgium	M. Stehman
Canada	G. Martel
China	Zhongzhe Wu
Denmark	H. C. Thyregod
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New Zealand	W. Beasley
Norway	G. Veres
Pakistan	N. M. Akhtar
Sweden	A. Jernberger
Switzerland	J. Vaucher
UK	C. Peacock
USA	M. LeBlanc

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K. Jansen (1974–1977)	Denmark
G. Murdoch (1977–1980)	UK
A. Staros (1980–1982)	USA
E. Lyquist (1982–1983)	Denmark
E. G. Marquardt (1983–1986)	FRG
J. Hughes (1986-1989)	UK

Secretary

Aase Larsson	Denmark

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Editorial

The Sixth World Congress in Kobe, Japan was a great success in all its different facets. The Society owes a debt of gratitude to Secretary-General Seishi Sawamura, to all the members of the Japanese Organizing Committee and to his staff, who ensured that this congress was a great success both scientifically and socially.

Friends could meet each other and there was also an excellent opportunity for the exchange of scientific information. During the World Congress there were many meetings such as the retiring and the new Executive Board meetings, the World Assembly and several standing committee meetings.

This past World Congress was till now the biggest and most complex we have ever had.

The formal events associated with the Congress are reported in some detail following this editorial, such as the World Assembly with the President's Report.

It was a great pleasure that the World Assembly was not only very well attended but also had a new and pleasing format. The Blatchford Prize and the Forchheimer Prize were for the first time awarded to Thorkild Engen and M. S. Zahedi respectively.

Before the last meeting of the retiring Executive Board the International Committee meeting was held. An important item on the agenda was the discussion about the review of the Constitution. The discussion was concentrated around three main items:

- a wish for greater involvement of national member societies in the decision making process.
- better information to national member societies and the membership at large about international activities.
- the system of election of the Executive Board.

The decision was made that to solve and tackle these questions an ad hoc committee will be formed under the chairmanship of the Chairman of the Protocol and Nominations Committee, two other Board members and three members of the International Committee. This new ad hoc committee has to report in the summer of 1991. I really hope that by forming this committee a better understanding may develop which may lead also to a strengthening of our structure.

The new Executive Board discussed and decided to hold a concensus workshop on amputation surgery. Such a workshop is needed to provide the material for the development of instructional material and to train surgeons in the techniques that provide optimum results.

In relation to this workshop, a further step will be made by organizing an International Conference for Amputation Surgery to bring the results of the workshop and the knowledge to the widest audience.

By this editorial some aspects of the activities of the last month are shown. The Society is an active organization formed by members and steadily growing. We all have to do our utmost to fulfil the task of our professions within the society in relation to prosthetics, orthotics and rehabilitation engineering.

I look forward to working with you during my Presidency.

Willem H. Eisma
President

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Sixth Triennial Assembly 1989

NORMAN A. JACOBS
Honorary Secretary, ISPO

The Sixth Triennial Assembly of the International Society for Prosthetics and Orthotics was held on Friday, 17th November, 1989 in Kobe, Japan at the time of the World Congress.

Before opening the Assembly, the President, John Hughes, introduced the winner of the Blatchford Prize, Thorkild J. Engen, C.O. for his work on the "Lightweight Modular Orthosis". Thorkild Engen presented a paper on this subject which will be published in this issue of the Journal.

The President also announced the winners of the Forchheimer Prize Paper award, M.S. Zahedi, W.D. Spence, S.E. Solomonidis and J.P. Paul for their paper on "Repeatability of Kinetic Measurements in Gait Studies of the Lower Limb Amputee".

The President then formally opened the Sixth Triennial Assembly and the Honorary Secretary briefly summarized changes to the Constitution. These had been communicated to the membership through 'Prosthetics and Orthotics International' (Vol. 11 No. 3, p.112) and were subsequently approved by the International Committee at their meeting held prior to the Congress.

The President presented his report which was offered to the Assembly for comment. He particularly thanked the Executive Board Members and Task Officers who had given him much support during his Triennium as President.

The Honorary Secretary announced the new Executive Board which had been elected by the International Committee prior to the Assembly. It is as follows:

President	Willem Eisma	Netherlands
President Elect:	Melvin Stills	U.S.A.
Vice Presidents:	Sepp Heim	F.R.G.
	Acke Jernberger	Sweden
Members:	Valma Angliss	Australia
	Per Christiansen	Denmark
	Thamrongrat Keokarn	Thailand
	Jean Vaucher	Switzerland
Honorary Treasurer:	J. Steen Jensen	Denmark
Honorary Secretary:	Norman A. Jacobs	U.K.
Past Presidents:	G. Murdoch	U.K.
	E. Lyquist	Denmark
	J. Hughes	U.K.

Willem Eisma then assumed the chair and addressed the Assembly. Both his Address and the President's Report are reproduced hereafter.

A presentation was given by Dudley Childress informing the Assembly of the VII World Congress which will be held in Chicago, U.S.A. from June 28th-July 3rd, 1992.

Professor K. Tsuchiya, Chairman of the Organizing Committee for the VI World Congress thanked all the participants for making the Congress such a stimulating event. Dr. Seishi Sawamura, Secretary General, gave thanks to his colleagues for their hard work which ensured a successful Congress. He passed the ISPO flag to Dudley Childress and wished him every success with his endeavours in Chicago. Maurice LeBlanc presented a framed print of "Unity for Rehabilitation" by Geza Kogler, on behalf of the United States National Member Society, to Seishi Sawamura.

Following this, the President invited general comments from the Assembly and subsequently, formally closed the Sixth Triennial Assembly.

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President's Report

JOHN HUGHES

It is my great pleasure to report on the activities of the Society over the last triennium. This has been a period of vigorous growth and activity! Starting with an enormously successful Congress in Copenhagen and concluding with this exciting Congress in Kobe. The intervening years have seen a multitude of meetings, activities, events and publications all signifying dedicated effort by the membership.

During the triennium the Society's membership has grown remarkably from 1,850 to 2,300. I am delighted to report that this growth has been accompanied by the establishment of new National Member Societies in Austria, China, India, Korea, New Zealand and newly announced Pakistan. Expansion into the developing world has been encouraged by the Executive Board by providing for a substantially reduced membership fee for low income countries. Satisfactory as the increase in membership is, we must push still harder for more members to strengthen the viability of our Society and spread its influence in patient treatment throughout the world.

Over the past three years the Society has honoured a number of its prominent members. Ernst Marquardt and Erik Lyquist have been elected to Honorary Fellowship in recognition of their outstanding contribution in this field and to the work of the Society. I am sure the membership would wish to join me in congratulating these distinguished individuals on their well-deserved recognition. Fellowships have also been conferred on Penelope Anthony, Per Christiansen, Mike Dewar, William G. Doig, Minni Kumar Goel, Oistein Johansen, Andrew E. Harding, Thamrongrat Keokarn, Roy Nelham, Colin Peakcock, Robin Platts, Bernard Schievink, Anders Stark-hammar, Hans Christian Thyregod, Jean Vaucher and Magnus Wall.

The Society has been particularly successful in organizing a whole series of meetings of a widely varying nature. The World Congresses continue to excite the interest of the membership worldwide. The Congress in Copenhagen at the start of the triennium was outstandingly successful by any measure, under the able direction of Secretary General, Steen Jensen. There is no doubt that the Kobe Congress, under the Chairmanship of Professor Tsuchiya and Secretary General Seishi Sawamura shows promise of matching the success of its predecessor. The magnificent facilities of Kobe and the Convention Centre, a varied and interesting programme and the social programme arranged by our gracious Japanese hosts promise that our first Congress in Asia will be a memorable occasion. Beyond that we are already deep in preparation for the Chicago Congress of 1992 under the experienced guidance of Secretary General, Dudley Childress and with the enthusiastic support of the American Academy of Orthotists and Prosthetists and the American Orthotic and Prosthetic Association. We hope this will be a voyage of re-discovery for many of our members in the 500th anniversary year of the discovery of America by Christopher Columbus.

I am somewhat bemused to report that the court case concerning the Bologna Congress of 1980 continues, with my report indicating precisely the same as my predecessor's three years ago, "the Judge who was dealing with the case has been transferred to another district and we are awaiting the appointment of a new Judge so that the hearing may continue." We must simply wait ready to respond and trust that justice will prevail.

The World Congresses are only one aspect of our varied programme of events and the last three years have seen many more. The first major international event to follow the World Congress was held in May 1987 in Miami and was a Workshop on Above-Knee Fitting Techniques. In particular this dealt with the controversy over the relative merits of conventional quadrilateral sockets and the newer group of sockets typified by the CAT/CAM (Contoured Adducted Trochanteric Controlled Alignment Method) socket. An international group of experts attempted to find order in chaos and identify the underlying principles. They identified the new group of sockets by the generic name of Ischial Containment and made recommendations for further work. The resulting publication will provide the source reference in this area. This meeting was followed in July 1987 by a further Workshop in the Society's education series and held in the University of Strathclyde, Glasgow. This international gathering of educators which was joined by representatives of other major international agencies, such as the World Health Organization and the International Committee of the Red Cross, developed a strategy for tackling the problem of Upgrading of Short-Course Trained Technicians. The implementation of that strategy, which included the provision of revision courses and distance-learning packages, has been delayed by our inability to attract funding, but it must remain one of our short-term priorities if we are to make a major impact on prosthetic/orthotic provision in vast areas of the developing world. The Society's next meeting in September 1987, held in Herzliya, was an International Conference organized by the Israeli National Member Society to deal with the problems of Traumatic Amputation and subsequent treatment and prosthetic fitting. This meeting provided a forum for the foremost practitioners in this important field whose collective experience will now be available to all through the publication of the proceedings. In October 1987, President-Elect, Wim Eisma, with the assistance of the Netherlands, Belgian and German National Member Societies and under the auspices of the International Society organized PROTECH II, an International Prosthetics/Orthotics Conference designed as a follow-up and just as successful as its predecessor offered ten years previously, PROTECH. The next major event, in June 1988, was a Workshop, held in Seattle, on the subject of CAD/CAM (Computer Aided Design/Computer Aided Manufacture). This subject had been singled out by the Executive Board as being of potentially dramatic importance in this field, and the workshop provided the opportunity for the world leaders to compare programmes and experiences and point directions for future investigation. Another important international event was the Conference on the Limb Deficient Child organized in August 1988 in Heidelberg by Past President, Ernst Marquardt, marking his retiral from the field. Attracting as it did the foremost specialists in this field, the conference provided an appropriate recognition of Ernest Marquardt's work and the publication based on the conference will be an essential text for years to come. Our other event in 1988 which tackled a different field of our members' interest was the International Conference on Wheelchairs and Special Seating held in Dundee in association with the Society. This most successful event attracted over 300 participants and was organized and run with the efficiency we have come to expect from the Dundee team.

This whole series of meetings must surely have spanned the interest of all of our members. These meetings were supplemented at national level by a multitude of events reflecting the type and needs of the individual society's and reported in the National Member Society reports. They are an essential element in the strength, life and growth of our national activities. The strength and value of all these meetings lies in their multidisciplinary nature which is the unique feature of our Society in this international area.

Much attention is now being focused by other International Agencies on the identification and application of "appropriate technology" in the developing world. For many agencies this was in the past equated to primitive methods and techniques which have no place in the treatment of patients. ISPO can rightly claim to have revolutionized attitudes in this field and pioneered the view that only devices based on sound biomechanical principles can be appropriate. This view has been promoted in a series of meetings held under the auspices of other international agencies, but where ISPO made significant contributions to their planning or conduct. These were:

August 1987
International Labour Office/
African Rehabilitation Institute Meeting
Cairo, Egypt

July 1988
United Nations Meeting — Moshi, Tanzania

November 1988
United Nations Meeting — Conakry, Guinea

January 1989
African Rehabilitation Institute Meeting
Bulawayo, Zimbabwe

June 1989
World Health Organization Meeting
Dakar, Senegal

Our participation in these meetings is part of our continuing efforts to collaborate with other agencies in this field, particularly where we believe they have the need for the professional input which the Society can provide. Many have now identified ISPO as an essential resource. In particular we continue to develop our links with WHO aiming towards a condition of "Official Relations". A new relationship has also been formed during the triennium with IVO, the international organization of orthopaedic shoemakers, with mutal representation on each other's Board. Close harmony with all of the international agencies, both governmental and non-governmental is essential to the continued development of the field and the avoidance of duplication of effort.

It remains our policy to publish the proceedings of workshops which we have organized so that the information and the deliberations contained may be made as widely available as possible. The following new publications have either become available, or are at at an advanced stage of publication:—

Training and Education in Prosthetics and Orthotics for Developing Countries (Jonkoping Report)

Upgrading for Technicians from Developing Countries Trained on Short Courses (Strathclyde Report)

Traumatic Amputation (Heidelberg Proceedings).

Above-Knee Fitting Techniques (Miami Report: advanced stage of publication).

CAD/CAM (Seattle Report: advanced stage of publication).

Prosthetic/Orthotic Education (Toronto Report: advanced stage of publication).

Another important publication to emerge from this triennium is "Amputation Surgery and Lower Limb Prosthetics". This represents the proceedings of the Conference on that subject organized in Dundee in 1985 and sponsored by the Society. However, the Conference itself was structured so that the modified proceedings would provide a logical, coherent text-book presenting the very latest in the "state of the art". The Dundee team are to be congratulated in having once more provided an essential text in our field.

Publications related to the Society itself include a new Directory of Members which will be available for circulation immediately following the World Congress. We are also indebted to Mel Stills for producing a tape/slide package for use in publicising the Society's activities. We are conscious of the need to produce better material for such purposes and to this end are working on a new, informative, attractive brochure illustrating and explaining our work.

Prosthetics/Orthotics International continues to thrive and astonishingly is now completing its thirteenth year of publication. It remains one of the tangible benefits of membership with a subscription price greater than the membership contribution to Copenhagen.

A major initiative which is nearing fruition is the Professional Register. The Task Officer, Hans Christian Thyregod, is presently working on the editing and entry of the response to the first mailing. This follows the preliminary work of assessing the format of the questionnaire and the ability of the soft-ware to process and access the information contained. It is hoped that the Register will be providing a service within a very few months. Of course, we do not have 100% response to the first mailing, and it will be necessary to follow-up in the New Year. It is hoped that National Member Societies will help by encouraging their members to respond. The Register has been a project favoured by successive Boards and it is gratifying to be able to report its eventual attainment.

On the European scene, the Society set up, in 1988, a Joint Education Commission with INTERBOR to prepare for the open market of 1992 and the effect of the requirement for the reciprocal recognition of professional qualifications. This presents special problems in the field of prosthetics and orthotics because of the wide variation in level of qualification encountered throughout the European Community from honours degree at one end to virtually no formal training at the other. The Joint Education Commission has developed a strategy to convince the European Commission of the special needs of this profession if the rights of the patient are to be protected. This is expected to involve a detailed study and reporting procedure over about the next year and will be the subject of a project grant application to the Community. Although European in focus, the outcome of this work will inevitably be useful and relevant right across the international scene.

On the wider international scene we continue to play a leading role in the International Standards Organization, and particularly in Technical Committee 168 on Prosthetics and Orthotics. All three Working Groups have been active in this triennium and much of their work nears fruition. These ISO Committees assume even greater and wider importance in relation to the "Open European Market" of 1992 and our contribution will be even more important and effective in raising standards of patient care throughout the world.

The Society continues to enjoy a sound financial base, although the Market problems of 1988 gave us some cause for concern and lead to a review of our investment policy. It has, as a consequence, been possible to hold the membership fees constant during the triennium. This means a steady reduction in real terms. Of course our income is supplemented by generous grants from the War Amputations of Canada and by SAHVA in Denmark, who also provide us with office space and other facilities. We also receive support and facilities from other organizations which are essential to our continued operation. I offer my grateful thanks to all of these bodies.

Our Society continues to grow and to thrive. We have initiated a review of our Constitution and our procedures aimed at widening the involvement and awareness of the membership. We continually seek to find ways of using more of our human resource, the professionals from all disciplines and from all quarters of the globe. This is our greatest strength! It is not always appreciated by the membership that ISPO has only one full-time employee. All of our on-going activity, and the range and volume is impressive, is sustained by the voluntary effort of individual members. It is our hope for the future that the Professional Register will allow us to identify more of the membership willing to take part in the work of the Society.

We can look forward to more exciting and valuable activity in the coming triennium. A "concensus conference" on techniques of amputation surgery, a further meeting on the deformed foot, international evaluation initiatives, collaborative ventures with World Orthopaedic Concern, are all new areas under active consideration. Also, we must continue the work we have started in supporting educational institutes in the developing world, both by inspecting and recognising their programmes and by developing material for up-grading and finding the funding to mount courses. There is much to be done and much help needed if we are to achieve the ambition of our Constitution to promote high quality care throughout the world.

I believe this has been another triennium of achievement. At national level the development of our National Member Societies is a measure of all the dedicated effort of our National Committees and their Officers. We are all grateful to them. At international level the programme of events and activities is due to the untiring efforts of our Executive Board, its Committees and our Task Officers, ably assisted by our Secretary in Copenhagen, Aase Larsson. The volume of work handled by our Honorary Secretary, Norman Jacobs, must be apparent to all who have any role to play in the Society. I am more than grateful to all these individuals, and in particular the Officers of the Society, who give generously of their own time to make the Society's achievements possible.

I wish my successor and the new Executive Board continued strength and success.

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Incoming President's Address

WILLEM EISMA

It is a great honour to me to have been elected to this, the highest office of our Society. I accept the task in the knowledge that there are great duties and tasks to fulfil now and in the coming three years.

I was very pleased that it was possible, as President-Elect, to take part in a lot of activities of the Executive Board as well as representing the ISPO Board on the Boards of Interbor and IVO.

It has to be stated that many initiatives have been taken in the past three years by the Board members, the Task officers, the National Members Societies and certainly also by the individual members of ISPO. The result is that I can now lead a healthy Society although I am also aware that a rapidly growing society needs a firm structure with flexibility in a form in which each member can feel at home. It will not be possible to make an individual approach to everybody, but the new Board will really try to go on with a philosophy in which constructive ideas may be incorporated.

It is with great pleasure to announce that we now have 20 national member societies and nearly 2300 members. New faces have appeared on our Board and in committees. A lot of work has to be continued.

We may look forward to the next Triennium with confidence, but with a strong awareness of the task which faces us. We have to work with the International Agencies to raise standards of training of professionals and treatment of patients. We have to continue with activities in the Developing World which have already been formulated and approved by the Executive Board and published in several reports.

Of great importance is Education. The President's Report has given a review of all the activities of the last three years consisting of symposia, congresses, instructional courses and workshops concerning education in prosthetics and orthotics and rehabilitation engineering. In the next Triennium these activities will continue, not only within the Society but also in close co-operation with other societies. A good example is the European Congress on the Advancement of the Rehabilitation Technology, 1990, where the organization will be in the hands of three societies, one of them being ISPO.

I would like to stimulate activities on education in the National Member Societies and also stimulate co-operation between different societies. It is evident that with the awareness of the increase in knowledge and the raising of standards the numbers of members of our societies will grow. New initiatives are welcome. Another important subject of education is related to the EEC council directive on the recognition of education of the professions. The ISPO/Interbor Education Commission has to continue its activities.

Now we are at the end of a very successful Congress at Kobe, Japan, under the Chairmanship of Professor Tsuchiya and our Secretary-General, Seishi Sawamura.

All the Japanese organizers really deserve our deepest gratitude for all the hard work which has been done. The performance was excellent. In every sense, it was a great success both scientifically and socially.

I would especially like to express my thanks to Seishi Sawamura. He has given an enormous stimulation to our Japanese friends to fulfil their task, the ISPO World Congress. I would like to express our gratitude by declaring that we will recommend to the next Board Meeting that Seishi Sawamura will be appointed as the Official Consultant for Asia for ISPO.

We are sure an equally successful event awaits us in the United States of America. I urge you to support our American friends by responding to their requests and most of all by your presence in Chicago.

I would like to thank John Hughes as President of the Executive Board of ISPO for the Triennium 1986-1989. In the last three years we have worked very closely together as already mentioned on several occasions. His knowledge of the Society, his leadership which has been illustrated by clearness, intelligence and resolution has been greatly in evidence. On behalf of the whole Society I would like to thank him for all the work he has done during the last three years.

I would ask you on behalf of the whole Society to continue your activities in the next Triennium with all the existing possibilities. Your experience, knowledge, facilities on education and research, your influence all over the world, all these features may reinforce and strengthen the philosphy of ISPO with the widest involvement of the Board, the International Committee and you, the members.

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THE KNUD JANSEN LECTURE

Technological choices in prosthetics and orthotics for developing countries

P. K. SETHI

Vivekanand Marg, Jaipur, India

Introduction

I am thankful to the President and the Executive Board of ISPO for asking me to deliver this prestigious lecture.

Knud Jansen was not only a humanist, as all good and wise doctors are, but he had an extraordinary ability to go directly to the heart of the matter. I sensed this when Prof. George Murdoch advised me to go to Copenhagen in 1971 to show him my work on a prosthetic footpiece. Dr. Jansen made me realize, in his characteristic gentle manner, that I should look beyond the *product* which I was viewing as a rather culture-specific innovation and understand the *process* by which this design was arrived at. "Sensitivity to user reaction is a more valuable tool", he said, "for designing appliances in developing countries, than an expensive laboratory back up." This has altered my perceptions very significantly. To him and to his friends George Murdoch and John Hughes, I owe a special vote of thanks for providing me with a sense of direction.

The reason which has prompted me to take up the subject of technological choices is because of the feverish activity which has been going on in the developing world, ever since the United Nations declared 1981 as the "Year of the Handicapped". Surveys of the handicapped have since been conducted and for the first time our governments have become aware of their staggering numbers. With 80% of our population living in abject poverty in remote rural and often inaccessible areas, the logistics of producing appliances for them and then "reaching the unreached" is truly mind boggling.

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Such surveys are always accompanied with inevitable promises to the people which convert what perhaps was a "felt but unsatisfied" need of the disabled to a "vocal demand" by them for prosthetic and orthotic aids.

Brainy committees are deliberating on this problem and Technology Missions are being set up to speed our entry into the 21st Century following the W.H.O. slogan of "Health for All by 2000 A.D.". Targets have to be achieved. We need more targeted research, more mission-oriented science. This is said to be the new drift. Suddenly the pressure is on and since there is little time to waste, it is considered prudent to buy technology packages from the west. There is no point in rediscovering the wheel.

I sense serious trouble when we initiate such a "top-down" move. Such moves require a much greater store of usable information, with coherence and connectedness, than actually exists. We have to face, in whatever discomfort, the real possibility that our level of insight into the actual needs of our disabled masses is far from complete. The developing world has a stratified social structure, with a top ten percent of the urban elite and a bottom ninety percent of our rural and urban poor. The top ten percent, many of whom have imbibed the life style, the culture and the value system of the west, want that their country too should have the same kind of appliances as are available in the advanced countries. They are the decision-makers and exercise control over what may be viewed as the "technology filter", through which the needs of society have to pass to create a "technology demand". The bottom ninety percent have no voice and they have never really mattered.

In a situation like this, it is almost inevitable that the policy decisions would tilt heavily in favour of the urban affluent and opt for expensive technology.

Realizing this, there is emerging another viewpoint which has taken up the cause of the rural poor. Taking into consideration our resource crunch, the pendulum is made to swing to another extreme. Primitive and traditional technology is romanticized and some simplistic solutions are being advocated by this group.

I must confess I have great respect for traditional technologies which are rooted in our culture. These have evolved through a long process of natural selection and therefore they must not be ignored as sources of innovations. But while these traditional technologies offered optimal solutions for the challenges of the past, they are clearly sub-optimal and inadequate today because of changed expectations, resource availability, materials and circumstances.

It has also to be understood that technology for the poor cannot either be trivial or second class because it invariably poses the tough challenge of having to be "zero-cost". Hassan Fathy's work on "Architecture for the Poor" is an excellent example of the kind of effort and thinking which is needed for this purpose, and I would strongly recommend his book from which valuable lessons can be learnt.

What I find missing from this debate, however, is that a distinction is not being made between science and technology. We are confusing expensive gadgetry with good science. This often is not so. It requires some very sophisticated thinking to arrive at a simple solution. It is much easier to work out a complicated and expensive solution. Indeed, whenever one encounters an expensive and complicated technology, one can take it that the basic issues have not been understood. Expensive gadgetry often possesses impressive "Symbolic Value" as opposed to "Use Value". What we want is more, and not less, science in the developing world.

There is one problem with science, however. It relies essentially on objectivity and quantitative measurements. In medical practice, the scientific method often decomposes the patient as a person and converts him to a set of laboratory findings. This shadow patient, reconstructed from the results of laboratory tests, then acquires a reality and autonomy of his own. It is with this shadow patient that our scientists are concerned. The rest, that is the patient's personal realities, are seen as variables which induce compromises with the science (as opposed to the art) of medicine. They are not seen as variables having an intrinsic scientific status. Indeed, as Tariq Banuri has pointed out, a basic postulate of modernization is the inherent superiority of the impersonal over the personal. The patient's voice, his language of suffering, is treated as a noise, somewhat like the "signal-noise ratio" on a radar screen. The cold reason of the medical scientist treats this noise as a nuisance and attempts to smother it to be able to read the signal properly.

We must realize that designing prosthetic and orthotic aids cannot be an impersonal, biomechanical solution of a locomotor deficiency and dysfunction. It is a very complex issue because we are dealing with live human beings with their varied life styles and cultures which have evolved through centuries of adaptation. Our technological solutions must respect these traditions to permit the users to integrate into their environment. Science should be utilized to simplify the solutions and the technology should not breed inequity. Above all, a feeling of empathy and a sensitivity to the user response must characterize our work.

To be able to learn about the 'felt needs' of our rural masses, we have to leave our institutional hideouts and mix with them and methodically study their ways of living and thinking. One would then realize that while they are poor and illiterate, they are not irrational. In fact, the poorer they are the more does their survival depend on rationality, i.e. upon a proper evaluation of costs and benefits. Since we are mere beginners in such an attempt, there necessarily has to be an intense back and forth interaction between the laboratory and the field. The first generation of our prosthetic and orthotic aids would be full of mistakes but if we are tolerant of the feedback, the subsequent attempts would be increasingly successful.

This kind of approach is necessarily more time-consuming, but in the long haul, it is more likely that our solutions would turn out to be more appropriate and durable. A lot of flexibility for modifications/corrections should be available and this would only be possible in small scale efforts. A centralized, top-down, capital-intensive, administered technology can never have the manoeuvreability to make such mid-course corrections.

Let me illustrate the foregoing by narrating my own experience in designing an appropriate lower limb prosthesis for our people.

When we first started providing lower limb prostheses to our amputees, the majority of whom belonged to the lower income groups, we used designs which we had learnt from the west. I thought we were making a decent attempt, even though our limbs looked like "blurred Xerox copies" of those available in the advanced countries. It came as a surprise, however, when I started encountering many of these amputees reverting to their crutches. I started closely questioning them about the reasons for this rejection. It soon became obvious that a design which was appropriate in the shoe-wearing, chair-sitting culture of the colder countries of Europe or North America was quite inappropriate for the barefoot walking, floor-sitting culture of the warmer countries.

Two cultures — floor sitting vs chair sitting

In the cold climate of Europe or North America, the feet have to be protected from cold by using warm socks and closed shoes. Chairs are used to move away from the cold floor and so a table becomes a work surface. People walk on paved streets and level floors and the foot is not often required to adapt to uneven surface.

On the other hand, in the warm climates of the developing countries, closed shoes are uncomfortable and most people walk barefoot or else in open well-ventilated footwear, often on the rugged terrain of our countryside where suppleness of feet is a vital attribute to adapt to uneven surfaces. Furniture is not used. The floor is used for sitting, sleeping, eating, working and worshipping. Shoes, if worn are removed when entering homes or places of worship to prevent dirtying the floor.

It is important to distinguish between chair-sitting and floor-sitting cultures because there are important design implications involved.

The western designed limb

The western designed footpiece is meant to be used within a shoe and so its shape conforms to a shoe last to provide an easy foot entry and it need have no resemblance to a human foot. The shoe not only hides its odd appearance but also protects it from damage. A shoe, in other words, becomes an integral part of the limb design. Take the shoe off and you cannot use the limb.

One can then easily appreciate how such a simple demand can pose major problems when closed shoes are not only uncomfortable in our hot climate but because they have to be repeatedly removed in a floor-sitting culture.

Not only this. We squat on the floor and this requires a range of mobility in the knee and ankle which is not available in a western limb. The SACH foot, with its solid keel does not allow any dorsiflexion and so the patient cannot squat on the floor.

An attempt to sit cross-legged on the floor presses the stiff foot piece along its outer border, which in turn forces the shank to twist, causing an unbearable pressure on the stump-socket interface. To be able to work sitting in a cross-legged position, the limb is usually taken off and then crutches have to be used to move around while at work. A farmer ploughing his field in traditional ways, cannot afford to wear a pair of Oxford shoes!

And so, unless the amputee changes his life style into a shoe-wearing, chair-sitting culture, he finds it simpler to revert to crutches.

Design criteria for a prosthetic footpiece

Based on the foregoing, it was decided to redesign the foot-piece by listing out a set of desirable criteria. It should not require a shoe to protect and hide it. So it should look like a normal foot and be made of a material which is not only flexible but also tough, abrasion and tear resistant and waterproof. The internal design should provide adequate mobility to enable sitting on the floor and walking on an uneven terrain where the foot is required to adapt to the rugged terrain of our country-side. And yet the foot should offer a stable support while walking.

I worked out the theoretical constructs, the main feature of which was to get rid of the solid keel of a SACH foot.

Reaction of formally trained prosthetists

The formally trained prosthetists working with me, were baffled when faced with such a design demand. In a way this was inevitable. For who are these people who man our formal limb-fitting centres? These are drawn from our urban middle classes where there is no culture of manual work or innovations. They were admitted to the training schools because they had learnt English language, which is a prerequisite to their admission. Reared in an urban environment they do not understand rural problems and cannot communicate with the rural disabled in their language, dialect and idiom. Their value system has mercenary overtones and they show little empathy when their patients point out their difficulties. They can use a technical jargon, drawn from the NYU curriculum which forms the basis of their training, and glibly talk of centre of gravity, kinetics and kinematics, shifting knee axis and the like, without really grasping the concepts involved. They have little capacity to innovate, and become helpless when a particular tool or material is not available. They are so conditioned by their system of education that any deviation from orthodox designs is sacrilage to them.

Traditional craftsmen

Finding that I could make no headway with them, I was forced to turn to our traditional craftsmen. They are often illiterate but they are the real possessors of manual skills in our countries. They have tremendous capacity to innovate and they know all about locally available materials. One, of course, has to learn to treat them with respect and communicate with them in a different manner. They feel ill at ease with drawings or illustrations but show them a 3-dimensional model and they would amaze you with the ease with which they can reproduce it using their own technology, tools and materials. So, with the help of our local craftsmen, an aluminium die was produced in the backyard of our hospital, using traditional sand casting methods to reproduce the shape of a human foot at a fraction of the cost a professional die making firm would ask. It was decided to use wood and microcellular rubber which is freely available in almost all countries for open sandals, glue the sheets together and then encapsulate these inserts with a solid rubber elastomer readily available for putting new treads on worn out tyres, mould the piece in the die and vulcanize it in our hospital autoclave. People everywhere know how to vulcanize rubber because of an extensive trade in retreading worn out automobile tyres.

I would not describe the evolution of this design, which went through several stages, with a constant feedback from our amputees till we arrived at a solution, which was a radical departure from a SACH foot. The solid keel was done away with. Instead, a universal joint was made available in the large microcellular hindfoot block, with freedom of movements in all directions.

The product of this simple and inexpensive technology was not only field tested but also subject to careful scrutiny in the laboratory of our engineering college, drawing up load deflection curves and testing for strength in a universal testing machine.

Need for alterations kept on arising and we were ready to respond to them. For instance, we had not foreseen the consequences of repeated flexions and soon the amputees started returning with the external shell cracking open and the various inserts popping out. To guard against such disastrous failures we started binding the three main structural blocks with rubberized tyrecord in a way that the mobility of the footpiece was not adversely affected. This greatly increased the strength of the footpiece and we obtained a breaking-load figure of 6 tons and a footpiece which could last for 3-5 years, under tough field conditions in village farms.

A second major change was introduced when a study of our broken footpieces showed a consistent pattern of cracks being always located at the ankle region. This could be readily explained because all the mobility resided in the hindfort region in the zone between the two wooden blocks. This is where all the stress concentration was located. Then we replaced the wooden forefoot block by another MCR block, adequately stiffened with extra tyre cord to prevent it from buckling in the late stance phase of the walking cycle. The stress distribution was thus dispersed over a much larger area, and we got an extra bonus of pronation and supination of the forefoot. The forefoot could now independently adapt to uneven surfaces and the transmission of ground reactions to the stump-socket interface was much more effectively dampened.

Transverse rotation

A rotator device, advocated by Radcliffe, is not needed because adequate transverse rotation of the shank on the footpiece is already built in to this design resulting in a more comfortable stump-socket interface.

Absorption of ground reactions has a higher priority when walking over a rough terrain than the energy-release kind of athletic footpieces which are getting popular. An analogy with the rubber bearings advised for earthquake proof high rise buildings which provide a "base isolation" and detune the building from the whiplash effect which can shake the top storeys to virtual destruction seems to me to be appropriate.

Jaipur foot

One can now match the list of our earlier objectives to what has been achieved. The foot fairly closely resembles a normal foot, and it is often difficult to identify the amputated side. In fact, women often adorn their feet in a manner which has even fooled me.

The amputee can squat and one can witness the angle which the footpiece can make with the leg. There are amputees employed in our workshop who sit cross-legged on the floor and work for the whole day without the need for taking their limbs off.

Villagers walk comfortably on a rugged terrain because of the adaptability of our footpiece.

The limb is waterproof and many amputees work in their farms, wading through water and mud. Drawing water for irrigation from a well is a heavy duty job and yet these amputees perform such work like an able-bodied individual. Rickshaw pulling is an urban vocation chosen by many poor amputees. They can even climb trees and in rural areas this is a valuable asset. Witness the way the footpiece can grip the trunk and adapt to its contours.

It would be appreciated that such activities allow the patients to continue to stay in their villages, with their own families and friends. It is no longer necessary for them to migrate to an urban area, and plead to the Social Welfare Ministry for a sedentary occupation in an alien setting. This is what "true rehabilitation" ought to mean.

All this was achieved, at a minimal cost, in the backyard of our hospital. I want to emphasize that this small scale effort allowed us a lot of room for flexibility in changing the design based on feed back from patients. Had the design been worked out on paper and then handed over to a manufacturer, it would have been very difficult to persuade them to make any changes.

Choice of materials — aluminium limb

For the socket and shank of our BK limb, we opted for aluminium as a suitable material. Most of my colleagues react adversely to this choice. "The modern world is moving towards polymers and composites and you are moving back to metals!" they comment. There are some good reasons why I have preferred aluminium — at least for BK limbs. We have skilled artisans in our country who can shape metal sheets with such ease and deftness that it takes one by surprise. A statue of a poor, emaciated amputee, which stands before our Rehabilitation Centre, was made by one of our craftsmen with aluminium sheets beaten into shape without any casting. For people who can produce such a stunning piece of art, shaping an aluminium limb is child's play.

Visitors from abroad gape with amazement when, within 45 minutes, from start to finish, a BK trial limb is fitted. The tools for this work are simple; no plaster moulds are needed. These workers have been taught the principles of why we deform sockets to exploit the pressure tolerant areas and relieve the pressure sensitive bony prominences and scars. Alignment principles have been taught and adjustments are effected by an open wedge technique familiar to most orthopaedic surgeons. The limb is shaped and fitted directly on to the amputee who becomes an active participant in the entire proceeding, guiding and informing the limb maker about the accuracy of the fit. The sensory feedback from a live stump is perhaps more accurate than a blanching of skin in a transparent check socket.

The live human interaction between the amputee and the limb maker is a marvellous thing to watch. There is empathy and understanding between the two and a lot of feeling goes into this work.

I have chosen aluminium because it is available to us, easy to work with, light and strong and does not rust. Pressure points can be easily lifted off with the tap of a mallet. Use modern FRP and you get into a much more expensive system where such manoeuvreability is just not available after the resin is cured. It is this simplification of the technology which enabled us to increase our turnover of work from one limb a week in 1975 to ten limbs a day in 1982.

Socket design

There has been criticism that we are not providing total contact sockets. It may be noted, however, that our sockets are not the old fashioned "plug fits" and there is a very intimate contact between the skin-socket interface with little loss of energy when the stump moves the limb. Unlike in the west, 80% of our amputees lose their limbs because of trauma or infection, are young and have a normal vascular tree. An open-ended socket is preferred because it is cooler and more comfortable. A suction socket, for instance, is usually not accepted for this reason. An initial selection can always weed out the dysvascular, the diabetic, or the anaesthetic stump in leprosy for whom every care is taken to provide a safer socket system. In over 20,000 amputees, we have only rarely been required to change the socket because of distal oedema.

Using this technique, we can offer a quicker delivery system at a lower cost than almost any alternative that I know of.

Materials should be chosen not only for their properties but also on the basis of availability and familiarity. Whether one opts for metal, wood, FRP or thermoplastics, is less important. The basic principles of socket fitting and alignment, I am convinced, are far more important.

Reaction of urban amputees

While our rural amputees are happy with our footpiece, our affluent urban amputees complain that they cannot insert this easily in fashionable shoes. It has to be understood that the barefoot population have a broader foot and this has been our target group. It is simple enough to have an external shape of a SACH foot with an internal design of a Jaipur Foot. We have prepared some, and with a detachable heel too, which preserves the alignment when shoes are removed indoors.

I am aware of all the shortcomings in our footpiece. Its cosmetic appearance needs to be refined, it should be lighter in weight and there should be quality control and product assurance, something difficult to achieve in a very labour intensive technology. We are currently making these attempts, both by trying to update our rubber formulations and production technology, and also to substitute rubber with polyurethane.

High technology

We have been facing one problem with exotic materials like polyurethanes. This requires a much higher capital investment and the operating conditions for manufacture are extremely critical. There is little margin of error permitted otherwise a catastrophic failure would occur. Rubber, on the other hand, may not be as elegant but is much less likely to fail.

An analogy from agriculture on the debate between "traditional" versus "high yielding varieties" of wheat may not be out of place. Let us not forget the nursery rhyme — "when she was good, she was very very good, but when she was bad, she was horrid.

We should not lose sight of the "worst case scenario" and only dream of the "best case scenario", when evaluating costs and benefits. It is also important to resist the temptation of yielding to an applause from the west, and in the process, forget our rural masses, for whom this work was taken up in the first instance.

Appliances for poliomyelitis

Likewise, different alternative approaches may be used for polio patients.

Metal calipers for stabilizing flail limbs in poliomyelitis have been used for decades. Patients dislike them for obvious reasons. The drop-out rate is disturbing and most children prefer to limp around without them.

With the advent of newer materials such as plastics, one could break away from the tyranny imposed by metals and use fresh geometries of design. I have used the "Floor-Reaction" principle for stabilizing an unstable knee with quadriceps paralysis with an 85% acceptance rate in over 600 cases. Using space-age materials like carbon fibre composites, a much lighter and effective appliance can be used. I am fully aware of the lack of availability of such materials in developing countries but this venture has been a great education, teaching me much more, not only about new design principles and new ways of looking at paralysed limbs, but also to have a feel for the child's feelings, difficulties and preferences. I am already moving away from FRP, which bring their own problems, to thermoplastics such as polypropylene which seem to offer many advantages. Our illiterate but skilled workers can now prepare these appliances with ease and have shown what a powerful tool demystification of professional knowledge can be, provided one has a belief in the intrinsic, native intelligence of people.

Such plastic appliances, however, are necessarily custom made and require great care and precision. Mass scale use is not feasible and heat retention over sweating skin is a problem still awaiting a solution. Components of metal calipers, on the other hand, can be mass produced and the design allows much better ventilation.

Realizing that any single village would seldom have more than half a dozen polio children, I have experimented with a simple design borrowed from Huckstep in Uganda, improved on its wooden clog to provide a better roll chracteristic and then utilized the village carpenter, cobbler and blacksmith, to prepare calipers with their own tools, materials and technology, by showing them the 3-dimensional samples I have alluded to earlier. The results have been astounding. Here then, is another alternative approach to utilize a readily available manpower in providing neighbourhood facilities to a village child on his doorstep. Our centralized authorities, overwhelmed by the staggering numbers of millions of such cases, are still struggling with their customary managerial approach with a track record which makes one rather sceptical of a successful outcome.

I know how our professionals react to such proposals which they find outrageous. On the one hand, such a strategy may provide *inadequate aids,* on the other hand, adequate technologies are inaccessible. Adhering to the idea of providing only the best usually means that 90% of our disabled population have to go without any aid whatsoever.

All the three alternatives — viz. mass produced caliper components fitted locally, simplifying existing design to utilize rural craftsmen for a more effective delivery system and to pursue R&D activities making use of new materials and new designs and field test them — can exist simultaneously. The costs and benefits of each will have to be worked out but in all this, let us not forget the user who would usually belong to the group of rural poor.

The constraints of time prevent me from multiplying such examples endlessly.

The main point I have tried to make is that in a dual society such as ours, and this is true of all developing countries, we are constantly running into a Hobson's choice. The technologies and designs evolved in the west are preferred by our rich urban elite and they really constitute the market forces which influence our decision makers and western trained professionals. The poor are outside the market forces and have no voice. Modern technologies are inaccessible to them. To permit the poor to escape from this dilemma scientists and technologists must generate new options, each more effective than the traditional, and more accessible than the modern. Ideally, the options should constitute a hierarchy of technologies with upward compatibility. Then, with rising incomes, the poor can climb from a cheaper, less cost-effective option to a costlier, more cost effective option. Only in such a situation will the people have genuine choices. Thus, the role of scientists and technologists is to be *option-generators* and *choice-wideners.*

People who control decision-making in our country are understandably in a hurry. They overlook that a more appropriate and equitable generation of technology involves a "learning curve". During the inital part of this learning curve, there has to be intense back-and-forth interaction between the laboratory and the field. The feedback from users in the field must lead to modifications and improvements of the product/process. This modified/improved product/process needs further "test marketing" in the field. As a result of this interplay between technology generation and dissemination, and between technologists and potential consumers of the technology, the penetration of the "market" is necessarily very slow during this phase. Only later, our learning curve shows a steep climb.

All these points are generally ignored when technology dissemination is planned and implemented. There is a general tendency for technology generation and technology dissemination to be thought of as two distinct non-overlapping sequential stages with the generation ending when the dissemination begins, and the generators "washing their hands of" the technology dissemination process.

However idealistic and romantic it may appear, my conviction is that the technologists must approach such work with empathy and affection for the people. Otherwise, they tend to be afraid of the people and hide behind their institutional walls. The poor are far more understanding of our failures than the so called educated, as long as they know that we are genuinely interested in them and not using them for populist slogans or advancing our own career structure. Science and technology ought not to be "value-free" and would stand to gain from these feelings of empathy and affection. Without this value-system, it tends to become amoral, unjust and violent.

A lot of hard and painstaking work lies ahead of us. The problems facing us are open-ended. This is why I am worried about a 'top-down' managerial approach which, some people think, will quickly solve our problems. Bernard Shaw's approval of "the inevitability of gradualness" carries for me a lot of wisdom.

Prosthetics and Orthotics International, 1989, 13, 125–129

This innovation was selected for the award of the Brian Blatchford Prize for the Triennium 1986-1989. This paper is based upon the acceptance speech of Thorkild Engen at the Annual Ceremony in Kobe, Japan on 17th November, 1989.

Lightweight modular orthosis

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Abstract

Background and highlights are presented concerning the development of a new orthotic system judged to be "the most outstanding innovation in prosthetics and/or orthotics practice" during the 1986-1989 period. The first Brian Blatchford Prize was awarded at the Sixth World Congress of ISPO held in Kobe, Japan, November 12-17, 1989. The new development selected as most deserving of this award consists of a system utilizing inexpensive, lightweight, modular components which can be quickly assembled with a few hand tools to provide custom-fitted knee-ankle-foot orthoses for persons with paraplegia and quadriplegia. These leg frames support standing and permit the patient to begin receiving the physical and psychological benefits of weightbearing as soon as medically feasible after injury. Later, if desired, specially designed knee-joints, with a variety of possible locking features, can be installed on the existing leg frames at a reasonable cost.

Introduction

It is with a deep sense of gratitude and honour that I accept this prestigious award in the memory of our colleague, Brian Blatchford.

When first informed of this award I was both elated and honoured that my project has been chosen for the Brian Blatchford Prize. To me, this award is the Nobel Prize of orthotics and prosthetics.

I am indeed grateful to my native country, Denmark, for the thorough education and training I received in orthotics, grateful for the professional opportunities extended to me in the United States, and deeply honoured to receive this tremendous recognition in this beautiful country of Japan.

The Blatchford family is to be commended for recognizing the need to stimulate interest in designing new and better means for meeting the orthotic and prosthetic needs of people throughout the world. Creation of this award to honour the most outstanding innovation in our field should stimulate renewed interest in undertaking research and development projects. Funding for projects and developments in orthotics and prosthetics has diminished to very low levels, internationally, during the past 15 years. However, our own experience has demonstrated that persistence in seeking financial support for research from governmental agencies, foundations and civic groups can be successful.

I should now like to take this opportunity to share with you some of the background and highlights of this new development. A number of follow-up studies published during the past 20 years have documented that a substantial number of paraplegic patients (approximately 80%) discard their conventional knee-ankle-foot orthoses (KAFOs) within months after receiving them (Kaplan et al. 1966; Hahn, 1970; Coghlan et al. 1980; McAdam et al. 1980; Mikelberg et al. 1981; O'Daniel et al. 1981; Priestley et al. 1982; Heinemann et al. 1987). The problems most often cited by the patients are: excessive weight, cumbersome, time consuming to donn and doff and not aesthetically acceptable. Thus, their expensive orthoses gather dust in a closet.

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Lightweight modular orthosis

The new development is an inexpensive, lightweight, modular orthosis for early standing of patients with paraplegia and quadriplegia of traumatic onset. The invention permits quick fabrication and fitting of leg frames which support standing and permit the patient to begin receiving the physical and pshychological benefits of weightbearing as soon as medically feasible after injury.

Being constructed from mass-produced plastic extrusions and other modular, plastic components (Engen, 1972), and assembled with the use of a few tools, straps and fasteners, it is possible to reduce the weight (1 to 2 pounds, 0.5 to 0.9 kilograms) delivery time and cost of these devices (Fig. 1). By making customized leg supports available as early as feasible, the patient has a choice of being weightbearing rather than confined to a wheelchair.

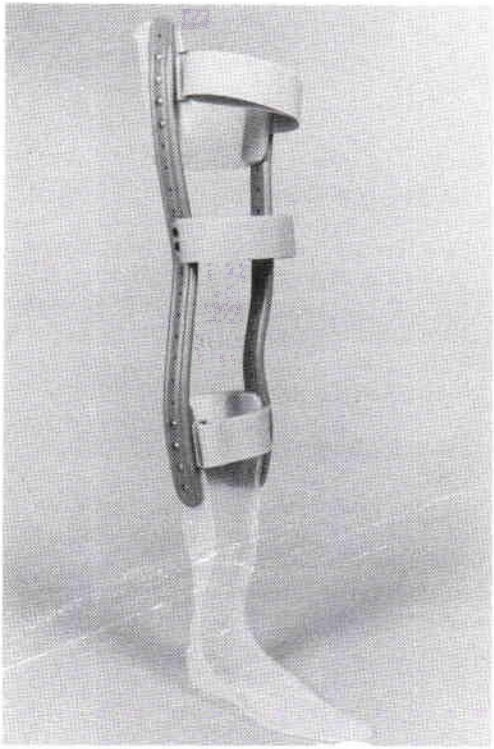

Fig. 1. New lightweight, inexpensive, modular leg frame developed by the author. Note the attachment of upright struts to the other plastic components and simple method of anterior strap attachments. Fine tuning of the foot/ankle segment of the orthosis for accurate balancing of patient is accomplished with a heat gun and heel and toe wedges. Patent process initiated.

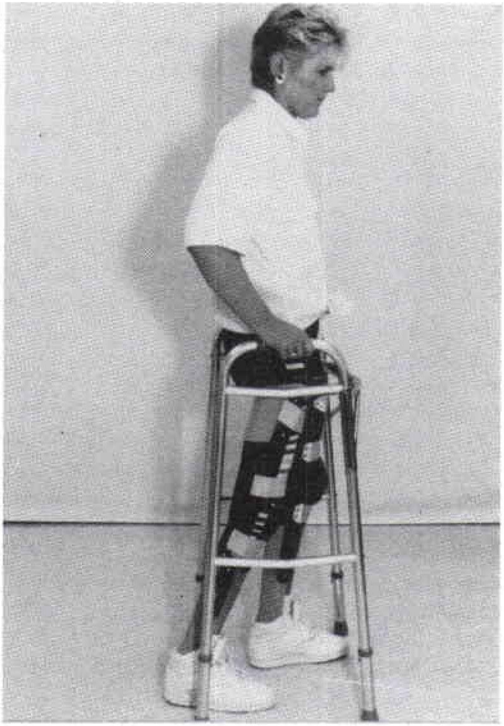

Fig. 2. Custom-fitted modular leg frames being used for early gait training by a patient with complete paralysis of muscles innervated below the T-10 spinal segment. She received a spinal injury seven months previously. Note that the plastic side members of each orthosis are *not* jointed at the knee. Patent process initiated.

In addition, the patient becomes a better informed participant in the decision about the feasibility of setting ambulation as a future goal (Fig. 2).

Such factors as effort in independent donning and doffing and expenditure of energy during ambulation with braces and crutches will have more meaning to the patient. If it is decided that even minimal ambulation is not a practical goal, the patient can still keep the inexpensive, supportive leg frames after discharge for erect weighbearing when he chooses. On the other hand, if it is determined by all concerned that the patient would benefit from an expanded ambulation programme, specially designed knee-joints, with a variety of possible locking features, can be installed on the existing leg frames at a reasonable cost (Fig. 3, top).

These transitional leg orthoses, designed to support standing in the early stages of the rehabilitation programme, have proven to be durable enough for the purpose intended. In the course of 20 months of usage, approximately 40 patients have undergone clinical evaluations in the orthotic research programme. No structural failures, nor any adverse effects on any of the participants have occurred.

An important feature of this modular system is the design of the extruded side members of the orthosis. In order to obtain necessary strength, with minimum weight, four hollow tubes are incorporated into the profile design (Fig. 3, bottom). These tubes also serve to hold cables, wires, or fluids. Thus, hydraulic fluids, or cables, may be used to control the locking and unlocking actions of the knee joint in relation to the gait cycle. Controlling signals can emanate from impact of the heel and sole of the foot.

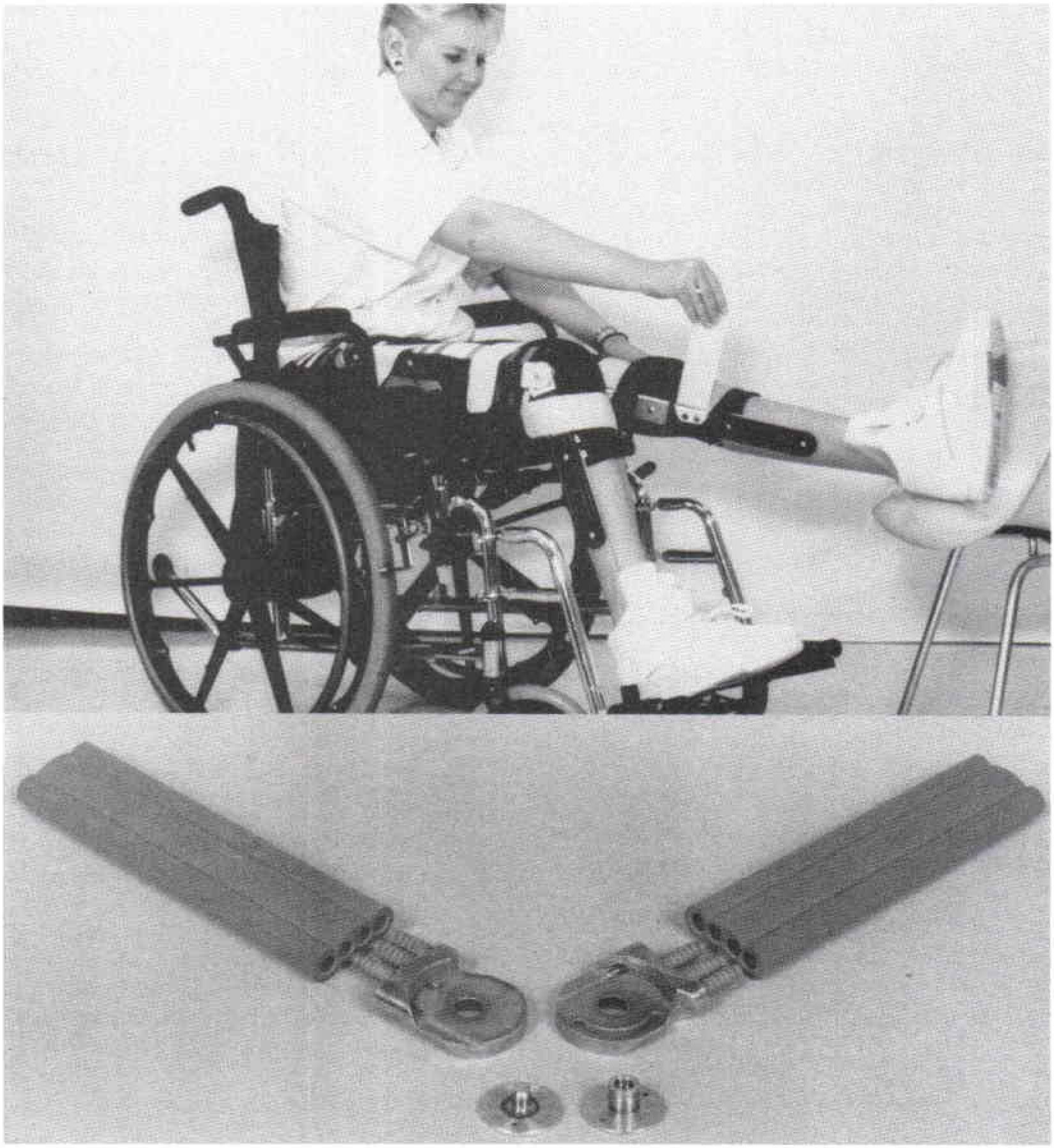

Fig. 3. Top, custom-fitted knee-ankle-foot orthosis following insertion of a modular joint into each side member to permit bending of the patient's knees. The locking mechanism for these joints is internal, thus eliminating external protrusions thereby minimizing wear on clothing. Patent process initiated. Bottom, close up, exploded view of the modular knee joint ready for insertion into the cut ends of the plastic extrusions from which the lightweight side members of the orthosis are constructed. Patent process initiated.

As reported by various groups of scientists internationally, and in the public media, functional electrical stimulation holds great promise for enhancing ambulation possibilities for the person with paraplegia (Kralj et al. 1988; Phillips, 1989). Electrical wiring connecting stimulators to muscle electrodes for functional electrical stimulation can be protected inside the tubes of the new orthotic system, thereby reducing the clutter of wires. We also anticipate that features of this new development may enhance the already developed LSU Reciprocating Gait Orthosis (Phillips, 1989). For example, the biomechanical action in walking can be more accurately duplicated using the extruded portion of our new orthosis. In all, we encourage others to capitalize on these new opportunities to further enhance the clinical usefulness of this new concept of orthotic patient management.

A number of our patients in the early part of the evaluation programme participated in a special outing to the beach (Fig. 4). For them it was a greatly appreciated experience. Such an expanded form of social involvement is possible for many others because sand and saltwater do not have any adverse effect on the devices.

Fig. 4. Two of the patients who have been testing the utility and durability of the new, lightweight orthoses are shown wearing them at the beach. These orthoses are not damaged by salt water or sand.

The future

In our long-term forecast, we envisage the system to be especially attractive to regions of the world with limited orthotic services. When commercially available, the modular components and instructions for their use on patients can be supplied at modest expense to any setting. The components can be selected from a limited number of sizes and custom-fitted to the individual patient in the clinic using basic tools. Thus, better services can be anticipated to become available to persons with paraplegia in underdeveloped, as well as in developed, countries.

It is a well-known fact that any successful research and development programme is staffed by highly qualified individuals possessing unique capabilities and skills. I have been blessed with the assistance of a small team of competent co-workers who deserve much credit for their individual contributions to the success of this project. Don Lehmkuhl, PhD, a Neurophysiologist, Kinesiologist and Co-Investigator has been largely responsible for securing funding for this project and for the clinical research design. Members of the orthotic staff: Tony Medina (Orthotist), John Wallace (Orthotist), Alan Pennock (Machinist), Tom O'Neil (Plastic Technician) and Margaret Morales (Data Collector) provided a high standard of technical expertise and quality control. Physical therapists participating in the clinical evaluation of the experimental orthoses include Sara Herber, Mandy Smith and Carol Link. They drew upon their own clinical experiences to suggest improvements in procedures for fitting and training patients.

It has been my privilege to share with you the present status of our orthotic project at TIRR in Houston, Texas, USA. Once again, thank you to the Blatchford family. On behalf of my colleagues, patients, and myself, I am honoured to accept the First Brian Blatchford Prize and look forward to the future developments that will be encouraged in our field of orthotics and prosthetics by the creation of this award.

Acknowledgements

The development and dissemination of results of this project were partially supported by grants from the Kappa Kappa Gamma Alumnae Association of Houston, Texas, the Meadows Foundation of Dallas, Texas and the National Institute on Disability and Rehabilitation Research of Washington, D.C., USA.

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Prosthetics and Orthotics International, 1989, 13, 130–139

A reference shape library for computer aided socket design in above-knee prostheses

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Abstract

A Reference Library of socket shapes for an Above-Knee Computer Aided Socket Design (CASD) System has been created. This library forms part of a more general CASD System (Dean & Saunders, 1985; Novicov & Foort, 1982). It consists of a matrix of reference shapes representing above-knee socket characteristics and is based upon skeletal structure, residuum length and tissue mass. A set of 27 biomechanical reference shapes in the form of male plaster casts were produced by a combination of CNC milling and traditional artisan techniques. Each reference shape was digitized to obtain its cylindrical coordinates. Cross-sectional areas and tissue distributions within each shape and between the shapes were analyzed, modified and then stored numerically within the computer for further implementation of the CASD System for the above-knee amputees. The creation and the analysis of the reference shape data is described.

Introduction

Fundamental to prosthetic fitting is the process by which the socket is modified in area and shape to match particular biomechanical characteristics of the residuum, in order to provide comfort, stabilization and control of the prosthesis. The socket, which links the amputee to the prosthesis, has several design features which are a function of the residual limb's tissue properties. The forces which are generated during ambulation (radial, shear and axial forces) must be transferred from the socket to the residual limb, and distributed over areas of the residuum which can tolerate repetitive loading without tissue damage. Loading of pressure-tolerant tissue, such as muscle, is achieved through a socket volume reduction over these tissue regions, while volume increases are introduced over load-intolerant bony prominences (Barclay, 1970).

Traditional socket fabrication procedures involve plaster casting and hand sculpting to produce a modified impression of the residuum, from which a socket can be manufactured. This is done on a trial basis until the appropriate fitting is achieved. Both the plaster casting and the modification procedure are performed on the basis of individual skills and judgement according to rules, habits or concepts that might change from centre to centre.

A Computer Aided Socket Design "CASD" System for below-knee (trans-tibial) amputees was developed at the Medical Engineering Resource Unit (MERU), of the University of British Columbia (Novicov and Foort, 1982). Other systems using CAD/CAM technology in the prosthetic field have since been reported (Dewar et al, 1985; Krouskop et al, 1987; Oberg, 1985). These systems differ from the approach of MERU however, in that they require full shape sensing of the stump in order to obtain its mathematical representation on the screen, whereas the MERU System uses a reference shape held in the computer memory, which is scaled differentially to match simple anthropometric measurements taken from the amputee's residuum. These measurements are sufficient to define the shape transformations required to generate a digital customized socket model known as the "Primitive" socket shape.

The CASD system of MERU is an interactive software package written in PASCAL, operating on an IBM PC/XT microcomputer in conjunction with a Vectrix graphic system. The objective of developing an automated shape management capability is to overcome the shortcomings in artisan production methods

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without forfeiting the accumulated knowledge and experience of the prosthetists. By relating details of socket shape modification and production to the computer, and by replacing the prosthetist's rasps and plaster socket model with a cursor and a digital socket model displayed on a graphic screen, it is possible to quantify the "art" of socket design more readily. The implications of such a quantification are that socket quality can be uniform, an explicit description of the socket fit can be defined, and a digital representation of the socket shape can be readily stored and transmitted (Dean & Saunders, 1985).

Methods

With the experience and positive results from the development and implementation of the CASD system for below-knee amputees, extension of the CASD system to include above-knee amputees was initiated. The approach for below-knee and above-knee differs in that initially the former used only one reference shape, whereas the latter uses a matrix of 27 reference shapes to accommodate the larger physical variability. This different approach emerged from the fact that when the reference shape is magnified by a large scaling ratio, particular features of the socket are distorted, and the primitive socket shape then requires considerable interactive modifications to reach an appropriate fitting. The concept of the reference socket shape is based on studies which established that some surfaces of the top portion of the thigh amputee socket can be constant, and that they change proportionately from size to size. This can be standardized (Foort, 1965).

Reference model

In common with the geometric similarities presented by below-knee stumps (Foort, 1984), analysis of the structure of the thigh shows similarities between stumps and between sockets. Studies on one hundred fittings reported by Foort (1965), showed that the distance between the ischial tuberosity and the adductor longus tendon among adults, measures not less than 6.4 cm (2.5 inches) or more than 11.4 cm (4.5 inches), and that most adults measure from 7.6 to 8.9 cm (3 to 3.5 inches). This anterior-posterior (AP) dimension determines the distance between the anterior and posterior walls at the top medial side of the socket. With respect to the distance between the adductor longus tendon and the greater trochanter, the studies indicated that this dimension is not less than 12.1 cm (4.75 inches) nor more than 20.3 cm (8 inches), while most adults measure from 14.0 to 15.9 cm (5.5 to 6.25 inches). This measurement determines the medio-lateral (ML) dimension at the brim of the socket. The above results were obtained at the Biomechanics Laboratory, University of California Medical Centre, San Francisco, Berkeley and were used to design the Adjustable-Brim fitting equipment for the total-contact above-knee socket in 1960 (Foort, 1963).

As a result of its successful use during the past two decades in the design and production of above-knee sockets, the socket type and brim structure selected to be used in the reference shape library of the proposed CASD System was the Quadrilateral Total-Contact Socket (rigid) using the Adjustable-Brim technique. For this purpose, a set of 27 biomechanical reference shapes, in the form of male plaster casts, was produced using a combination of CNC milling and traditional techniques.

Reference shape library

A reference shape library was designed in the form of a 3 x 3 x 3 matrix of 27 socket shapes as shown in Figure 1, having as a common origin a disarticulated knee model of an average adult. The reference shapes represent three above-knee socket shape determinants: skeletal structure, residuum length and tissue mass.

The first characteristic of the reference shape matrix is the brim size and is represented by the ML dimension. Three brim sizes were selected: 13.3, 15.2 and 17.8 cm (5.25, 6 and 7 inches). Stump length, defined as the distance from the ischial tuberosity to the distal end of the residuum, constitutes the second characteristic of the matrix set. The three lengths selected were: 8.6, 18.1 and 26.4 cm (3.375, 7.125 and 10.375 inches), representing short, medium and long. The third characteristic, tissue mass is represented by three perineal circumferences included in the matrix as follows: 38.1, 43.2 and 48.3 cm (15, 17 and 19 inches) representative of sparse (skinny), moderate (average) and bulky (fat) residuum tissue. The reference matrix was

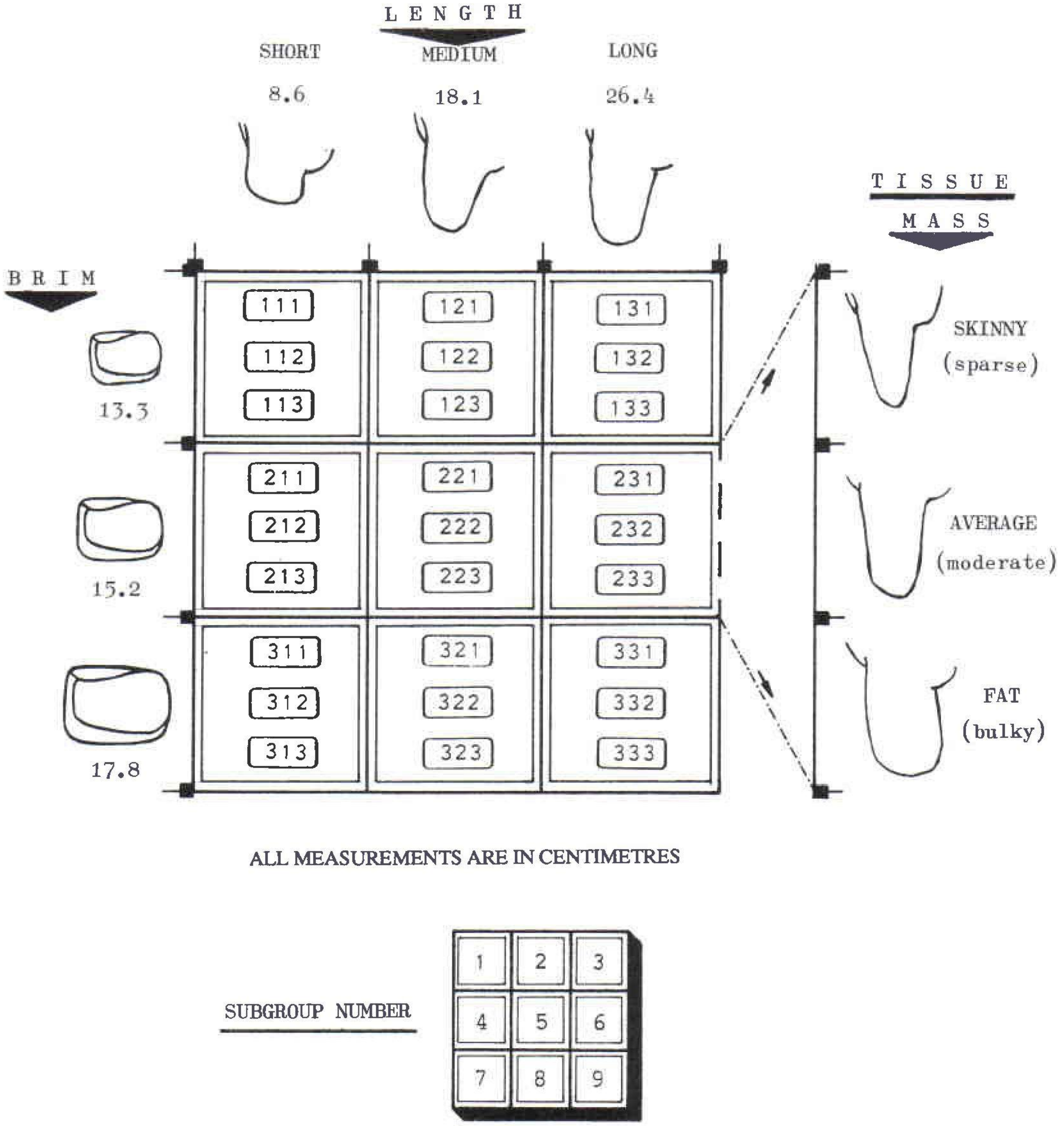

Fig. 1. Schematic representation of the reference shape library, based upon the skeletal structure, residuum length and tissue mass.

divided into 9 subgroups based on brim size and residuum length. Each subgroup consists of three shapes of different tissue mass: skinny, average and fat. In order for the CASD algorithms to distinguish between the 27 reference shapes, a code system was implemented by which each reference shape is coded with a unique three digit number (e.g. 231). The first digit indicates the distinct brim size (1=13.3 cm, 2=15.2 cm, or 3=17.8 cm); the second digit relates to the stump length (1=short, 2=medium, or 3=long); and the third digit represents the particular tissue bulk characteristic of the stump (1=skinny, 2=average, or 3=fat). The matrix set was designed to span all combinations of brim size, residual length and girth of socket for the above-knee amputee population.

In order to maintain a fixed relationship between reference shapes, the sequence of production started by digitizing the disarticulated knee positive model to obtain its cylindrical coordinates. This model was made from an average adult thigh fitted with the intermediate brim (15.2 cm), with a skeletal length of 36.5 cm from the ischial tuberosity to the tibial plateau and, an average (moderate) tissue girth (43.2 cm perineal circumference). The disarticulated knee model was then displayed on the graphic screen and "amputated" mathemetically at the length of the long residuum (26.4 cm). The cylindrical coordinates of this truncated disarticulated knee shape were first transformed into a helical path and then down-loaded to the Computer Numerically Controlled (CNC) milling machine. This data was translated by the CNC postprocessor into a series of machine instructions which control cutter tool movements, axis rotation, and axis translations. When executed by the CNC, these instructions result in a positive "cast" carved from a polyurethane foam block.

From this positive cast, the first reference shape positive cast was manually sculpted to provide a suitable distal end shape and emphasize areas of socket support. This modified shape (reference shape 232) was then digitized and carved to yield additional "casts", from which the adjacent cells (231 and 233) within subgroup 6 of the matrix (Fig. 1) were manually constructed and then digitized. Taking again the numerical data of the original disarticulated knee model, this was "amputated" to the medium length residuum (18.1 cm) and carved. From this, reference shape 222 was manually sculpted and digitized. This shape was then in turn carved and modified to yield the neighbouring cells (221 and 223) which were then digitized in turn. The procedure was repeated for the short residuum (8.6 cm) to produce shape 212 from which shapes 211 and 213 were then generated. At the end of this sequence the first set of 9 reference shape positive casts and their digital equivalents (subgroups 4, 5 and 6) were produced.

By repeating this procedure in the first and third brim size (13.3 and 17.8 cm) the remaining 18 reference shapes were produced to complete the reference shape library. By this method, the three distinctive characteristics were represented throughout the matrix set.

A disarticulated knee model was chosen as the best basis from which to develop a complete family of socket shapes. It was considered that this approach would provide a more uniform distribution of shape characteristics than would be achieved if the socket shapes were to be derived from a series of unrelated amputee socket shapes. The modifications to the original disarticulated knee model to produce individual socket shapes were made by an experienced prosthetist and based on previous clinical observations and measurements (Foort 1965, 1984).

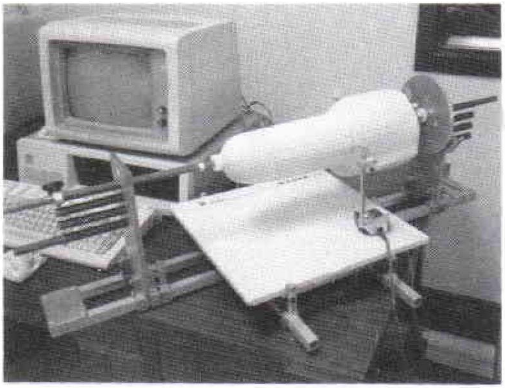

Fig. 2. Shape Copier device used in the digitization of the reference shape positive casts.

Digitization of the shapes

Digital recording of the reference shapes was performed by means of a Shape Copier (Saunders, 1986). Each positive cast was mounted on a horizontal jig similar to a lathe. The Shape Copier (Fig. 2) consisted of a cast holding device, an indexing turntable with notches at 10 degree intervals, an electronic digitizer tablet, and a cursor with an offset probe.

To digitize the male shapes, the cast was supported through its longitudinal axis by a rotatable vertical plate at its proximal end and a guide-pointer at its distal end. The cast was rotated 360 degrees in 36 steps of 10 degrees. At each step, a longitudinal trace of the cast shape was acquired by guiding the probe from the distal end to the proximal end. The software collected data corresponding to the perpendicular radii every 2.5 mm along the external wall, radii representing the distance from the longitudinal axis of the reference shape to the external wall of the cast. Once the horizontal trace was completed, the vertical plate was rotated to the next angular step and the operation was repeated until the complete cast had been digitized. At the end of one complete revolution, the numerical data consisted of a maximum of 5760 and a minimum of 3240 radial points describing each reference shape. Due to the limited dimensions of the electronic digitizer tablet being used, some shapes were too long to be digitized in a single file, therefore, those shapes were digitized in two independent data files with an overlapping range of 25.4 mm and later integrated to create the final output file. The cylindrical coordinates were then transformed into CASD system units compatible with both the CASD and the CASM software.

The final output file consisted of a two-dimensional array of raw radii; one dimension (referenced by the cross-section number "*j*") representing a certain distance from the Ischial Gluteal Shelf along the longitudinal axis; and the other ("*i*") representing the angle of rotation. Each individual cross-section within the shape was represented by 36 circumferential points, 10 degrees apart, expressed as radii from the longitudinal axis to the internal wall of the socket. This matrix represented the cylindrical coordinates (height, angle and radius) of the particular reference shape as shown in Figure 3.

Analysis

To assess the accuracy of the digitizing device, analysis of a known shape was performed. A solid cone was truncated into four sections; each section was connected to its neighbour by a solid cylindrical body to match the cone dimension, ranging from 15.2 to 5.1 cm (6 to 2 inches) in diameter. Similarly, cylinders of matching diameters were attached to either end. Using the Shape Copier device and the measurement technique employed with the reference shapes, this known volume was digitized to obtain 61 cross-sections containing 36 radii.

To quantify the deviation of the acquired cross-sections from their expected circular shape, the raw radii were plotted as a function of angle and fitted by the "least-square linear regression" method. The linear regression equation (Y=a+bX) obtained for each of the 61 cross-sections analyzed yielded b=0.00. The "standard error of estimate" had a mean value of ±0.36 mm. This represents the random error of the digitizing device. Taking the value "a" of the linear regression as the performance radii (Rp) and the expected radii as the target (Rt), the "constant error" (CE) (Schutz, 1973) was calculated using equation 1. This yielded a constant error of CE=+0.56 mm independent of the distance being measured.

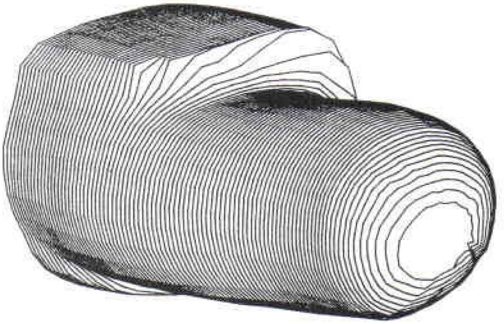

Fig. 3. Latero-posterior view of the three dimensional representation of the "left" reference shape code 222. Its "right" version can be obtained numerically by producing its mirror image.

$$CE = \frac{\Sigma(Rp - Rt)}{cases} \qquad (1)$$

Analysis of the reference shapes

To quantify tissue distribution (cross-sectional shape) and size differences along the longitudinal axis of the reference shapes, a series of statistical analyses were performed within each shape and between adjacent shapes of the subgroups within the reference shape matrix. Taking each cross-section independently, the Equivalent Radii (ER) (equation 2) representing the radius of a circle with an area equivalent to that of the shape being analyzed, and the Cross-Sectional Areas (CSAR) of all the 27 reference shapes were calculated. The CSAR was derived by calculating the areas of a series of circular sectors (ACS) with an angle of 10 degrees (equation 3). The sum of the 36 circular sectors represented the CSAR given by equation 4.

$$ER = \sqrt{\frac{1}{36}\sum_{i=1}^{36} R_i^2} \qquad (2)$$

$$ACS = \frac{\pi(R_i^2)}{36} \qquad (3)$$

$$CSAR = \sum_{i=1}^{36} ACS_i = \pi ER^2 \qquad (4)$$

By plotting CSAR as a function of residuum length, and comparing adjacent reference shapes, a comparison of tissue distribution was obtained. By plotting superimposed cross-sections within each socket shape (10 cross-sections evenly spread along the shape) the horizontal and vertical orientation of the tissue distribution with respect to the longitudinal axis and the ischial gluteal shelf was determined. To quantify the differences in shape between adjacent cross-sections within each reference shape and between adjacent reference shapes (average -vs- fat and skinny -vs- average), the RMS of the difference in shape was obtained (equation 5). In order to eliminate the effect of size differences from this comparison of shape, the raw radii were divided by their respective ER to obtain a normalized radii. This shape analysis was performed between cross-sections of adjacent socket shapes within each subgroup at the same longitudinal location; and between cross-sections within the same socket shape, selected at intervals of one, four and eight cross-sections to provide different levels of sensitivity in the analysis.

$$RMS = \sqrt{\frac{1}{36} \sum_{i=1}^{36} \left(\frac{R_{ia}}{ER_a} - \frac{R_{ib}}{ER_b}\right)^2} \qquad (5)$$

Results

Discrepancies in CSAR were seen in shape 333 and 323 at 12.4 cm in the longitudinal axis from the ischial gluteal shelf. This was the result of inaccuracy of alignment at the digitization stage where some shapes were collected into two files due to their oversize with respect to the electronic tablet and then merged to form a single shape. The analyses also revealed some unexpected results: firstly, the unmatched position of the rear flare (with respect to the cross-section number zero at the ischial gluteal shelf) between shapes, which reflects longitudinal misalignment (Fig. 4, top), secondly, an overlapping of CSAR between some neighbouring shapes (i.e. shape 312 and 313) and, thirdly, perineal area discrepancies between shapes of similar brim size and tissue bulk; this being a product of the previous area overlapping and the longitudinal mismatch. Shapes of similar brim size and tissue bulk, were expected to have similar perineal CSAR, independent from their length.

Modification of the reference shapes

Each reference shape was displayed on the graphic screen and the midcoronal plane of the socket was visually located. The coordinate grid was then medially rotated about 30 to 40 degrees within the transverse plane to superimpose the maximum ML dimension with the angular coordinate position zero. This was necessary in order that the brim scaling procedure be representative of the real ML dimension parallel to the coronal plane. Finally, the coordinate grid was re-aligned vertically to locate the cross-section representing the midpoint between the proximal and the distal portions of the socket (cross-section zero) exactly at the ischial gluteal seat.

The perineal CSAR were analyzed in order to normalize the systematic proportional CSAR increments between the three different brim sizes, and the proportional increments between the three different tissue bulks. This analysis indicated that between the three brim sizes, the perineal area of the 13.3 cm (5.24 inches) ML brim size represented 79% of the perineal area of the 15.2 cm (6 inch) ML brim; and the 15.2 cm (6 inch) ML brim size represented 70% of the perineal area of the 17.8 cm (7 inch) ML brim. For any given brim size, even though the ML remains the same, the perineal area changes due to differences in tissue bulk between skinny, average and fat socket shapes. With respect to the systematic perineal area of proportion between the three tissue bulks, the perineal area of the skinny represented 91% of the area of the average socket, which respectively represented 86% of the area of the fat. To normalize the CSAR proportional increments, an homogeneous area scaling routine was implemented. The overall radial scaling factor for each reference shape was calculated by obtaining the square root of the ratio between the required perineal area and the actual perineal area of the shapes. Taking each cross-section within the shape, the original radii were then multiplied by the radial scaling

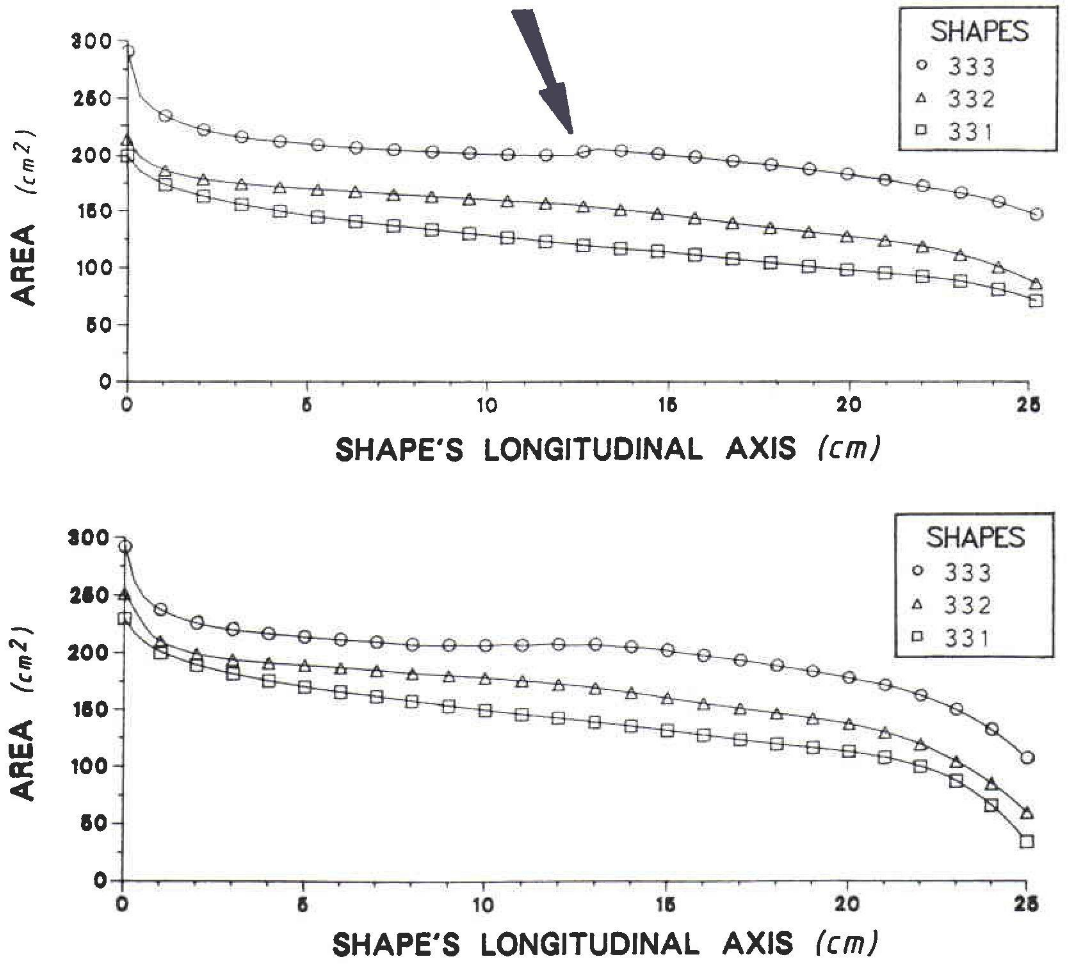

Fig. 4. Cross-sectional area plotted as a function of the residual length within subgroup 9 of the reference shape library: brim 17.8 cm, length 26.4 cm. Top, raw data, bottom, following the adjustments of the reference shapes.

factor, thus scaling the area without altering the cross-sectional shape or tissue distribution.

Scaling of the primitive library shapes was followed by smoothing the numerical data representing each circumferential string or horizontal cross-section, and along the 36 longitudinal strings. The smoothing routine used was based on the technique known as Fourth Differences (Lanczos, 1964). It assumes that the data is sufficiently close together to justify the hypothesis that in a certain finite neighbourhood of points, the second derivative of $f(x)$ does not change significantly, and adjacent points can be joined by a least-squares parabola of the second order. For circumferential strings, 5 adjacent data points were taken, whereas for longitudinal strings, which displayed less curvature, 7 points were taken using the same technique.

Final shapes

Once the refinement of the complete Reference Shape Matrix was performed, the 27 reference shapes were re-analysed in shape and area as described for the original digitized shapes. The cross-sectional shape analyses within each shape showed (Fig. 5) that in the central portion of the sockets, there is no significant change in shape. Change in the proximal portion (proximal 2 cm) of the socket results from the effect of the medio-posterior flare as the socket reaches its proximal end.

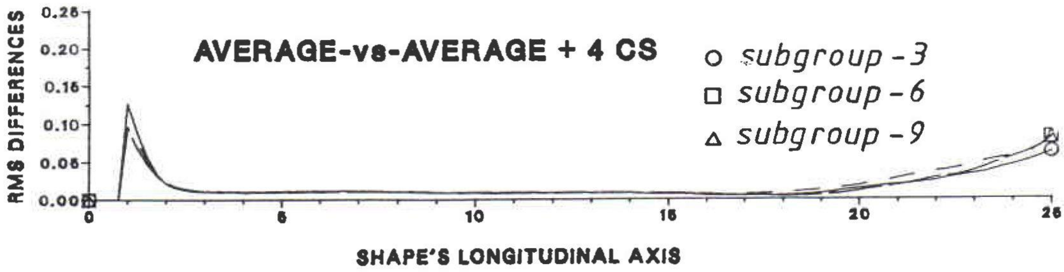

Fig. 5. Differences in shape between cross-sections at intervals of four cross-sections for the reference shapes within subgroups 3, 6 and 9: length 26.4 cm, average tissue girth.

Towards the distal end (distal 4 cm), there is a gradual change in shape but not to the extent seen at the proximal end. These changes in cross-sectional area and shape (tissue distribution) are designed to account for differences in muscle mass at the thigh and the way the residuum was designed during the amputation. The particular shape changes at both ends are emphasized when the analysis is performed between cross-sections at intervals of four cross-sections.

Three well established trends show that there is a larger degree of shape similarity between average and fat socket shapes than between skinny and average socket shapes. In the case of the skinny and average comparisons, shape similarity decreases in a linear fashion as the distance from the ischial gluteal shelf increases; whereas for the average and fat socket shapes, their similarity remains relatively constant along the socket until the distal 5 or 6 cm (Fig. 6). Three socket shapes (skinny, average and fat) of similar brim size and length, can be seen in axial view along the longitudinal axis (Fig. 7). Each of the three diagrams contains 10 superimposed cross-sections which where taken from their respective socket shapes at similar levels. As tissue mass decreases, the medial wall gradually shifts laterally towards the distal end, guided possibly by the femur's position. As the muscle mass increases (fat) the cross-sectional shape maintains its circular shape towards the proximal end, rather than tending towards an eliptic shape as in the case of less muscle bulk (skinny). This may be due to a greater change of muscle mass in the anterior

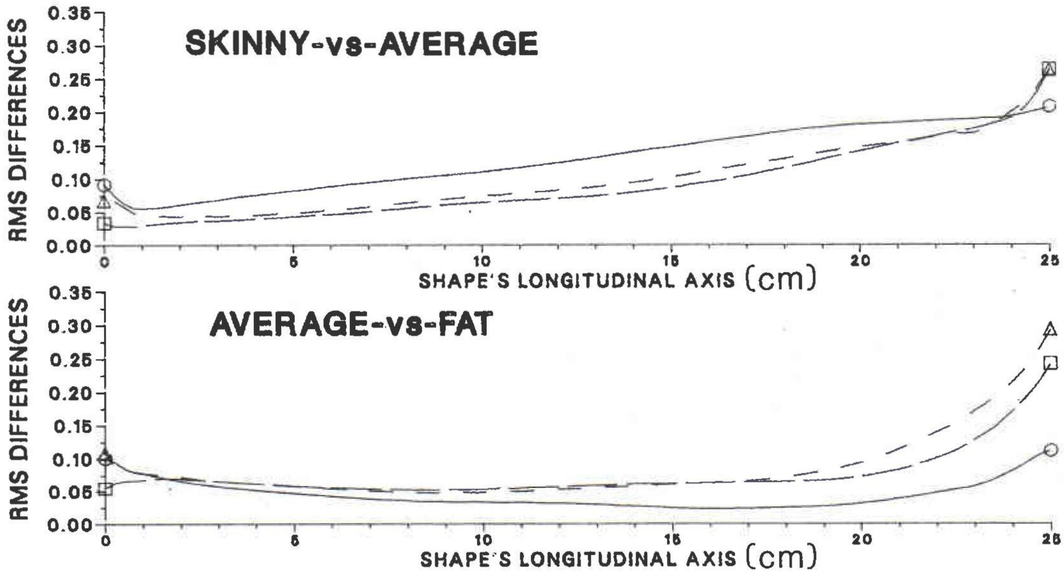

Fig. 6. Differences in shape of corresponding cross-sections between the reference shapes within subgroups 3, 6 and 9: Three brim sizes, length 26.4 cm.

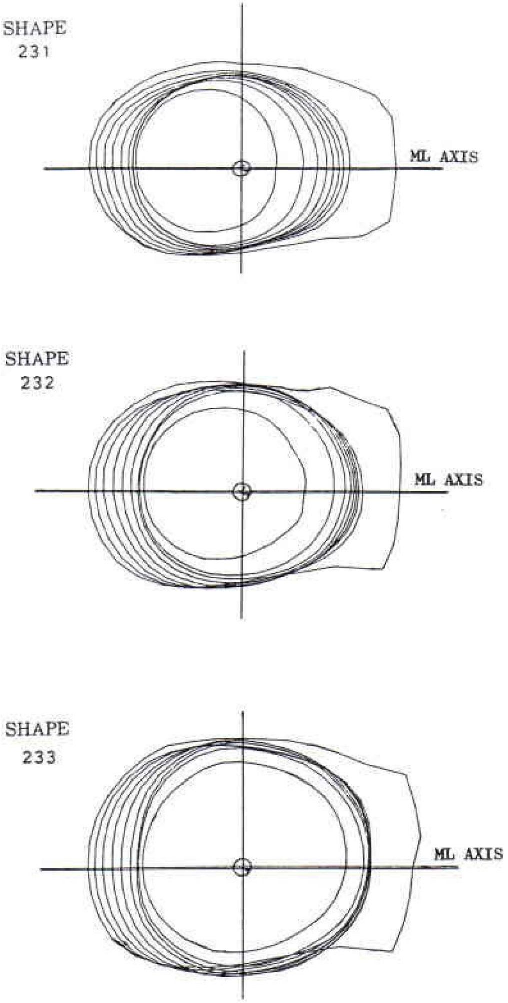

Fig. 7. Difference in tissue distribution along the longitudinal axis between the three tissue girths (skinny, average and fat): brim 15.2 cm, length 26.4 cm.

and posterior muscle groups than in the lateral and medial muscles.

Implementation

The above-knee Reference Shape Library has been integrated with the MERU shape modification procedures in order to produce socket shapes customized to the individual amputee. Using these procedures, a primitive socket shape was produced to fit an above-knee amputee. The primitive shape was then modified interactively using the CASD System to obtain a final socket shape. This shape was manufactured and worn by the amputee during a 2 month trial period with satisfactory results. As a further outcome of this process, a Reference Shape Library is now under development to enhance existing below-knee CASD procedures.

Conclusion

The basis of a computer aided socket design procedure (CASD) has been developed, whereby the unique configuration of an above-knee amputee's socket can be systematically created based on measurements of skeletal structure, residuum length and girths taken from an amputee. The complete library of above-knee reference shape data files, comprising a Matrix of 27 Reference Socket Shapes for the CASD System, have been stored on magnetic tape in the Research Data Library at Simon Fraser University. The data files may be accessed through the MTS operating system on University's main frame computer.

Nomenclature

ACS : area circular sector
CASD : Computer-Aided Socket Design
CASM : Computer-Aided Socket Manufacture
CNC : Computer Numerically Controlled
CSAR : cross-sectional area
ER : equivalent radii
i : angular location within the slice
IGS : ischeal gluteal shelf
Ri : raw radius
R'i : new radius
Rp : performed radius
Rt : target radius
RMS : root mean square

Acknowledgements

This project was funded by the Workers Compensation Board of British Columbia, Canada. Educational grants were provided by the National Council of Science and Technology, CONACYT, Mexico, and the National Autonomous University of Mexico, UNAM, Mexico.

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Prosthetics and Orthotics International, 1989, 13, 140–144

The effect of footwear mass on the gait patterns of unilateral below-knee amputees

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Abstract

This study reports an investigation into the effect of shoe mass on the gait patterns of below-knee (BK) amputees. Ten established unilateral BK, patellar-tendon-bearing prosthesis wearers were assessed using a VICON system of gait analysis. Incremental masses of 50g (up to 200g) were added to the subjects' shoes and data captured as they walked along a 15m measurement field. Coefficients of symmetry of various parameters of the swing phase (knee frequency symmetry, swing time symmetry, maximum flexion to heel strike time symmetry) were measured and their correlation was tested with the patient's preferrerd shoe mass and also their own shoe mass, all expressed as a proportion of body mass.

The subjects' 'preferred' shoe mass (139–318g) showed the greatest symmetry in all the parameters examined (correlations 0.78–0.81 $p<0.01$ and <0.005), whereas there was no correlation between the subjects' own shoe mass (121-325g) and the symmetry coefficients measured.

Introduction

Over five and a half thousand amputees are now being referred to Disablement Services Centres around the United Kingdom each year for prosthetic prescription, the majority of whom suffer from peripheral vascular disease, (Ham et al. 1989). Any advice given to them by members of the management team (therapists, prosthetists, bioengineers, doctors etc.) regarding their rehabilitation is very important, especially if this advice helps to improve their function during normal prosthetic use. The advice regarding footwear for the amputee is either non-existent, or that "the lighter the footwear the better". Lighter footwear is often thought to minimally affect the design performance of the prosthesis, despite the fact that there is little published evidence of consideration of footwear in prosthetic design.

In an early study of the effect of prosthetic foot mass, Godfrey et al. (1977) described the effect of changing the foot mass of a prosthesis on above-knee amputee gait. Stride length and heel rise velocity were considered to be of major importance because of the pendular quality of the above-knee prosthesis. However, no significant differences of performance were noted between the three different masses tested.

Several authors have looked at the different prosthetic feet available and their effects on gait. Doane and Holt (1983) compared the SACH foot and the single-axis foot in the gait of unilateral below-knee amputees. Temporal and kinematic data were obtained for a complete gait cycle on both sides. Of the data collected, only one parameter was thought to have any clinical significance and that was the difference of 6.5° in the range of ankle movement found between the single-axis foot and the SACH foot. In addition, the SACH foot also showed a limited range of plantarflexion.

Burgess et al. (1985) have evaluated the Veterans Administration (VA) Seattle foot. In their study the role of the energy storing/returning keel (which provides extra push at toe-off) was assessed, as were the natural feel and stability of the foot, the durability of the materials used and the mass of the foot. Currently prosthetic feet weigh between around 230g and 690g, with the VA Seattle foot

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weighing 460g. Consumer acceptance was the final measure of the Seattle foot and the amputees' comments were noted. The relative ability (compared with the use of other feet) to run at different speeds and on different surfaces was favourably commented upon, as was the extra push perceived at toe off. There was however no mention of the effect of the mass of the prosthetic foot.

A review of current prosthetic feet by Edelstein (1988) commented on many areas, such as the ability to accommodate different heel heights, the performance of the feet during stance phase, the energy storing materials used, and also their cost of production. Edelstein commented that to accommodate a change of more than 0.5cm in heel height either higher or lower, a change in the alignment of the prosthesis may be required, most designs of prosthetic feet were able to accommodate changes of up to 2-3cm, (this being achieved either by mechanically altering the alignment of the keel of the shoe to its heel, or by wedging material under the heel, as in the Seattle foot). The new energy storing feet, for which superior performance is claimed, use a variety of materials, from double carbon-fibre composite in the Carbon Copy II foot, to acetyl polymer and Kevlar fabric in the Seattle foot. The type of shoes used in their assessments may have influenced the performance of the various feet but they were not mentioned.

In the belief that many of these studies may have overlooked a factor which may significantly influence prosthetic use, this present pilot study looks at the subject of footwear, specifically the effect of shoe mass on the gait patterns of unilateral below-knee amputees.

Subjects

Ten unilateral BK amputees were assessed in this investigation. Nine were male, three subjects having undergone left-sided amputations and seven right-sided amputations. Body mass ranged from 57.0kg to 95.5kg with a mean of 79.9kg (±14.6). All subjects were patellar-tendon-bearing prostheses wearers and could walk at least 100m without the use of a walking aid. The subjects were all wearing single-axis feet except one, who was wearing a Quantum foot.

Method

The mass of the shoe with which each patient arrived at the laboratory was recorded, as was their body mass and the mass of the shoe the subject preferred during the tests.

The mass of shoes available commercially was tested and ranged from approx 250g (a light canvas shoe), to 460g (a heavy leather shoe). For the afternoon of the test the subjects wore a pair of Drushoes*. This is a make of orthopaedic footwear readily available in many hospitals and often issued to amputees with their first prosthesis. Each Drushoe weighed 260g. Investigations were carried out with the unweighted shoes and then following the sequential addition of plasticine (50g, 100g, 150g, 200g) to the front of each Drushoe. The plasticine was attached to the shoes as close to the ankle joint as possible to reduce any effect on ankle moments to a minimum. The range of shoe mass (Drushoe plus extra mass) was thus 260–460g, effectively covering the 'normal' range of shoe mass.

Kinematic information was obtained using the VICON 3-dimensional gait analysis system consisting of four infra red cameras and a PDP 11/23 computer. Foot switches were used in order to obtain accurate foot contact timing information and thus swing phase times.

Each subject was required to wear shorts and reflective markers were placed on the subject's skin at the following anatomical landmarks on the non-prosthetic side:

1 anterior superior iliac spine,
2 greater trochanter,
3 lateral line of the knee,
4 lateral malleolus,
5 head of the fifth metatarsal.

Markers were also placed at equivalent positions on the prosthetic side. Marker trajectories were recorded whilst the subjects walked down at 15m walkway at their own comfortable pace. From these marker trajectories information was obtained about hip, knee and ankle joint angle variations in the sagittal plane, throughout the swing phase of one gait cycle on each side. Joint angles were computed for the swing phase for both left and right sides. Each data set was normalised in time to 64 data samples using linear interpolation. In order to compare the change

* John Drew (London) Ltd.

in joint angle values rather than the absolute magnitude, the mean angle value for each data set was subtracted from all points in that set. A Fast Fourier Transform was then performed in order to obtain the power spectrum for each angle waveform.

$$r=(\Sigma xy-(\Sigma xy)/N)/\sqrt{\{((\Sigma x^2-((\Sigma x)^2)/N)(\Sigma y^2-((\Sigma y)^2)/N)\}} \quad \ldots\ldots\ldots\ldots\ldots 1$$

The Index of Symmetry was calculated as the correlation index using Equation 1 (above). In this equation x represents the amplitude of the angle at each harmonic for the left hand joint, and y the amplitude at the same frequencies for the right hand joint. The coefficient was calculated for the first ten frequency samples with the exception of the first since the joint angle offset had been previously removed. A symmetry coefficient of 1.0 would represent perfect symmetry, with the coefficients ranging from 0–1, this is the same procedure as followed by Hannah & Morrison (1984) and Pepino et al. (1986). Symmetry Indices were calculated for the hip, knee and ankle (Hip Frequency Symmetry, Knee Frequency Symmetry, Ankle Frequency Symmetry).

Swing time symmetry was calculated from the swing phase times obtained from heel and toe switch information. Left and right feet were compared and a symmetry coefficient (SWTS) was obtained.

The time taken from maximum knee flexion to heel strike was calculated from the knee joint angle vs swing time waveform. Again left and right were compared and a symmetry coefficient (MF-HS) obtained.

Results

From the temporal and kinematic data obtained, symmetry coefficients were calculated for three parameters at each mass tested. The three parameters were, Knee Frequency Symmetry in the Swing Phase (KFSS), Swing Time Symmetry (SWTS) and Maximum Flexion to Heel Strike Time Symmetry (MF-HS). Table 1 shows the information collected for one subject and is typical of the data collected on all ten. From this information the shoe mass which gave the most symmetrical gait, as indicated by the three parameters, could be identified and recorded.

Table 1. Symmetry coefficients for Subject 5.

Shoe mass tested (g)	KFSS	SWTS	MF-HS
260	0.921	0.833	0.893
310	0.932	0.709	0.786
360	0.987	0.935	0.935
410	0.933	0.833	0.921
460	0.942	0.719	0.719

The subject's own shoe and their preferred shoe mass was expressed as a proportion of their body mass, to allow comparison of results between subjects. Table 2 shows this and also whether the subjects preferred heavier or lighter shoes than their own.

Table 2. Body/shoe mass proportion related to preference.

Subject	Body mass (kg)	Own shoe mass proportion	Preferred mass proportion	Heavier/ Lighter
1	57.0	121	139	Lighter
2	60.0	300	193	Heavier
3	63.5	128	138	Lighter
4	76.0	325	245	Heavier
5	80.2	221	174	Heavier
6	84.0	258	183	Heavier
7	89.0	168	194	Lighter
8	95.5	281	265	Heavier
9	95.5	382	208	Heavier
10	98.6	253	318	Lighter

The shoe mass which indicated the most symmetrical gait in each of the parameters looked at was also expressed as a proportion of body mass (Table 3). The body to shoe proportion which gave the most symmetrical gait patterns for the subjects ranged from 146–318.

Table 3. Symmetry—body/shoe mass proportion.

Subject	KFSS	SWTS	MF-HS
1	158	184	158
2	146	146	231
3	155	176	176
4	245	245	245
5	223	223	223
6	233	271	183
7	247	217	217
8	233	233	208
9	208	208	208
10	318	274	274

Since all shoe masses were expressed as a proportion of body mass a correlation between indices is possible. In order to achieve this the shoe mass which provided the optimum results for each of the parameters was identified. A correlation was then tested between these shoe

Table 4. Correlation coefficients.

KFSS	
Own shoe correlation	0.44
Preferred mass correlation	0.78 ($p<0.01$)
MF–HS	
Own shoe correlation	0.57
Preferred sho correlation	0.80 ($p<0.05$)
SWING PERIOD PARAMETERS	
Own shoe correlation	0.49
Preferred mass correlation	0.81 ($p<0.005$)

masses and both the original shoe mass with which the subject arrived, and with the shoe mass which the subject preferred.

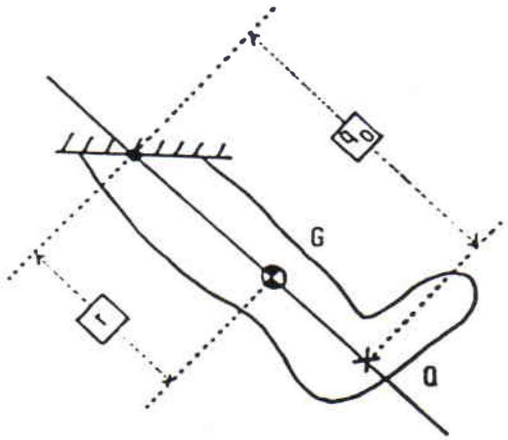
Table 4 shows the correlation coefficients calculated for KFSS, MF-HS and a combination of all three parameters looked at. The correlation calculated for the swing period parameters, used an average of the body to shoe mass proportion which produced the most symmetrical gait in each of the three parameters (KFSS, SWTS, MF-HS), for each subject.

Although the results showed that the optimum shoe mass exhibited little correlation with the subjects own shoe mass, it was however significantly correlated with their preferred mass in each parameter.

Discussion

Since changing footwear mass is most likely to change the gait pattern in the swing phase, this present study has been confined to only that part of the gait cycle. During the swing phase of the gait cycle the knee is flexing and then extending under pendular action. If the prosthetic shank and foot act as a simple pendulum the natural frequency and therefore the period of swing would be unaffected by the pendulum mass (i.e. prosthetic foot and shoe) but would be dependent only on the distance of that mass from the axis of rotation ie. the knee joint.

However, it can be argued that a prosthesis may more realistically resemble a compound pendulum due to the mass being distributed throughout the stump, prosthetic shank and foot, with the added restraints of muscular control of the knee. Figure 1 shows a prosthesis represented as a compound pendulum, (Steidal 1971). The position of the plasticine mass, close to both the normal and prosthetic ankle joints prevents a significant shift in the centre of mass of the shank and foot in an antero-posterior



$$f = \frac{1}{2\pi}\sqrt{\frac{g}{q_0}}$$

G – centre of mass

Q – centre of percussion

$$q_0 = \frac{K_0}{r}$$ (K_0 – radius of gyration)

= distance from the axis to Q

Fig. 1. Compound pendulum.

direction. By adding mass to the footwear, the position of the centre of mass will however be shifted distally therefore increasing r and consequently altering q°, (the distance from the knee joint to the centre of percussion). Note that the natural frequency of the pendulum is inversely proportional to q_o, which in turn will be affected as suggested, by the shoe mass.

In this present study, evidence was found that altering the shoe mass changed the swing time, as shown by the swing time symmetry (SWTS). Components of gait symmetry, ie. knee frequency symmetry, maximum flexion to heel-strike time symmetry and SWTS have been examined to see how much the prosthetic side altered and approximated to the natural side during the swing phase. The possible correlation between gait symmetry and the subjects' acceptance of the shoes has also been examined.

The lack of correlation between the subjects' own shoe and symmetry could have been for two reasons. Either the subjects had received the wrong advice about their footwear (six out of the ten subjects preferred walking with shoes that were heavier than their own) or the subjects were accustomed to walking with the same type of shoes and had not experimented or tried any other type of shoe.

Consumer acceptance and approval was the final measure of success when the VA Seattle foot was evaluated (Burgess et al. 1985), and so it should be for the amputee's total prosthetic prescription. Footwear should be included as an item on the final prescription if it is found to have an influence on their walking patterns. It would seem from this present study that footwear *does* influence the amputee's gait pattern, both from an objective and subjective point of view.

Conclusions

Although only a preliminary study, the data collected are sufficiently convincing to be able to draw certain conclusions. Firstly, changing footwear mass *does* alter the gait pattern, as shown here, during the swing phase. Secondly, lightweight footwear does not necessarily provide the most symmetrical gait as shown by the collected data, or the most acceptable gait as preferred by the amputee. Thirdly, amputees should be encouraged with their choice of footwear to find a pair which suits them individually. This may be their only way of finely tuning their artificial limb to their everyday needs. Their footwear would then become part of their total prosthetic prescription.

Acknowledgements

With grateful thanks to Mr. J. M. Regan, Senior Prosthetist, Chas Blatchfords & Sons Ltd. Roehampton, formerly of Vessa Ltd. Also to the registered charity Action Research for The Crippled Child who sponsored J. D. for a Research Training Fellowship which enabled her to finish this work.

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Prosthetics and Orthotics International, 1989, 13, 145–148

A single case study: myoelectrically controlled exoskeletal mobilizer for amyotrophic lateral sclerosis (ALS) patients

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Introduction and clinical pathology of Amyotrophic Lateral Sclerosis (ALS)

Amyotrophic Lateral Sclerosis (ALS) also known as Lou Gehrig's disease is the generic name for progressive muscular atrophy and bulbar palsy. It refers to all disorders of the cortico spinal pathways which are characterized by progressive muscle weakness. After multiple sclerosis, ALS is the most common purely neurological disorder (Janiszewski et al. 1983). Information available from the ALS Society indicates that the most common age of onset is 55 years.

Literature shows that the incidence of ALS is 1-2 per 100,000 population. There are, however, geographic pockets where this figure doubles (Sarnia, Ontario) or even jumps 100 fold as on the island of Guam in the Pacific (Guamainian ALS) (McLachlan, 1988).

To date, no etiological or epidemiological factors that could be linked to ALS have been found nor is there any cure for the disease.

A major feature of ALS is that a mentally alert person who is accustomed to being active and independent becomes trapped in a weakened body. As a result of the disease, people lose the motor functions of their muscles and limbs. This report concerns itself with the loss of muscle power in the upper extremities which, in the advanced stages of the disease, leaves the arms of 16% of these patients virtually flail, except for limited weak grasp (Beggs, 1988). While these patients retain full sensation, reach and grasp become impossible and most normal activities of daily living cannot be performed any longer.

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In the past, significant efforts have been made to improve the functionality of the upper limb amputee through the provision of externally powered prostheses (Lewis et al, 1975; McLaurin, 1975; Prior & Lyman, 1975). It might well be that upper limb amputees were targeted because their problems were relatively easy to resolve and the resulting improvements were often dramatic. The real need however, certainly in degree of disability, is in the authors' opinion much greater among persons with flail limbs. One of the outstanding efforts to provide assistive hardware to the quadriplegic and post polio group was the Ranchos Los Amigos "Golden Arm" (Nickel et al, 1964). Mounted on the back of a wheelchair, the orthosis was powered by nine different electrical actuators and controlled by a bank of tongue switches. The device was complex, expensive and difficult to don. The tongue switch control was less than hygienic and difficult to combine with eating and drinking. The device is no longer in use and no new developments that would benefit persons with bilateral flail arms have been reported.

This paper reports on the provision of an externally powered, myoelectrically controlled forearm lift and prehension device for a person with a flail arm.

Patient profile

On initial examination, this 31 year old male showed nearly flail arms with very poor hand function. He was, however, able to walk a few steps when pulled up to standing and given a walker. His speech was slurred and his vital functions reduced. Three years previous to referral to the myoelectric clinic he was diagnosed as having ALS. He is married and living at home, with a supportive wife who has to go to work.

In discussion with the team and patient, self-feeding was rated as the greatest need followed by being able to access a computer keyboard. It was decided jointly that an attempt be made to fit his left arm.

Control system

Before embarking on the design and fabrication of the orthosis, the problem of how to control hand prehension and forearm lift had to be addressed. It was decided that to be effective, the mode of control chosen had to be unaffected by normal body movement or sway, as well as other functions such as eating or speech. The control function had to be easy to produce, while having an acceptable degree of reliability and repeatability. Suck and puff switches, tongue switches and head attitude controls were excluded because of their interference with eating and drinking. In the search for control modes and control sites, it became evident that only the upper facial muscles of ALS patients remain unaffected as the disease progresses. It therefore seemed reasonable to use the occipito-frontalis muscle group as the signal source for an electromyographic (EMG) control system.

With the patient seated a jogger's head band was used to hold two Otto Bock* surface electrodes in place just above each eyebrow. A jogger's headband was used because the patient disliked the idea of wearing eye glasses to support the electrodes on his forehead. The electrodes were wired to a battery and a myoelectric hand. The patient was shown how, with separate left and right frontalis muscle contractions, it was possible to open and close the hand. The patient and his wife were shown how to apply the system and were then given the equipment to take home so that the patient could practise on his own.

As predicted, the jogger's headband proved inadequate. Every time the patient perspired, the electrodes would work themselves higher up and away from the control sites. The electrodes were therefore transferred onto a pair of eyeglasses with the ground electrode mounted in the middle across the bridge.

The EMG signals from the frontal part of the occipito-frontalis muscle group were picked up by the 2 electrodes mounted on the eyeglasses and located 7cm from mid-line of the forehead, approximately 1cm above the eyebrow ridge and at approximately 30° of lateral rotation. With the electrodes spaced in this manner, it was possible to avoid involuntary triggering of the system thus preventing inadvertent activation.

A negative cast of the patient's left arm was used to make a full plaster replica of his limb. The resulting positive mould was used to custom form the device. The upper-arm and forearm sections were hinged by spring-loaded (energy storing) elbow joints. The hand prehension splint was powered by an electric dual-action linear actuator. Forearm lift was achieved by an electrical miniature winch winding up a timing belt. Both these devices were made in-house by the centre's mechanical engineering staff. After three weeks of home training, the patient became proficient in generating sufficient signals from either the left or right frontalis muscle, to either open or close his hand. However, in order to operate both hand and elbow with the chosen 2-muscle site system, an electronic mode selector had to be incorporated into the system. The mode selector, normally at rest, responded to a co-contraction from the fontalis muscles lasting at least 0.7 seconds after which the device would switch control from hand to elbow or vice versa. After switching control from the hand orthosis actuator to the elbow winch, the patient could contract the right frontalis muscles to raise the forearm and vice versa. This meant that the orthosis provided 4-degrees-of-freedom for forearm lift and finger opening and closing. The system was powered by a 7.2 volt, 1200 mAh nickel cadmium battery with an operational capacity of 8 hours.

Brace redesign

Whilst this orthosis worked well enough to demonstrate the effectiveness of the approach taken, it was structurally too weak, causing the elbow joints to lose their alignment under load. It also became evident that to enable the patient to feed himself, his arm needed to be held in a position of approximately 20° abduction and 30° of humeral flexion. It was also noted that the patient's gleno-humeral joint tended to sublux under the combined weight of the arm and orthosis. The most

* Otto Bock Orthopaedic Industries, Cat. #13E60. (Otto Bock Canada, 251 Saulteaux Crescent, Winnipeg, Manitoba, R3J 3C7).

evident short-coming of this orthosis, however, was the lack of pronation-supination to facilitate self-feeding. Therefore, a second device was designed with 6-degrees-of-freedom. This Mark II brace was constructed of sturdy stainless steel uprights of 4mm × 15mm cross section. Two transverse bands of the same material on the humeral section held the elbow joints securely aligned. The forearm section had one sturdy band of 4mm × 15mm stainless steel approximately 30mm distal to the elbow centre. Both elbow joints were equipped with lift assist springs. These energy storing springs were cranked up to balance the weight of the forearm almost completely. In order to achieve pronation-supination, the forearm segment was constructed in such a way as to simulate the movement of the osseous structure of the forearm. The lateral forearm bar was cut off at the proximal third and a piece of stainless steel tubing was welded to it. The tubing formed the bearing for a 6mm stainless steel rod which connected with an aircraft tie rod end to the wrist joint. On the medial side, a similar rod with a tie rod end on each end makes up the forearm section. This arrangement allowed the forearm section of the brace to supinate 45°. The electric elbow winch was mounted to the lateral upright of the humeral section. The winch winds up a timing belt which connects to a stainless steel cable. The cable was sleeved through a bowden housing on the lateral forearm from where it crossed over the forearm to the anchor point on the medial forearm rod. Thus supination was effected by the forearm being raised under power. Because of offset stops on the mechanical elbow joints, pronation was produced when the arm was extended. The fingers of the patient's hand were held in a powered orthosis. A double acting linear screw actuator moved the fingers of the hand against a stationary thumb. Because the patient had full sensation, he could feel what he picked up. The addition of pronation-supination greatly improved the usefulness of the device because the hand was automatically rotated into the appropriate position for picking up food at table level and then bringing it to the mouth.

In addition to fabricating and fitting the orthosis for the patient's upper extremity, it was necessary to hold and support the patient's arm in a position of 20° of abduction and 30° of humeral flexion to accomplish self-feeding effectively. A laminated, lateral body panel held in place with a strap around the waist was used as a mounting base for an adjustable support strut holding the arm out and away. Because of painful subluxation of the glen-humeral joint, it became necessary to fabricate a shoulder saddle which would comfortably support the assembly. Donning and doffing was simplified by having the orthosis, the body panel, the shoulder harness, and the eye-glasses-electrode assembly separate into different units which are applied one at a time. The complete device is shown in Figure 1.

Fig. 1. The complete orthosis being worn by the patient.

Results

It is now 24 months since delivery of the device to the patient. He continues to use the device almost daily. The device has helped him to accomplish various activities of daily living which have enhanced his independence and thus, the quality of his life. He can place a drinking straw into a cup or glass, operate a telephone communications device and operate a T.V. remote control. He can play board games with his children and, most importantly, he can eat solid foods such as a sandwich or fruit that has been previously cut. Since being fitted with the device, the patient has used it to access a computer. Using a word processor, he has completed a book on landscaping. He has also become employed as a part-time book-keeper because of his ability to access the computer.

It is believed that the positive outcome of this fitting is attributable to several factors. These are:

(a) an enthusiastic and well motivated patient;
(b) wearing the brace on the arm rather than having it attached to the back of the wheelchair;
(c) this orthosis, in contrast to previous complex designs, provides grasp, elbow flexion, pronation and supination with a minimum of hardware and a simple electronic control system. In addition, with some lateral tilt of the torso, the hand can swing in the coronal plane.

The positive outcome of this fitting leads us to believe that the approach taken with this subject could also benefit other people with conditions such as quadriplegia, spinal muscular atrophy or poliomyolitis.

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Prosthetics and Orthotics International, 1989, 13, 149–151

Bacteria on stumps of amputees and the effect of antiseptics

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Abstract

Amputees get stump infections usually from the natural inhabitants of the healthy skin and probably due to the unnatural environment of tight fitting sockets. The aim of the present study was to investigate the natural stump bacteria and the effect of antiseptics as well as the amputees' evaluation of such treatment. Fifteen amputees using their prostheses all day were investigated. Bacterial samplings were taken by swab technique with respect to bacteria and fungi from the stumps in the morning before prosthetic application and in the evening after a whole day's prosthetic use without antiseptic cleaning; after antiseptic cleaning with a combination of Isopropanol 45%, N-propanol 30% and N-cetyl-pyridiniumchloride 0.2% for one day; after fourteen days continuous use. The patients were asked if they liked the antiseptic and if they would like to continue to use it. Two patients did not submit bacteriological samples after the cleaning period. Before cleaning S. epidermidis, S. aureus and alpha-hemolytic streptococci were commonly found. In two instances gram negative rods were found. After the cleaning period there was a reduction of bacteria in 11 out of 13 patients. All patients liked the antiseptic and the simplicity by which the stumps and the sockets could be kept clean. The authors feel that the use of antiseptics to increase stump and socket hygiene is justified.

Introduction

It is a well known clinical observation that recurrent superficial infections are common in stumps of amputees (Barnes, 1956; Levy, 1956; 1983). Bacterial samplings from the infections usually show Staphylococcus aureus, Staphylococcus epidermidis, diphteroids, and alpha-hemolytic streptococci, known to be natural inhabitants of the healthy skin (Davis et al, 1980; Levy, 1983). It is well known that occlusion and raised temperature of the skin leads to changed bacterial flora both with respect to amount and type of species (Aly et al, 1978; Hartman, 1983; Marples & Klingman, 1969). The unnatural environment for the stump skin of a tight-fitting occlusive plastic socket with increased temperature and moisture compared to the normal in combination with high repeated loads makes the stumps extra vulnerable to infection (Barnes, 1956; Levy, 1956). If the amount of bacteria can be kept low by, for instance, antiseptics there are reasons to assume that the risk of stump infection will decrease.

The aim of the present investigation was to study stump bacteria and the effect of antiseptics as well as the amputees' evaluation of the treatment.

Materials and methods

Fifteen persons of which 5 were below-knee, 4 above-knee and 6 arm amputees using their prostheses all day were investigated. The amputees were studied in three different series. In the first no antiseptics were used and the amputees cleaned their stumps and sockets as usual. In the second series the stumps and the sockets were cleaned with antiseptics i.e. Isopropanol 45%, N-propanol 30% and N-cetyl-pyridiniumchloride 0.2% on a one-time-use cloth, twice during one day. In the third series antispetic cleaning was used twice a day for fourteen days. In the two latter series the amputees cleaned their stumps and prosthetic

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sockets in the morning before prosthetic application and after a whole day's use. Samplings were made by swab technique with respect to bacteria and fungi from the stumps before prosthetic application and antiseptic cleaning in the morning and in the evening after a whole day's use before socket and stump cleaning.

Specimen swabs were processed by the laboratory within 24 hours after the collection. Bacteria were isolated and identified using the routine techniques of the Department of Microbiology at Karolinska Hospital laboratory (Lenette et al, 1980).

The patients were asked if they liked the antiseptic and if they would like to continue to use it.

Results

Two patients did not submit to bacteriological samplings after the cleaning period. One of these, who had a previous history of eczema, got skin irritation from the treatment. The other used the antiseptic and gave no reason for not sampling but could be evaluated for his subjective feeling of stump hygiene. Before the cleaning period S. epidermidis, S. aureus and alpha-hemolytic streptococci were commonly found. In two instances gram negative rods were found, one in an above-knee and one in a below-knee amputee. In the cases of above-knee amputees group B, C and D streptococci were commonly found. There were no obvious changes of bacteria during the day when no antiseptics were used. After the cleaning periods there was reduction of S. aureus and streptococci. Bacterial reduction was observed in 11 out of 13 amputees. No difference in reduction was observed between the short term and the long term use of antiseptics. In spite of inconstant apparent reduction of bacteria all the patients experienced subjectively improved hygiene and wanted to continue to use the antiseptic. The results are summarized in Table 1. In one patient the leather covering of the socket partly lost its flexibility due to cleaning with the antiseptic.

Discussion

The present investigation showed a reduction of the natural bacteria of the stump skin with respect to species when cleansed with antiseptics. The amount of bacteria are probably always decreased in spite of the fact that the investigation failed to demonstrate any constant decrease. All the patients liked the antiseptic and the simplicity by which the stumps and the sockets could be cleaned.

The sole of the foot is the only part of the body developed for high repeated loads. The stump skin of an amputee is therefore subjected to unnaturally high loads. In a tight plastic socket the skin gets warm and wet by perspiration decreasing the physical strength and increasing the amount of bacteria (Allende et al, 1961; Aly et al, 1978; Hartman, 1983;

Table 1. Bacteriological finding before and after the use of antiseptics

No.	Age	Sex	Type of amputee	Bacteriological finding before	Bacteriological finding after	Subjective feeling
1.	22	F	arm	A;C;	A;	improved
2.	35	F	arm	A;	A;	improved
3.	45	F	arm	A; B;	A; G;	improved
4.	46	M	arm	A; B;	skin irritation	
5.	67	M	arm	A; C;	A;	improved
6.	67	M	arm	A; B;	A; B;	improved
7.	17	M	BK	A; B; C;	A; C;	improved
8.	33	M	BK	A; B;	A;	improved
9.	39	M	BK	A; B; G;	A; B;	improved
10.	42	M	BK	A; D;	A;	improved
11.	49	M	BK	A; B;	A;	improved
12.	24	M	AK	A; B;	–	improved
13.	47	M	AK	A; D; E; G;	A; E; G;	improved
14.	48	M	AK	A; C; D;	A; D;	improved
15.	53	F	AK	A; F;	A;	improved

Abbreviations

A = S. epidermidis
C = alpha-hemolytic streptococci
E = Group-C-streptococci
G = Gram-neg rods.
B = S. aureus
D = Group-B-streptococci
F = Group-D-streptococci

Levy, 1983; Marples & Klingman, 1969). It is therefore not surprising that the stump skin gets easily torn and is vulnerable to infections. Since the skin of the stump is so vulnerable it must be of utmost importance to keep it clean. It is often difficult for the amputees to maintain high standards of hygiene in their sockets since the skin is covered by tight fitting plastic material. If the hygiene is bad the situation gets even worse with dominant odour, recurrent infections and sometimes ruined stumps (Jackman, 1982). The theory of the present investigation was that cleaning stumps with a well known and long lasting combination of antiseptics might increase stump hygiene by reduction of bacteria (Barnes, 1956; Davis et al, 1980). All patients studied reported an increased feeling of stump hygiene probably due to reduction of both bacterial spectrum and amount. The reason for the failure to demonstrate a constant effect on the bacteria could be that there really was a very limited effect. Another more plausible reason is that the methods used were simple clinical routine bacterial sampling directed to demonstrate the presence of bacteria and not the amount of bacteria present. Whether long time use of antiseptics can decrease the rate of stump infections remains to be investigated.

The type of bacteria observed in the study corresponds well with reports from other authors (Allende et al, 1961; Roth & James, 1989). The combination Isopropanol, N-propanol and N-cetyl-pyridiniumchloride is widely used for preoperative hand washing and is known to inhibit growth of bacteria, fungi and some viruses (Korting et al, 1987). To avoid drying out effects on the skin a somewhat oily skin protecting agent was added to the solution. The wet one-use cloths were chosen since it was felt that it would be the most convenient way for the amputees to administer the agent.

Sockets made of leather should be cleaned carefully with antiseptics containing isopropanol. There are reasons to assume that the physical properties of this leather may be changed by the disinfectant. This of course does not imply that the stumps cannot be cleaned with the agent. Patients with a history of eczema should be warned that the mixture may cause skin irritation.

Because of the positive reports from the amputees and the effect on skin bacteria we feel that the use of antiseptic agents to increase stump and socket hygiene is justified.

Acknowledgements

To the personnel of the Department of Microbiology at Karolinska Hospital laboratory and of the Department of Orthopaedic Surgery at Karonlinska Hospital who performed the routine work.

To the Centri Company who provided the antiseptic cloths needed for the investigation.

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Prosthetics and Orthotics International, 1989, 13, 152–155

Technical note

Standing pressure distribution for normal and below-knee amputee children

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**Alberta Children's Hospital, Calgary*

Abstract

Below-knee (BK) amputee children have a different morphology from normal children and amputees may thus have atypical limb loading during standing. The purpose of this investigation was to examine differences in standing ground-shoe pressure distribution between BK and normal children. A pressure plate was used to measure the ground-shoe weight distribution of three BK children and ten normal children during standing. Results indicated that the weight distribution between prosthetic and non-prosthetic limbs of BK children was not significantly different from the feet of normal children. The anterior-posterior weight distribution for the prosthetic and non-prosthetic feet was significantly different from that of the normal children. Further quantification of weight distribution and analysis of more subjects is necessary to determine the benefits, detriments, or irrelevance of these results.

Introduction

Significant periods of time are spent standing during day-to-day activity. This is neither a fatiguing task nor a potentially injurious task for children with two intact functional lower limbs. However, unilateral lower limb amputees have been forced to adapt to a new artificial morphology that may produce bone and joint abnormalities as an adult (Borgmann 1960; Burke et al. 1987; Hungerford & Cockin 1975; Radin et al. 1986; Radin et al. 1987).

The purpose of this investigation was to examine differences in standing ground-shoe pressure distribution between BK and normal children.

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Methods

Three unilateral BK amputee children and ten normal children volunteered as subjects for this study. These children ranged in age from 7 to 9 years. Each BK had a SACH foot as part of his/her prosthesis.

An EMED pressure system (cell areas 0.5 cm^2) was used to sample the ground-shoe pressure distribution at 20Hz for 1.55 sec, yielding 31 samples for each trial. The EMED pressure plate had a relative error of six percent. Three trials were carried out per subject. Each subject wore his/her own shoes and was told to "stand normally" within the boundaries of the pressure plate (19.6 cm by 33.6 cm).

The mean pressure of each cell was calculated from the 31 samples per trial. This mean pressure distribution trial was divided into areas for the right and left foot, and for a given foot, heel and forefoot areas. From the mean pressures, the total weight in each of the four areas was calculated. These weights for the BKs and normals were compared using one-way analysis of variance ($p<0.05$).

Results and discussion

Pressure plots

A typical pressure distribution plot for a normal subject is displayed in Figure 1. The vertical scale represents the amount of pressure recorded in a given cell. Pressures for this subject appear to be distributed evenly over both feet and between forefoot and heel areas. Figure 2 shows the mean pressure distribution plot for one BK subject trial. The pressures under the non-prosthetic heel were higher than

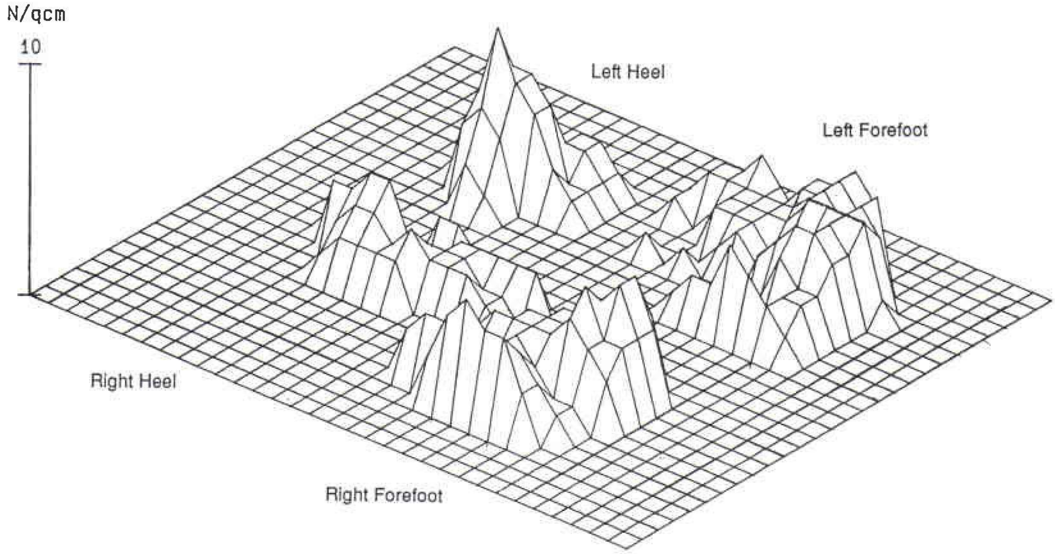

Fig. 1. Typical ground-shoe pressure plot for a normal child standing.

under the forefoot. Data for the prosthetic foot indicate all of the pressure was applied by the forefoot with no pressure being applied by any other part of the foot.

Weight distribution between feet

Ratios of the right and left foot area forces divided by the whole body weight (foot-body weight ratio) are presented in Figure 3. A foot-body weight ratio value greater than 50 percent for a given foot would indicate more weight was placed on that foot than on its counterpart.

Significantly more weight was placed on one foot for each normal and each BK subject.

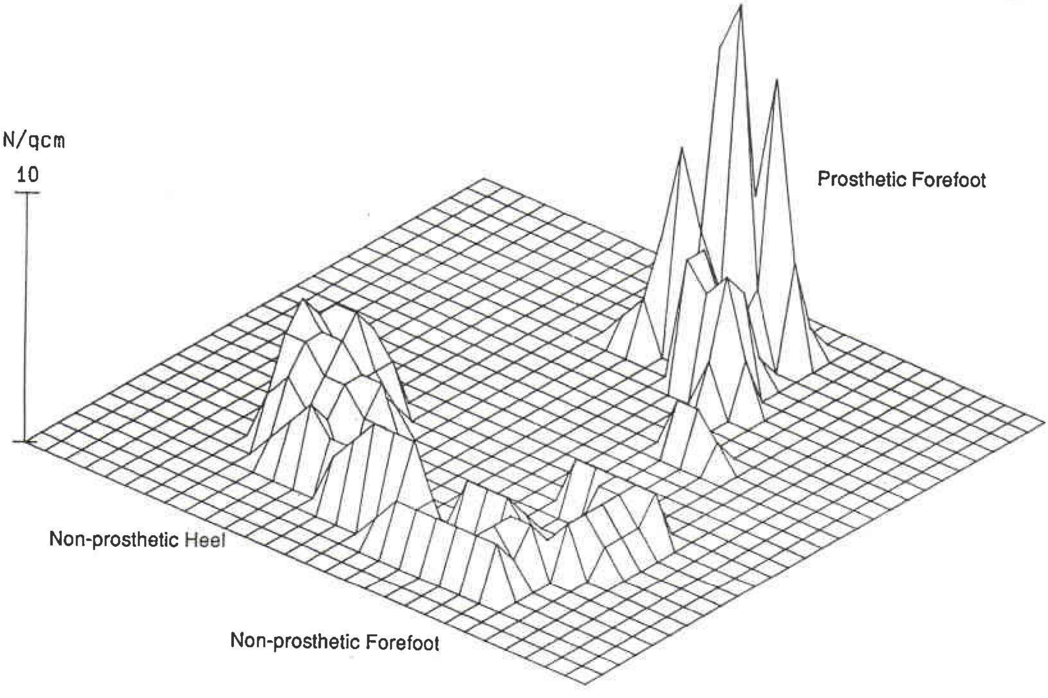

Fig. 2. Ground-shoe pressure plot for a below-knee (BK) amputee child standing.

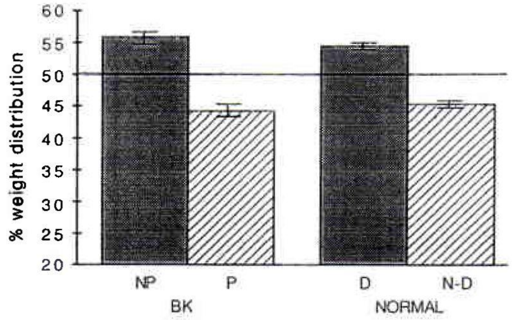

Fig. 3. Foot-body weight ratio for standing, placed on the dominant (D) and non-dominant (ND) foot for three BK (9 trials) and 10 normal (30 trials) children. The BK non-prosthetic (NP) foot is dominant and the prosthetic (P) foot is non-dominant. "I" bars are ± one standard error.

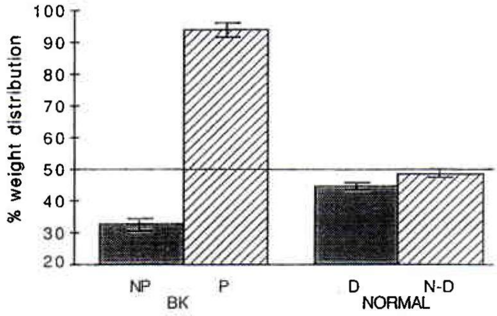

Fig. 4. Forefoot-whole foot weight ratio for standing, placed on the dominant (D) and non-dominant (ND) foot for three BK (9 trials) and 10 normal (30 trials) children. The BK non-prosthetic (NP) foot is dominant and the prosthetic (P) foot is non-dominant. "I" bars are ± one standard error.

Thus, based on the asymmetrical weight distribution between the feet of each subject (mean of three trials), a dominant and a non-dominant foot was declared (i.e., the foot with the larger values was classified as dominant). This grouping was found to be more descriptive than other possibilities. For example, if the normal children's right and left feet were combined in one group, there was a significant difference between the normals and both the prosthetic and non-prosthetic foot-body weight ratios of the BKs.

A comparison of the foot-body weight ratio between the BKs non-prosthetic limb (dominant leg) [55.8±4.9] and the normals dominant limb [54.6±0.95] produced no significant differences. There also was no significant difference between the BKs prosthetic (non-dominant) limb [44.2±4.9] and the normals non-dominant limb [45.4±0.95]. Therefore, the BKs weight distribution between feet was similar to the normal children.

The results of the present investigation differ slightly from the objectives listed in a prosthetic manual (New York University Medical Center, 1980) which proposes that the foot-body weight ratio should be 50 percent on each limb. Considering that no method of quantification of these loads is currently being utilized by the Calgary area prosthetists, their method of aligning the foot, with respect to the weight distribution between feet, appears reasonable.

Anterior-posterior weight distribution

Forefoot force divided by the whole foot force for a given foot, or a forefoot-whole foot ratio (similar to anterior-posterior weight distribution) is illustrated in Figure 4. A forefoot-whole foot ratio value of 50 percent would describe a case in which weight was evenly distributed between heel and forefoot areas, and a value greater than 50 percent would indicate that more weight was placed on the forefoot than on the heel.

Results for the normal subjects indicated they stood with significantly more weight on the heel area than on the forefoot area. There was no significant difference between the dominant and non-dominant foot for these subjects.

BK subjects placed significantly more weight on the non-prosthetic heel than normals placed on either of their feet. This result may be due to the high loads on the prosthetic forefoot of the BKs and could be analogous to results presented by Kirby et al. (1987). They stated that a normal person placing one foot forward (shifting that foot's centre of pressure (COP) forward) caused the COP on the other foot to shift posteriorly.

Results for the BKs are different from that stated in the prosthetics manual (1980). The present study found a forefoot-whole foot ratio in percentage of 33.0±3.6 (mean ±1 Std. Error) on the non-prosthetic foot and 94.2±3.7 on the prosthetic limb. The manual stated that 66.7 percent of the weight on the prosthesis should be on the forefoot. The pressure plate utilized in this investigation could be an aid to the prosthetists during prosthetic alignment to quantify the patients weight distribution during standing.

Interpretation

The differing results between normals and BKs, between the non-prosthetic and prosthetic feet of BKs, and between the forefoot and heel of the BKs raises two important issues. The first is that the asymmetrical loading patterns of the BK during standing may be a logical result of the morphological differences between the prosthetic and non-prosthetic limb. The differing morphology also produces intrafoot loading which is different from normal children. The second issue is that these asymmetrical loading patterns may be placing abnormally high loads on the joints of the lower extremities of these BK children. In either case, it is currently not known whether this type of loading is a detriment, a benefit, or of no concern in maintaining the skeletal integrity of the BK.

It may be desirable to develop a typical profile for BK children during standing to determine whether the results obtained in this investigation are characteristic of BK children in general. It may also be desirable to determine the reaction forces at the joints of the prosthetic and non-prosthetic limbs to gain insight into the relevance of the loading differences.

Conclusion

The results of this preliminary investigation warranted the following conclusions. The standing ground-shoe weight distribution for BK children between prosthetic and non-prosthetic limbs was not significantly different from the feet of normal children. The anterior-posterior weight distribution for the prosthetic and non-prosthetic feet was significantly different from that of the normal children. Further quantification of weight distribution and analysis of more subjects is necessary to determine the benefits, detriments or irrelevance of these results.

Acknowledgements

Funding provided by the Variety Club of Southern Alberta, Tent 61.

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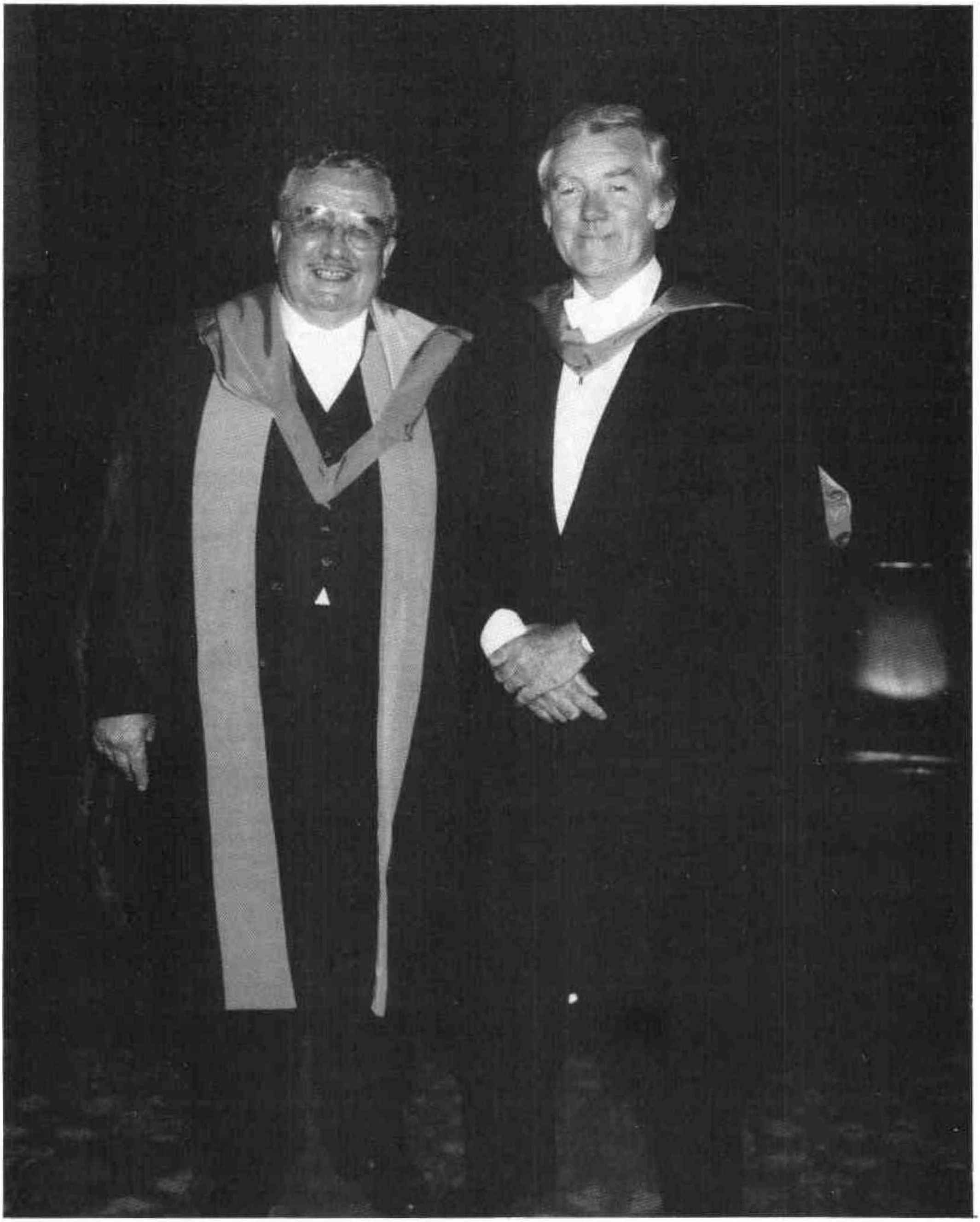
Honorary Degree for ISPO Past-President



The editors are pleased to announce the conferment of the Degree of Doctor of Science of the University of Strathclyde upon our past-President Professor George Murdoch.
The photograph shows Professor Murdoch following his graduation on 12th July, 1989 with, on his left, Professor John Hughes, Director of the National Centre for Education and Training in Prosthetics and Orthotics of the University of Strathclyde and at that time President of ISPO.

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Book Reviews

Amputation and Prosthetic Management of the Lower Extremity: Indications, Surgery, Postoperative Treatment, Prosthetic Management, Gait Training, Rehabilitation (Amputation und Prothesenversorgung der unteren Extremität: Indikationsstellung, Operative Technik, Nachbehandlung, Prothesenversorgung, Gangschulung, Rehabilitation)
R. Baumgartner and P. Botta
Stuttgart, Enke, 1989
ISBN 3–432–97501–5

As the title reveals amputation and prosthetic management of the lower extremity are dealt with in every respect on 303 pages by the two authors with the collaboration of Dieter Bellmann, Bruno Friemel, Bernhard Schievink, Gisela Trebes and Karl Türk — all very well known for their expertise in the field of amputation and prosthetics of the lower limb. The superb arrangement with 645 illustrations — 20 in colour — and 16 tables illustrates perfectly the written content of this book. The contents are clearly arranged in 8 major chapters such as etiology, level selection for amputation, amputation surgery, prosthetic management (including orthopaedic footwear), physical exercise and physiotherapy, stump problems and a short and very critical chapter on evaluation of results; a reference list of the international standard literature plus specific publications and an index complete and round off this book.

To this reviewer it seems less a textbook in the routine way than a very helpful and, especially for the already experienced, a readable compilation of partly very specific and individual solutions either for amputation surgery or prosthetic fitting, — illustrated by an impressive material of photographs and sketches for better understanding of the respective procedure. The vast experience of René Baumgartner in amputation surgery and, stump correction of dysvascular patients and the always innovative, even artistic production of highly functional as well as cosmetic prostheses by Pierre Botta, make the reading of this book an instructive delight and moreover an extraordinarily helpful source of reference for each member of the rehabilitation team dealing with amputation and treating amputees.

With this respect René Baumgartner's and Pierre Botta's book can be recommended very warmly and without any reservation to everybody looking for new ideas or even to enhance their own experiences in the management of lower limb amputation.

Priv.–Doz. Dr. med. G. Neff
Leiter der Abteilung Technische Orthopädie, Dysmelie und Rehabilitation
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der Freien Universität Berlin.

Comprehensive Management of the Upper-Limb Amputee.
Edited by Diane J. Atkins, Robert H. Meier III.
Springer-Verlag New York Inc.
252pp £48.50.

One is always wary of books which claim to deal comprehensively with their subject, but in this case the title is justified as this book manages to cover the whole treatment of the arm amputee without going into the more esoteric minutiae. There are good chapters on amputation level selection, therapy programmes and rehabilitation planning, together with excellent contributions on prosthetic training containing useful practical advice. The surgical options for the Brachial plexus injury are well described, as is the problem of pain and its treatment. The psychology of limb loss is explored and suggestions made for the assessment and treatment of the limb deficient child.

Inevitably, and properly, there is a full account of prosthetics in which technical data and some evaluation of the various externally powered hands and joints is provided, in addition to description of body powered components.

There are a few minor criticisms — the use of the phrase "congenital amputation", implying that a limb which was present has been lost before birth should not be applied to the transverse deficiences which are failures of formation. Again, this pedantic reviewer does not like the term "myoelectric prosthesis", when in fact the prosthesis incorporates an electrically powered hand which is myoelectrically controlled.

More important, it is unnecessary to repeat the technical descriptions of the same powered components in successive chapters, and to include three further chapters describing commercially available externally powered elbows.

This volume is recommended to all who are members of the clinic team involved with the rehabilitation of the upper limb amputee, providing that it is recognised as being an account of North American practice. Indeed it is a pity that, with the exception of two chapters from Germany and Sweden, both dealing only with the treatment of congenital limb deficiency, the editors have not achieved their stated aim of bringing together a variety of expert views from around the world.

H. J. B. Day,
Manchester, U.K.

Sport — and Overload Injuries from Running: The region of the Foot and Ankle
(Sport-und Oberlastungsschäden beim Lauf)
Dr. W. Schultz
C. Maurer Druck und Verlag

The steadily growing number of patients with foot injuries as a result of running and overload awakens a large interest in what can be done for this group.

In many cases the injuries are small and for this reason can be understood both by the sportsmen and physicians as a bagatelle. However, damage caused by repeated small injuries in many cases can be cumulative and result in serious consequences. The importance of taking care of all types of injuries to ensure an optimal therapy, including substitute sport activity and prophylaxis, is pointed out.

A large complexity of different elements govern the kind of injuries, and consequently the treatment and prophylaxis. It is an important value of the book that the author gives a systematic analysis of how the single elements influence the complex result.

The concise description of the functional anatomy of the foot and ankle complex gives a solid basis for understanding the role of the anatomical structure, especially related to load distribution and injuries.

The basis of injury analysis is further enlarged by the biomechanical description of running. The different phases of running and the professional terms related to them are clearly set out.

The presentation of the overload injuries are well arranged and ordered in groups around musculature, regions of the foot, ankle and knee. Information is also presented on bursitis, nerve compression syndromes and stress fractures. The description of the different types of injuries includes the pathogenesis, treatment and prophylaxis.

A special chapter takes care of treatment including general aspects, rehabilitation and rehabilitation training as well as prophylaxis. The description of treatment is well prepared to be applied by the practitioner in the daily clinical situation.

There is a separate chapter offered on running shoes. In addition to the general aspects and the listed specifications of the running shoes there is also a survey of the concepts of the different running shoe producers and a practical guide to the various shoe corrections. Each chapter has an adequate and up to date literature list.

The whole book is characterized by the interdisciplinary approach which makes it extremely useful for the reader regardless of his basic profession. One of the main values of the book is the method of presentation. The concisely presented material is structured in a well organized form supplemented with simplified, easily understood figures.

For the same reason it is also suitable as a reference book for physicians, physiotherapists, orthotists, orthopaedic bootmakers, sport trainers and other qualified interested people.

George Veres
Principal
National College of Prosthetics
Oslo, Norway.

Prosthetics and Orthotics International, 1989, 13, 159–161

International Newsletter
Autumn 1989

ISPO National Member Societies worldwide have been exceedingly active in presenting both broadly based and highly focused educational programmes to their members and others in the professional community.

Hong Kong National Society held its annual general meeting in January. In addition to electing Lee Kwing-yue as Chairman; Lee Yat-king Vice Chairman and Kwan Hung-hei Secretary-Treasurer, members discussed scientific papers concerned with prosthetic and orthotic service in Hong Kong, as well as a polypropylene socket for hip disarticulation prostheses; temporary prosthetic sockets using low-temperature thermoplastic materials; and prosthetic-orthotic training and education in Hong Kong. The society continues to co-sponsor seminars with the Hong Kong Prosthetic-Orthotic Association.

Australian National Member Society co-sponsored with the Department of Veterans' Affairs and the Australian College of Rehabilitation Medicine the Annual Scientific Meeting in August. David N. Condie, engineer at the Dundee Limb Fitting Centre, Dundee, Scotland, and M. Elizabeth Condie, physical therapist at the National Centre for Training and Education in Prosthetics and Orthotics, University of Strathclyde, Glasgow were the overseas speakers who joined 31 national speakers for an intensive, widely ranging programme. Several papers explored the biomechanical basis and clinical application of gait analysis in prosthetics and orthotics, with speakers including David Condie, Wendy Hubbard, Bill Contoyannis, and Rowan English. Lower-limb prosthetics received attention from Lorraine Jones, Wendy Hubbard, David Wilson-Brown, Susan Hull and Marcus Fahrer. Discussants concerned with congenital amputation were Anthony Lipson, P. H. Hopkins and W. Marsden. Lower-limb orthotics focused on paraplegic care, with papers by David Condie, Robert Cole, and M. McKenzie. There followed presentations on fracture bracing by A. A. von der Borch, a new knee joint by Bernard Silberstein, post-polio mobility aids by W. E. Fisher, Legg-Perthes orthosis by William Goldthorpe, Scottish Rite orthosis by Andrew Cox, management of talipes equinovarus by Jane Griffith, and three papers on upper-limb orthoses by Wilma Walsh, Sapna Lazarus, and Bodil Hutsbo. The Sydney, New South Wales meeting was preceded by a full day Workshop on Lower Extremity Orthotics conducted by David and Elizabeth Condie. Current officers of the Australian National Member Society are Chairman W. G. Doig, Chairman-Elect Adrian von der Borch, Vice Chairman George Carter, Secretary Valma Angliss, Treasurer Martin Masson, Committee Members Jean Halcrow, Jan Griffith, Michael O'Toole, and Belle Davis, and representatives to the International Committee Valma Angliss and W. G. Doig. Future plans include a five day course on upper extremity prosthetics, May 21-25, 1990 in Melbourne co-sponsored with the Department of Veterans' Affairs, and participation in the triennial congress of the World Federation of Occupational Therapists, April 2-6, 1990 also in Melbourne.

United States National Member Society, in collaboration with the Texas Chapter of the American Academy of Orthotists and Prosthetists, sponsored a seminar, Before 911: Emergency Medical Management for the Health Care Practitioner, in August, in Houston, Texas. The programme focused on proper procedures to deal quickly and efficiently with patients with infectious diseases, unexpected trauma, and sudden life threatening conditions. The programme was coordinated by ISPO Executive Board member Diane Atkins, and featured Edward Septimus who spoke on infectious diseases and acquired immune deficiency syndrome; Marni Bonnin who outlined life threatening events and on the scene emergencies; John Van Reig who described cardiopulmonary resuscitation, seizures and diabetic shock; Thomas Sartwell and colleagues who addressed medico-legal considerations so that clinicians might understand the basics of law in the event of malpractice litigation.

The association now has an official office and telephone number, through the generous cooperation of the Orthotics and Prosthetics National Office. The new address is 717 Pendleton Street, Alexandria, Virginia 22314, and the telephone number is (703) 836-3858.

Representatives met in Washington to promote prosthetics and orthotics in developing countries. The purpose of the meeting was to facilitate response to clinical needs from Central and South America because most professional workers do not know what programmes exist and therefore cannot respond to requests for help from abroad or volunteer their services readily. Existing programmes were described by representatives from the Health Volunteers Overseas, World Rehabilitation Fund, Rehabilitation International, Pan American Health Organization, Partners in the Americas, United Nations International Children's Emergency Fund, Pan American Development Foundation, and the Hesperian Foundation. Representatives of organizations having professional interest in prosthetics and orthotics included those from the Association for the Advancement of Rehabilitation Technology, Veterans Administration, American Academy of Orthotists and Prosthetists, National Institute on Disability and Rehabilitation Research, and the National Association, Prosthetic and Orthotic Educators.

The Annual Meeting of the association will be held in conjunction with the annual scientific meeting of the American Academy of Orthotists and Prosthetists in January 1990 in Phoenix, Arizona. In April 1990, members will be active in the fourth biennial Pacific Rim Prosthetic/Orthotic Conference in Kohala, Hawaii.

Joan Edelstein
Editor

Addendum — United Kingdom National Member Society

In the course of the last three years ISPO UK NMS has held three successful Scientific Meetings: in the University of York 1987, the University of Bath 1988 and the University of Nottingham 1989. These meetings are well attended by both members and non-members and are the focal point of membership in our Society.

We have been grateful to BLESMA, the British Limbless Ex Servicemen Association, for the donation of two prizes for the best scientific paper at these meetings.

A Newsletter has been produced twice a year by David Condie, who has managed to combine the duties of Chairmanship with that of the role of Newsletter Editor. This excellent publication provides information and news of activities in the UK. It is a much valued addition to membership of the UK Society.

The Scientific Sub-Committee, under the Chairmanship of Roy Nelham, has provided programmes and organization for our Scientific Meetings. This is a most hard working and effective Committee who have also considered means of broadening the scope of our scientific activities by additional meetings.

In 1988 a symposium was held with the Biological Engineering Society on the Biomechanics and Orthotic Management of the Foot, and ISPO was also associated with the International Conference on Wheelchairs and Special Seating at Dundee.

A Report on the Study of the Orthotic Services by the National Health Service Management Consultancy Service was sent to ISPO for comment and a detailed reply was submitted; broadly welcoming the report but with several points of criticism. The action on the report has not so far been published but we await it with interest.

A drive was made to recruit more sponsoring members with limited success. A new initiative will be taken for 1990. In 1991 the UK NMS is to hold a joint meeting in Nottingham with the Netherlands NMS and we are all looking forward to this occasion.

Our Committee sought active sponsorship for travelling bursaries to the Kobe World Congress. Robin Platts, our Secretary, was particularly successful in his quest and we were able to grant seven bursaries of £1000, including two provided by the UK Society.

Representatives of ISPO UK NMS continue to make substantial contributions to the activities of a number of important national and international committees with functions pertinent to ISPO. These include the British Standards Institute (BSI) and the International Standards Organization (ISO).

Much debate has taken place both in and out of the Committee relating to ISPO International. Our Member Society is an enthusiastic supporter of the concept and activities of ISPO International but believe that, as the Society progresses, a regular review of the constitution should take place. We have made several suggestions relating to this subject and look forward to the debate that will follow.

Our Chairman, David Condie, has led the UK NMS in a most impressive manner. His precise running of Scientific Meetings, where his ever present leadership qualities were backed up by informed and well thought out comment, has been clearly visible. His committee work has been similar and any member will tell you that by the end of one of David's energetic meetings, their stamina has been severely tested. We will miss him as Chairman but appreciate all the hard work he has covered on our behalf.

What of the future? Our next Annual Scientific Meeting is to be held at Queen Margaret College, Edinburgh on the 4th-6th April 1990, and on the 10th-12th April 1991 a meeting is to be held in Norwich in conjunction with the Netherlands. We have plans to try and create a regional programme, and progress our initiatives on twinning proposals. It is hoped to publish a register of UK establishments involved in research, development and evaluation. I look forward to the next three years with interest and the opportunity to meet members of the Society both National and International.

Colin Peacock
Chairman — UK NMS

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Calendar of events

National Centre for Training and Education in Prosthetics and Orthotics
Short Term Courses 1990

Courses for Physicians, Surgeons and Therapists

NC511 Clinical Gait Analysis; 17-19 January, 1990
NC502 Upper Limb Prosthetics and Orthotics; 22-26 January, 1990
NC510 Wheelchairs; 7-9 February, 1990
NC506 Fracture Bracing; 3rd–7th September, 1990 (also suitable for orthotists and plaster technicians).

Course for Orthotists and Therapists

NC217 Ankle-Foot-Orthoses for the Management of the Cerebral Palsy Child; 26th February–2nd March, 1990.

Further information may be obtained by contacting Prof. J. Hughes, Director, National Centre for Training and Education in Prosthetics and Orthotics, University of Strathclyde, Curran Building, 131 St. James' Road, Glasgow G4 0LS, Scotland. Tel: 041-552 4400 ext. 3298.

North Western University Medical School
Short Term Courses 1990

Course for Physicians, Surgeons and Therapists

603C Lower and Upper Limb Prosthetics; 5-9 March, 1990

Courses for Physicians and Surgeons

703B Spinal, Upper and Lower Limb Orthotics; 2-6 April, 1990
603D Lower and Upper Limb Prosthetics; 9-13 April, 1990
603E Lower and Upper Limb Prosthetics; 30 April-4 May, 1990

Further information may be obtained by contacting Michael D. Brncick, Director, Prosthetic-Orthotic Center, North Western University, 345 East Superior St., Room 1723, Chicago, Illinois 60611, USA. Tel: (312) 908-8006.

New York University Medical School
Short Term Courses 1990

Courses for Physicians, Surgeons and Therapists

741B Lower Limb Prosthetics; 26 February-2 March, 1990
751B Lower Limb and Spinal Orthotics; 5-9 March, 1990
744A Upper Limb Prosthetics and Orthotics; 2-6 April, 1990
741C Lower Limb Prosthetics; 23-27 April, 1990
751C Lower Limb and Spinal Orthotics; 30 April-4 May, 1990
754A Foot Orthotics; 17-18 May, 1990 (also suitable for orthotists)

Further information may be obtained by contacting Ms. Sandy Kern, Registrar, Prosthetics and Orthotics, New York University Post-Graduate Medical School, 317 E. 34th St., New York, NY 10016, USA. Tel: (212) 340-6686.

22–28 January, 1990
American Academy of Orthotists and Prosthetists Annual Meeting and Scientific Symposium, Phoenix, USA.
Information: AAOP, 717 Pendelton St., Alexandria, VA 22314, USA.

1–4 February, 1990
Combined Sections Meeting of the American Physical Therapy Association, New Orleans, U.S.A.
Information: Information Dept., APTA, 1111 N. Fairfax St., Alexandria, VA 22314, U.S.A.

8–13 February, 1990
American Academy of Orthopaedic Surgeons Annual Meeting, New Orleans, U.S.A.
Information: AAOS, 222 South Prospect, Park Ridge, IL 60068, U.S.A.

13 February, 1990
CAD/CAM in Orthopaedics, Engineering and Medicine Group, I.MECH.E.
Information: Miss I. Raivadera, Manufacturing and Technology Support, The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, SW1H 9JJ.

15–17 February, 1990
6th International Seating Symposium, Vancouver, Canada.
Information: Seating Symposium, 105-2194 Health Sciences Mall, U. of British Columbia, Vancouver, British Columbia V6T1W5, Canada.

10 March, 1990
Annual Scientific Meeting of the Association of Prosthetists and Orthotists, Stirling, Scotland.
Information: Mr Gordon Watters, Orthotic Centre, Stracathro Hospital, Brechin, Angus, Scotland.

26–30 March, 1990
ACOPA "90" Congress. First Central American Multidisciplinary Orthotic and Prosthetic Congress, Coribici Hotel, San Jose, Costa Rica.
Information: John G. Craig, C.P.O., President, Texas Chapter A.A.O.P., 3600 Galston Avenue 123 Dallas, Texas 75246.

30–31 March, 1990
9th Annual Meeting of the European Pediatric Orthopaedic Society, Athens, Greece.
Information: Henri Bensahel, Hopital Robert Debre, 48 Boulevard Serurier, 75019 Paris, France.

April, 1990
British Orthopaedic Association Scientific Meeting, Glasgow, Scotland.
Information: BOA, 35-43 Lincoln's Inn Fields, London WC2A 3PN, England.

1–6 April, 1990
6th World Congress on Pain, Adelaide, Australia.
Information: L. Jones, International Association for the Study of Pain, 909 NE 43rd St., Suite 306, Seattle, Washington 98105-6020, U.S.A.

2–6 April, 1990
W.F.O.T. 10th World Congress, Melbourne, Australia.
Information: W.F.O.T. 10th World Congress Secretariat, 1st Floor, 387 Malvern Rd., South Yarra, Victoria, 3141, Australia.

4–6 April, 1990
ISPO UK Annual Scientific Meeting, Edinburgh, Scotland.
Information: Dr. D. J. Pratt, ISPO Edinburgh 1990, Orthotic and Disability Research Centre, Derbyshire Royal Infirmary, London Rd., Derby DE1 2QY, England.

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