The Journal of the International Society for Prosthetics and Orthotics

Prosthetics and Orthotics International

August 1992, Vol. 16, No. 2

Prosthetics and Orthotics International

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ISPO

Editorial

A tremendous amount of work has gone into developing and promoting the Seventh World Congress of the International Society for Prosthetics and Orthotics. The response from scientific and commercial contributors has surpassed all our expectations. Almost 200 hours of educational material were presented. One hundred and twenty exhibitors, occupying two hundred and twenty-six booths presented the latest in technology and scientific advancement. Participants could view the current state-of-the-art and also experience first hand the future of prosthetics, orthotics and rehabilitation engineering.

Important also to any international meeting is the opportunity for participants to experience the cultures of the host country. Chicago is an international city with all the ethnic and national groups represented. This was experienced with "The Taste of Chicago" event and the American Fourth of July Celebration. Participants had the opportunity to experience American baseball, the architecture of Chicago, and its world class museums. Entertainment included an opening reception sponsored by the Orthotics and Prosthetics National Office, The American Academy of Orthotists and Prosthetists, the American Orthotic Prosthetic Association, and the American Board for Certification in Orthotics and Prosthetics teamed up to sponsor the opening reception and gave all participants the opportunity to experience America at play.

Sports in America play an important part in separating our professional lives from our private lives, and we hope all enjoyed this fun filled evening. During the Congress, participants also had the opportunity to hear America's music. Heartland Night gave everyone an opportunity to experience an earlier form of American entertainment. American gospel music presented one of our religious cultures and the beauty of this unique style of music.

The Open House and reception at the Rehabilitation Institute of Chicago gave each of the members of the rehabilitation team an opportunity to meet with their colleagues in the RIC's outstanding facilities.

A lot of work goes into planning a World Congress. Dr. Dudley Childress was hard at work for more than three years pulling this Congress together. He and his staff deserve appreciation and thanks from all of us.

Work has already begun with planning the Eighth World Congress in Melbourne, Australia, April 2–7, 1995. The Australian National Member Society will serve as our host, and Valma Angliss will serve as Secretary General. Our colleagues "down-under" are already hard at work. It is not too early to mark your calender for this important international event, April 2–7, 1995. Each Congress builds upon the experience of previous Congresses, and the Australians want us to see and hear the latest prosthetics, and orthotics and rehabilitation engineering developments, plus they hope we all take the opportunity to explore their great country.

The ISPO Executive Board and I are looking forward to these next three years and the Eighth World Congress. We will endeavour to ensure the continued growth of the society and to work toward the removal of the barriers that prevent the physically challenged from assuming their rightful place in society.

Melvin L. Stills
President

Prosthetics and Orthotics International, 1992, 16, 80–81

Seventh Triennial Assembly 1992

Norman A. Jacobs
Honorary Secretary, ISPO

The Seventh Triennial Assembly of the International Society for Prosthetics and Orthotics was held on Friday, 3rd July, 1992, in Chicago, USA, at the time of the World Congress.

Before opening the Assembly, the President, Willem H. Eisma, announced that the Brian Blatchford Prize would not be awarded this triennium as no suitable application was made. New criteria for award of the prize were being discussed with the Blatchford family and will be announced in due course.

The President also announced the winners of the Forchheimer Prize Paper award, H. W. L. van Jaarsveld, H. J. Grootenboer, J. de Vries and H. F. T. M. Koopman for their paper entitled "Stiffness and hysteresis properties of some prosthetic feet" which appeared in ***Prosthetics and Orthotics International*** in August 1990. John Hughes presented a cheque for SEK 10,000 on behalf of the Forchheimer family to J. J. Grootenboer who addressed the assembly outlining the work of his department.

The President then formally opened the Seventh Triennial Assembly and presented his report. He particularly thanked the Executive Board Members and Task Officers who had given him much support during his Triennium as President.

The Honorary Secretary summarised the changes to the Constitution. The proposed amendments had been published in ***Prosthetics and Orthotics International*** for comment by the membership and had been duly discussed and voted on by the International Committee at their meeting held prior to the Congress. The changes to the Constitution are as follows:

Original Clause	New Clause
3.1.2 The ISPO may supply affiliated societies or groups with certain publications which in the opinion of the ISPO Secretariat are appropriate for distribution among those members of the society or group who are not Members or Fellows of ISPO. Such distribution will be made at the expense of the respective society or group, unless the society or group in question has given due notice to the Secretariat that it waives to receive certain publications to be further specified in the said notice.	DELETE
4.2.2 Persons on the International Committee will each have a 3-year term being eligible for re-election but may not serve more than six consecutive years with members taking office only at the conclusion of a Triennial Assembly. The International Committee will meet at least once every three years just prior to the Assembly meeting. The President may call an additional meeting of the International Committee at his discretion.	**4.2.2** Persons on the International Committee will each have a 3-year term being eligible for re-election with members taking office only at the conclusion of a Triennial Assembly. The International Committee will meet at least once every three years just prior to the Assembly meeting. The President may call an additional meeting of the International Committee at his discretion.
4.3.1 The Executive Board will consist of the President, the President-Elect, two Vice-Presidents, and four other Fellows of ISPO. The Honorary Secretary, the Treasurer, all Past-Presidents and all Standing Committee Chairmen join the Executive Board as non-voting members. The President, with majority approval of the Board, may appoint non-voting consultants to the Board.	**4.3.1** The Executive Board will consist of the President, the President-Elect, two Vice-Presidents, and four other Fellows of ISPO. The Honorary Secretary, the Honorary Treasurer, the Immediate Past-President and all Standing Committee Chairmen join the Executive Board as non-voting members. The President, with majority approval of the Board, may appoint non-voting consultants to the Board.
4.4.1 The officers shall be the President, the Immediate Past-President, the President-Elect, two Vice-Presidents, the Honorary Secretary and the Treasurer. The responsibilities of the Officers, the terms of office and the manner of election or appointment will be as specified in these By-laws.	**4.4.1** The officers shall be the President, the Immediate Past-President, the President-Elect, two Vice-Presidents, the Honorary Secretary and the Honorary Treasurer. The responsibilities of the Officers, the terms of office and the manner of election or appointment will be as specified in these By-laws.

4.4.5.1 He shall be responsible for arrangements for all Executive Board and International Committee meetings including preparation of agenda and publication of these to all members of the Board or the International Committee. At least two months notice of such meetings shall be given where possible.	**4.4.5.1** The Honorary Secretary shall be responsible for arrangements for all Executive Board and International Committee meetings including preparation of agenda and publication of these to all members of the Board or the International Committee. At least two months notice of such meetings shall be given where possible.
4.4.6 The Treasurer (normally with the assistance of the Executive Officer) and under the direction of the President shall have general supervision of the fiscal affairs of the ISPO and shall be responsible for the keeping of accounts thereof and any other record required by law.	**4.4.6** The Honorary Treasurer (normally with the assistance of the Executive Officer) and under the direction of the President shall have general supervision of the fiscal affairs of the ISPO and shall be responsible for the keeping of accounts thereof and any other record required by law.
4.5.5 The Protocol and Nominations Committee shall comprise the President, the Past Presidents, the President-Elect, two Fellows from the membership at large, the Honorary Secretary (ex-officio).	**4.5.5** The Protocol and Nominations Committee shall comprise the President, the immediate Past-President, the President-Elect, two Fellows from the membership at large, the Honorary Secretary (ex offico) and up to two Past-Presidents nominated by the President.
6.1 The President, the Honorary Secretary and the Treasurer shall each have individual authority to commit the Society to obligations of funds within the budget approved by the Board in accordance with paragraph 4.5.4.2 of these By-laws. Standing Committee chairmen shall be entitled to commit funds made available to their committees by the Executive Board or obtained from outside sources.	**6.1** The President, the Honorary Secretary and the Honorary Treasurer shall each have individual authority to commit the Society to obligations of funds within the budget approved by the Board in accordance with paragraph 4.5.4.2 of these By-laws. Standing Committee chairman shall be entitled to commit funds made available to their committees by the Executive Board or obtained from outside sources.

The President thanked the Members of the Executive Board who were rotating off the Board: Valma Angliss, Sepp Heim and Acke Jernberger. In particular he thanked the Past Presidents, George Murdoch, Erik Lyquist and John Hughes, for all the efforts and hard work they had made on behalf of the Society and all the achievements that they had accomplished. He then handed over the Presidency to Melvin L. Stills who assumed the Chair.

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:	Melvin L. Stills	U.S.A.
President-Elect:	Seishi Sawamura	Japan
Vice-Presidents:	Per Christiansen	Denmark
	Jean Vaucher	Switzerland
Members:	Hans Arendzen	Netherlands
	David N. Condie	U.K.
	Thamrongrat Keokarn	Thailand
	Harold Shangali	Tanzania
Immediate Past President:	Willem H. Eisma	Netherlands
Honorary Treasurer:	J. Steen Jensen	Denmark
Honorary Secretary:	Norman A. Jacobs	U.K.

Valma Angliss made a presentation informing the Assembly of the Eighth World Congress which will be held in Melbourne, Australia, from 2nd–7th April, 1995.

Dudley Childress, the Secretary General of the Seventh World Congress, thanked all the participants and his colleagues on the organising committees for making the Congress such a successful and stimulating event. He outlined the difficulties of organising such a large Congress. Being a man of many talents he then exhibited his skills as a juggler, explaining that organising a Congress was similar to juggling, the secret being to keep all the balls in the air at the same time.

The ISPO flag was then passed to Valma Angliss to be displayed at the Eighth World Congress in Melbourne.

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

Prosthetics and Orthotics International, 1992, 16, 82–87

President's Report

WILLEM H. EISMA

It is my great pleasure to present the report of the Society's activities of the past three years.

During this period, the Society has consolidated its position, it has steadily grown in size, and its influence both at national and international levels has increased. The membership of the Society has increased over the triennium from 2,300 to 2,500 which excludes subscribers to "Prosthetics and Orthotics International" whose number has increased from 368 to 412 over the same period. The Society now has members in 69 different countries which includes 22 strong and active National and Regional Member Societies. I am delighted to report that this growth has been accompanied by the establishment of new National Member Societies in Finland and Pakistan and a new Regional Member Society in the Caribbean. 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. I am delighted to announce that John Hughes had been elected as Honorary Fellow recognising the outstanding contributions that he has made to the Society and to prosthetics, orthotics and rehabilitation engineering in general. In addition, Fellowship has been conferred on A. Starkhammar, M. Wall, J. Halcrow, M. Le Blanc, B. P. McClellan, D. Childress, R. W. Spiers, D. J. Atkins, M. Schuch, J. Michael, T. Aoyama, Y. Ehara, F. Endo, H. Furukawa, Y. Hatsuyama, I. Kawamura, S. Morimoto, S. Nakajima, E. Sukizono, K. Takami, O. Tanaka, S. Tanaka, E. Tazawa, E. Watanabe and M. Fahrer.

During this triennium, discussions have taken place between the Executive Board and the International Committee which has a prominent role to play in our Society. Prior to the World Congress in Kobe, 1989, a meeting was held and the major outcome was the establishment of a joint International Committee/Executive Board Working Group under the chairmanship of John Hughes to examine the following:

- ways in which there could be greater involvement of National Member Societies in the decision making process;
- the provision of better information to National Member Societies and the membership at large about international activities;
- the system of election of the Executive Board.

The representatives of the International Committee were: J. H. Arendzen (the Netherlands), D. N. Condie (U.K.) and J. Edelstein (U.S.A). The Executive Board representatives were: the President, J. Hughes and S. Heim. The International Committee/ Executive Board Working Group met again prior to the Executive Board Meeting in Rome in April 1990. The Working Group decided to report with its proposals to the Executive Board and the International Committee in the summer of 1991. The report was presented to the Executive Board in January 1991 and circulated to the International Committee through the National Member Societies. The major recommendation of the Working Group was to hold an interim meeting of the International Committee Representatives and the Executive Board. The Executive Board endorsed the need to hold such a meeting within 1991. The main points which would be discussed at this meeting would include the report of the Working Group, ISPO Policy and the Slate of Nominations for the new Executive Board.

The Executive Board finanlised the paper on ISPO Policy and Activities and sent it to the National Member Societies. The Honorary Secretary wrote to National Member Societies with the report of the Working Group and also the draft agenda. Because of the low level of response the Honorary Secretary wrote again to

National Member Societies and indicated that in view of the high costs involved and the low response the Executive Board felt it irresponsible to go ahead with the meeting without first seeking the views of the National Member Societies as to whether or not the meeting should take place.

A minority responded positively and as a consequence the arrangements had to be cancelled. After this the decision was made to organise a two day meeting of the International Committee prior to the World Congress in Chicago. This will be a very important meeting where policy and current and future activities of the Society will be discussed.

The Society has been very successful in organising a whole series of meetings of a widely varying nature. The World Congresses continue to be a major focal point of the Society when large numbers of our members from many different parts of the world get together and exchange ideas and views on many different topics. My Presidency started at the Sixth World Congress in Kobe, the congress which was outstandingly successful by any measure, under the able direction of Secretary-General, Seishi Sawamura. There is no doubt that the Chicago Congress, under the leadership of Dudley Childress, shows promise of matching the success of its predecessor. This coming congress in Chicago will have a wide ranging, well planned and innovative scientific programme, a comprehensive commercial and scientific exhibition and a very attractive full social programme in close connection with the 500th anniversary of Columbus' voyage to the Americas.

Beyond that we are already in preparation for the Australian Congress of 1995 under the experienced guidance of Secretary-General Valma Angliss. We are looking forward to attending a World Congress on another continent of the world, Australia. It must be reported again that the problems relating to the 1980 Bologna Congress have still to be resolved due to delays in the Italian Courts. It is a pity to report that there has been no progress with regard judgement in this case. We must wait 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 was a meeting of the World Health Organization (WHO) Consultation in Training of Personnel in Developing Countries for Prosthetics and Orthotics, in June 1990. The meeting was held in Alexandria, Egypt and attended by John Hughes and Sepp Heim. The meeting was productive and encompassed ISPO philosophy on education and training in developing countries as well as using ISPO reports as base documents for discussions. The meeting focused on the problems of poliomyelitis and a major outcome was a proposal to develop courses for prosthetics and orthotics assistants who would be trained to the same level as orthopaedic technologists but limited to either prosthetics or orthotics. As a result of the meeting in Alexandria a further meeting was held in Copenhagen in January 1991. This meeting was attended by representatives of the Society, WHO, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and the Tanzanian Training Centre for Orthopaedic Technologists (TATCOT). As a result a proposal to establish a one year course in Lower Limb Orthotic Technology was put to WHO and the Tanzanian Ministry of Health for support. It is a great pleasure to report that approval has now been given by WHO and the Ministry of Health.

The Society is now also examining and preparing a proposal for a one year course in Lower Limb Prosthetic Technology.

In the same year a very important meeting was held at the University of Strathclyde in Glasgow, Scotland from 1–5 October 1990. The Conference critically examined literature related to amputation surgery published over the past 20 years with a view to identifying the best amputation techniques currently available. Literature on each level of amputation had been thoroughly scrutinised by a team comprising a surgeon and a prosthetist who reported their findings to the workshop. The reports and subsequent discussions were of a very high standard and a report of that meeting is finished and available. This report is in my opinion a real mile-stone in the history of ISPO. The report is dedicated to the late Dr. Marian Weiss. This very successful Conference was organised by our Past-President, George Murdoch and A. Bennett Wilson Jr. Local organisers were the Immediate Past-President John Hughes and the Honorary Secretary

Norman Jacobs. It was the Society's will and philosophy to distribute the knowledge of this Consensus Conference as soon as possible to all parts of the world. A planned course in Tunisia, summer 1991, had to be cancelled due to the Gulf crisis. But it is with great pleasure that I can report that the first Up-date Course on Lower Limb Amputations and Related Prosthetics was held at the University of Groningen, in the Netherlands. The Conference was very successful and attended by members from Western Europe and also the Caribbean and it was evident that the participants were really the target group which we have to address. There were mostly teams of medical doctors and prosthetists. Course organisers were George Murdoch and Steen Jensen. Local organisers were a team of members of my department of the University Hospital Groningen.

It is the intention to hold further courses on this theme in Tanzania this autumn and possibly in January 1993 in Bangkok. Other courses are planned in Eastern Europe and Central or South America.

Unfortunately the Foot and Shoe Seminar which was planned to be held in Jönkoping in Sweden in June 1991 had to be cancelled due to lack of support.

The Society was also in this triennium very active, participating in other meetings with institutions and organisations. More and more the Society's involvement is invited to such meetings to bring in its philosophy and contributions.

The following meetings have taken place with the participation of our Society:

- Eleventh International Congress of INTERBOR in close co-operation with ISPO, 28 April – 1 May 1990, Rome, Italy.
- European Conference on Rehabilitation Technology (ECART) in November 1990, Maastricht, the Netherlands. John Hughes represented the Society on the Scientific Committee, the President on the Organising Committee. The next conference will be held in Sweden, 1993.
- Dundee '91 – Orthotics, an International Conference and Instructional Course, 16 – 20 September 1991, Dundee, Scotland. This was a successful and important meeting under the chairmanship of David Condie, just as successful as its predecessors Dundee '85 and Dundee '88.

As President of ISPO I was invited on several occasions to attend meetings, conferences and congresses to represent the Society in different ways. Sometimes this was a role in the opening ceremony, plenary sessions or specified parts where ISPO could fulfil a task.

The strength and value of all these meetings lies in their multidisciplinary nature which is the unique feature of our Society in the international area.

The Society has continued to further its relationship with international and national bodies. Co-operation with INTERBOR is again much closer as a result of reciprocal representation on both Boards and as a result of the ISPO/INTERBOR Joint Education Committee which has the purpose of examining the implications of the Open European Market in 1992 for the prosthetics and orthotics profession. A report was sent to Brussels after a pilot study which was supported by ERASMUS, a Bureau of the European Community concerned with education. Although this report and study is directed to Europe, the outcome of this work will inevitably be useful and relevant right across the international scene. Our Immediate Past-President, John Hughes, represented our Society on INTERBOR's Board and he was, as Task Officer for Education, also the chairman of the Joint Committee. Discussions are underway with INTERBOR to put forward a project proposal on CAD-CAM Evaluation as part of the European Community Programme, Technology Initiative for Disabled and Elderly People (TIDE). It's anticipated that a second bid will be made with ISPO and INTERBOR as full partners.

There is an excellent co-operation with the World Health Organization (WHO). The society has established a working relationship with WHO and has applied for official relations in July 1992. The last meeting took place in May 1992 in Geneva. I have already mentioned the important meeting with WHO in Alexandria, Egypt, and its consequences.

ISPO's foundation was in the International Committee on Prosthetics and Orthotics, a Standing Commission of the International Society for Rehabilitation of the Disabled, the forerunner of Rehabilitation International

(RI). Ever since its formation, ISPO also has remained a member of RI and from time to time has participated in its regional and international congresses. In the recent years the Society has organised sessions in prosthetics and orthotics at the following RI congresses:

- The Fifth European Regional Congress, May 1990 at Dublin, Ireland, where I represented the Society in a plenary session and the Honorary Secretary, Margaret Ellis and I presented an ISPO session with other members of RI.
- The Ninth Asia and Pacific Regional Conference in October 1990 where our consultant for Asia, Seishi Sawamura and Thamrongat Keokarn participated and organised an ISPO session.
- ICTA. Margaret Ellis has represented the Society at the last meeting of ICTA, the International Commission on Technical Aids, a commission of RI.

As far as the United Nations is concerned, we have our Official Representatives to this international agency. The Honorary Secretary, Sepp Heim and Jean Vaucher represent the Society in the Geneva and Vienna Offices and the President-Elect Mel Stills and Joan Edelstein represent the Society in the New York Office.

The Society from time to time has attended a number of meetings from non-governmental organisations associated with the Centre for Social Development and Humanitarian Affairs (CSDHA), the latest of these being held in December 1990 and 1991 in Vienna, Austria. The Society is also a member of the International Committee on Disability (ICOD) a full consultant body to the United Nations. The Society attended their latest meeting in December 1990, Vienna, Austria.

In September 1991 the President and the Honorary Secretary had a meeting with the President of the World Rehabilitation Fund and his consultants. We are looking forward to a closer co-operation and a reciprocal attendance at each other's Board meetings. In addition the Society remains in contact with the Internationaler Verband der Orthopädie Schuhtechnik (IVO), the World Orthopaedic Concern (WOC), the International Committee of the Red Cross (ICRC) and the International Labour Organization (ILO), amongst others and is attempting to establish stronger links with them. 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 and conferences which we have organised 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 an advanced stage of publication:

- 1989: Directory of Officers and Members. Compiled by A. A. Larsson.
- 1990: CAD-CAM in Prosthetics and Orthotics. Report of an ISPO Workshop, Seattle, USA. Edited by R. M. Davies, R. G. Donovan, R. W. Spiers.
- Prosthetics and Orthotics International.
  - April 1991: Special Supplement on Wheelchairs. Edited by G. Bardsley.
  - December 1991: Special Supplement on Seating. Edited by G. Bardsley. Both supplements are drawn from material presented at "Dundee '88" an International Conference on Wheelchairs and Seating.
  - August 1991: Special Issue on the Limb Deficient Child. Edited by H. J. B. Day. Drawn from material of the Heidelberg Symposium 1988 and dedicated to Prof. Dr. Ernst Marquardt.
- 1992: Consensus Conference on Amputation Surgery. Report of an ISPO Workshop, Glasgow, Scotland. Edited by G. Murdoch, N. A. Jacobs and A. B. Wilson Jr.

Publications related to the Society itself include a new Directory of members which will be available for circulation immediately following the World Congress in Chicago. As a last remark related to publications I would like to express my great pleasure in the prominent role which Prosthetics and Orthotics International is now playing with the supplements in three issues in one year. The journal is now one of the most leading journals in the field of prosthetics, orthotics and rehabilitation engineering.

On the wider international scene we also continue to play a leading role in the

International Standards Organization and particularly in Technical Committee 168 on Prosthetics and Orthotics. The work of the Committee related to prosthetics has been progressing steadily and during the last meeting in 1991, it had been agreed that proposals should be formulated to expand the work of TC168 to include orthotics. All these working groups have been active in this triennium. The 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 and is in a rather stable position. At the last Board Meeting in January 1992 it was agreed that the international fee should remain at 450 DKK for 1993 and attempts would be made to hold this rate throughout this triennium. It was also a very important decision that the 450 DKK fee should apply to the 25 countries of the Organisation for Economic Co-operation and Development (OECD) and other high income areas as defined by the World Bank and that all other countries will have a subscription of half that amount, i.e. 225 DKK per annum.

We have to recruit more members to the Society as well as subscribers and advertisers to the Journal.

Of course our income is not altogether due to membership fees and successful events. We should recognise the fact that 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 received support and facilities from other organisations which are essential to our continued operation. I would like to mention two institutes which have facilitated the activities of our Society in more than one triennium. First the University of Strathclyde, the home base of our Honorary Secretary and the Immediate Past-President and second the University of Groningen and the University Hospital of Groningen, my working area. These universities have given the Society enormous support to facilitate, without any charge, the activities of these officers. I offer my grateful thanks to all of these bodies.

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. That is our greatest strength! All of our on-going activity, and the range and volume is impressive, is sustained by the voluntary effort of individual members. It is also our hope for the future that the Professional Register under the chairmanship of Hans Christian Thyregod will allow us to identify more of the membership willing to take part in the work of the Society.

We can look forward to continued activities in the coming triennium. Up-grading Courses on Lower Limb Amputation and Related Prosthetics in Asia, Africa, Eastern-Europe and Central and South America. Collaborative ventures with many international agencies and organisations such as GTZ, WHO, United Nations, World Orthopaedic Concern, International Committee of the Red Cross are under direct active consideration. Our activities for the developing countries must have the highest priority. 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 organise these activities. With the Constitution in our hand we know what we have to do. To promote and to bring the highest quality patient care throughout the world.

A lot of activities have taken place during this triennium.

I would like to take this opportunity to thank the Executive Board members and all the others for all their help and encouragement during the period of my Presidency. The Society is growing very fast. There is a danger that the activities can overwhelm our Society. We have to take care that we are working in a well co-ordinated and co-operative way with a maximum of efficiency and fulfilling the tasks to which we are committed. 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.

I would especially like to thank our Honorary Secretary, Norman Jacobs, who is handling an enormous amount of work for our Society. I really appreciated the very good team support from the President-Elect, the Immediate Past-President, the Honorary Treasurer, the Honorary Secretary and also my secretary Inge Zweerts de Jong. I am grateful for all their help and their enthusiasm.

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

Prosthetics and Orthotics International, 1992, 16, 88–89

Incoming President's Address

MELVIN L. STILLS

It is a great honour to have the opportunity to serve as President of the International Society for Prosthetics and Orthotics. On behalf of the newly elected ISPO Executive Board, we want to thank you for the confidence that you have shown by electing us into office. We accept this responsibility and promise to work toward the goals and objectives of the Society.

The Society's goals certainly include our continued growth. We now have membership in 73 countries and 22 national member societies. We will continue to provide an opportunity for all those involved in the delivery of orthotics, prosthetics, and rehabilitation services to come together and share knowledge and experience. We can put aside professional, territorial, and political differences in order that we might learn how we can better provide care for our patients.

The objective of the Society is simple, but will require constant effort for many years to come. I believe our objective is education: the education of the clinical team, the professionals involved in the delivery of prosthetic and orthotic services; the education of the technicians who fabricate these very complex devices; the education of administrators who must agree to develop a delivery system and pay for these expensive services. We must also educate government officials so that they understand that poor or inadequate orthotic and prosthetic services are more costly to the community than appropriate services. Appropriate technology varies according to local conditions. Everyone can benefit from advanced technology, but appropriate education, facilities, and materials must be available to support and service this technology. The very latest in flexible ischial containment sockets, hydraulic knee mechanisms, and energy storing feet may work well in Chicago or Glasgow, but is certainly inappropriate for the man who spends all day knee deep in water or who lives hundreds of miles from modern medical facilities or roads, for that matter.

We must also spend time and money educating ourselves. Not only do we need to keep up with evolving technology, but we must also learn to communicate with those who are outside of our profession.

We work closely with other international agencies to try to ensure that prosthetic and orthotic services are made available in communities and countries where only limited services are currently available. The World Health Organization estimates that two million more children will develop polio before the year 2000. It is estimated that twenty thousand new orthotic technologists will be needed, ten times the number available today. Our school systems cannot begin to train the numbers needed. Only with close co-operation with other international agencies and organisations can a solution be found. ISPO has a responsibility, not only to assist in the training of technical support to treat disabilities, but also to help in the prevention of disabilities as a result of disease and trauma.

The Society has organised and conducted many consensus conferences. The Society has addressed the subject of education in the developing world, computer aided design/ computer aided manufacture, above-knee socket design, amputation surgery, and many others. The goal is to establish a consensus, to separate truth from fiction, and to publish a report so that all can benefit from these efforts. This is difficult these days when so much effort and money goes into marketing and little is spent on research and evaluation. The Society spends money derived from dues, Congresses, and private donations to seek out the truth and to publish a consensus opinion. The published reports are widely circulated and used.

It became apparent, as a result of the consensus conference on amputation surgery in Glasgow, that education of surgeons in modern amputation technology was badly needed. The Society conducted its first update course on amputation surgery and related prosthetics this past winter in the Netherlands. We will conduct similar courses in Africa and South-east Asia later this year or early next year.

We are now ending a very successful Congress. A tremendous amount of information has been shared. We have had the opportunity to see the latest technological advances and identify our sources for technical support. Old friendships have been renewed and new friendships have begun.

I want to particularly thank Dr. Dudley Childress and his staff for their tremendous effort and hard work in organising this Congress. The exhibitors, the contributors and all of the participants have made this a memorable event. I want to thank my colleagues in the Orthotic Prosthetic National Office, The American Academy of Orthotists Prosthetists, The American Orthotic Prosthetic Association and The American Board for Certification for sponsorship of the Opening Reception and the promotion of this Congress over the past three years. I sincerely appreciate your support.

An equally spectacular event awaits us in Australia at the Eighth World Congress. The Australian National Member Society is already hard at work, and I encourage you not only to go to Australia, but to make sure friends also come with us "down under" in April of 1995.

I must thank Professor Willem Eisma for his hard work and dedication to the Society. We have worked closely these past three years and we all have benefitted from his style, knowledge, and leadership. Willem has made friends for the Society around the world. He has worked hard to remove the barriers that face the world's physically challenged every day.

The new Board meets tomorrow to begin planning the activities of the Society over the next three years. I will do my best to ensure that National Member Societies and membership are kept informed. We need your ideas, suggestions and support so that we can better serve you. There will be an interim meeting of the International Committee before the next Congress and I encourage your participation. On the anniversary of this country's independence, let's all work to ensure that all those with physical disabilities may one day be able to celebrate their own independence.

Prosthetics and Orthotics International, 1992, 16, 90–97

THE KNUD JANSEN LECTURE

Education: an investment in everyone's future

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Opening remarks

Frequently one starts a presentation with the expression, "It is a great honour to be here," and thinks of it as little more than a polite form of words. This is not the case for me today. I am very conscious of the honour of giving this lecture and the honour we do to our founding President Knud Jansen. I am grateful to the Executive Board for their support and to the President for selecting me.

I never fail to be surprised when I find myself in a gathering such as this. It is at first sight a far cry from engineering in the Clyde shipyards, where I started my career, to rehabilitation engineering and the field of prosthetics and orthotics. Perhaps this is only a reflection of the changing face of society and the increasing recognition of the contribution which engineering can make in this field. Perhaps also it is a manifestation of happenstance and the vagaries of human behaviour. More likely it is a result of the influence and attraction of those who guided and directed me; engineers such as Kenedi, Radcliffe and Foort, medical practitioners such as Murdoch and Jansen and prosthetists like Lyquist and Kragstrup. I am grateful to them for moving me in this direction and to this Society to which they all belong or belonged.

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Introduction

It is not surprising that ISPO and its forerunner ICPO, the International Committee for Prosthetics and Orthotics have expended, and continue to expend, more effort in the field of prosthetic/orthotic education than in any other area. The fact is that twenty odd years ago just before ISPO was formed there were no universally accepted standards or even guidelines for the education and training of the prosthetist/orthotist. There were few nations with organised programmes and fewer still with any great interest in developing them.

And yet the prosthetist/orthotist enjoys a central position in the treatment of the group of patients with musculoskeletal disabilities. If the clinic team is to function effectively this key figure has to be adequately educated and trained.

If the situation was bad twenty years ago in the industrial world, it was worse in the developing world. Most international agencies displayed little appreciation of the need. Some would say that third world countries could not afford prosthetic/orthotic services and must concentrate on primary health care. Many who did believe prosthetic/orthotic services were necessary thought they could be provided by relatively unskilled workers.

ISPO has made enormous progress in moving thinking forward. Things are beginning to happen. It is astonishing, however, that even yet in the last decade of the twentieth century there is a key member of the clinic team whose education and training has not yet evolved to a more or less uniformly accepted level.

Historical

Of course it is not surprising that there was a slow beginning. The profession was very much craft-based and medical-led well into the twentieth century. The surgeon had the understanding of the clinical problem and the general education to apply physics to obtain a more or less adequate solution. He then depended on a craftsman to give his solution a physical expression. Ambroise Paré (1575), for example, whose designs of artificial limbs are remarkably similar to many still in daily use, was a sixteenth century military surgeon who worked along with a highly skilled locksmith to produce his sophisticated prostheses.

In many countries the situation changed little and slowly with no formalisation of the place of the limb fitter or maker. Progress was marked by events, such as the development of the famous Anglesey leg, by a London limb maker named Potts who, in 1805, patented an above-knee artificial leg articulated at the knee, ankle and toe-joints. The leg was named after the Marquess of Anglesey, who was the most famous recipient of the device. He lost his leg at the Battle of Waterloo when a grape shot shattered his leg. He is said to have exclaimed to Wellington, who was riding beside him, "By God, Sir, I've lost my leg!". The Duke removed the telescope from his eye, had a look, retorted, "By God, Sir, so you have!" and then returned his attention to the battlefield (Anglesey, 1990).

The first upsurge in the profession in Europe came with the First World War. The scale of the casualty lists was unbelievable. In 1915, in the first two hours of the Battle of Loos, more British soldiers died than the total number of casualties on both sides on D-Day 1944. On the second day of the battle 12 British battalions, totalling just under 10,000 men lost 358 officers and 7,861 other ranks killed and wounded in three and a half hours of fighting (Calder, 1982).

Many of the casualties suffered amputation. By 1915 it became obvious that a large modern hospital was needed in Scotland. The project was pioneered by Sir William Macewan, then Regius Professor of Surgery at the University of Glasgow. The hospital, as was common then, would be under the royal patronage of Princess Louise, Duchess of Argyll. An early indication of rivalry to come between England and Scotland in this field, and American influence lurking in the background, may be gathered from extracts from a letter which Princess Louise sent to Sir William in March 1916:

> "...... I kept back this letter so as to add that I thought it wiser to tell His Majesty, The King, that the Lord Provost had requested me to take an interest in the movement, and he seems very anxious, that nothing should be done, which would, in any way cause a competition with Roehampton ......
>
> It seems that the King has been approached, and the hope expressed, that such a Scotch Institution would not be started, which would in any way hinder the success of Roehampton Institution which is the originator. I did say, that I was going to urge you to be in communication with those 3 Americans at Roehampton who are thought to be the only really successful men with the artificial limbs at present ......"

Well, despite the King's reservations, the Princess Louise Hospital was established and, under Macewan's dynamic leadership, flourished, and still exists for disabled ex-service men, though no longer involved in limb fitting. It was of considerable interest to me to discover that the Scottish limbs were designed and built in Clyde shipyards, including the shipyard in which I received my training, and the limb makers were patients trained in the shipyards to make the limbs.

By the 1960's no dramatic change was obvious. Limb makers served an apprenticeship as leather workers, metal workers, or in other related trades. The better were selected to be fitters, but received little in the way of structured training on the route to qualification.

Many countries displayed a similar pattern. The West German system represented a more structured and controlled version of this system. USA led in the way of providing, within the University setting, structured training, while seeking to ensure adequate educational standards. By the 1960's the famous schools in the University of California, Los Angeles, Northwestern University and New York

University, were up and running. There were, however, no universally accepted standards.

Holte

A watershed in the development of training programmes was the so-called Holte Report (United Nations, 1969). This was the Report of the United Nations Inter-regional Seminar on Standards for the Training of Prosthetists, held in Holte, Denmark in 1968 and organised and run by ICPO for the United Nations. Past Presidents George Murdoch, Anthony Staros and Erik Lyquist played key rôles in its organisation and successful conclusion. Experts like Miles Anderson, Helmut John and Joe Traub contributed, and participants were invited from all corners of the globe.

The resulting document was all embracing, specifying everything from the provision of service through job descriptions of the prosthetist/orthotist and the technician, ethical conduct, educational standards, curricula, teaching methods down to terminology and standards. In particular it provided a blue-print for the education and training of the prosthetist/ orthotist.

This was a remarkable meeting and a remarkable product. Literally every major educational event since that meeting has been based on the Holte Report. Nearly twenty five years later so far as education and training are concerned the findings still provide a model in continuous use.

Key elements in the proposal as far as training was concerned were

University entry level
Course duration of four years
Identified theoretical subjects
Specified clinical and laboratory practice
Ratio of practice: theory of 4:1

Scotland

The Holte meeting was timely so far as Scotland was concerned. Continuing complaints abour poor service, particularly in regard to prosthetics, had persuaded the Secretary of State for Scotland to set up a Working Party to advise him on "The Future of the Artificial Limb Service in Scotland" (Scottish Home and Health Department, 1970). The life span of this Working Party encompassed the time of the Holte meeting. A major conclusion of its report was that an adequate training scheme for prosthetist/ orthotists should be instituted and that the National Centre for Training and Education should be established.

And so twenty years ago we in Scotland found ourselves in the position at which, astonishingly enough, many countries have still not arrived. A system which was not even an apprenticeship had to be replaced by a formal, high level training system with clear educational goals.

A number of circumstances came together and a number of decisions were made, some fortuitous, which combined to produce a good outcome. In retrospect they could be considered sound recommendations for any of the many nations which are currently considering their options. The first and perhaps most important factor is adequate funding for what is an unusually expensive course. The Scottish Home and Health Department accepted this responsibility and have continued to do so. The second was to find an appropriate home for the course. Fortunately, there was an active research group in this field in the University of Strathclyde's Bioengineering Unit and there was consequently a nucleus from which the National Centre might grow. Thirdly, there was a recognition of the appropriate level and content which came with acceptance of the Holte report and a mechanism to incorporate such a course within the national tertiary education system. For any country about to tackle this problem, adequate funding, an appropriate and enthusiastic host institution and proper integration within the national education system are pre-requisites for a successful outcome.

The difficulties were, however, daunting. The information as to what was required might be available, but the problem was how to make it happen. We were very considerably helped by the fact that, in the mid-sixties, Professor Charles Radcliffe had spent a year's sabbatical leave in Strathclyde. Flushed with the success of the Quadrilateral and Patellar-Tendon-Bearing sockets, he ran courses in these techniques for Scottish limb fitters. A number of these traditionally trained fitters who had taken part in the Radcliffe courses, formed the nucleus of the clinical teaching staff in the new National Centre. They were sent on short courses to the American Schools so that they might take part in the same kind of up-grading activities as had been prescribed for American practitioners.

For the design of the National Centre premises, and for teaching manuals and other material — everthing from sources of supply to lists of machinery — the existing English speaking schools and the school in Oslo, were plundered shamelessly. A special tribute is due to New York University and Northwestern University Prosthetic and Orthotic Schools which were the main sources of information, and to their respective directors, Sydney Fishman and Charles Fryer who, knowing what was being done, so willingly and openly shared their experience.

When the University of Strathclyde prosthetics/orthotics course was initiated in 1973 it led to the award of a Higher National Diploma wihch was a nationally monitored and validated award. It was based on the Holte recommendations but it leant heavily on what were then already well established, respectable and respected courses in USA.

There are two interesting asides which perhaps highlight what was then a dilemma and is also a reflection of attitudes, since changed, which were entrenched in the traditional University system. Firstly, it was not possible to go directly to a degree qualification — the University community would at that time not have accepted prosthetics and orthotics as a legitimate field of study, especially as it had previously been barely the subject of an apprenticeship. The second relates to the cumbersome title of the Centre where "training" was not enough for the University and was accompanied by "education" to signify a more respectable rôle in academic terms.

In 1986, responding to the perceived needs of the profession and its development within advancing technology the Higher Diploma course was replaced by an Honours Degree Course leading to the award of Bachelor of Science of the University of Strathclyde. This is not quite the same as a Bachelor of Science degree within the American system. To give an international measure of its currency, it represents four years of University study following 12 or 13 years of schooling, i.e. 16 or 17 years of study.

It is a common misconception in Europe to describe degree courses within a University setting as "academic" with the implication that such courses could not contain the necessary elements of practical or clinical instruction. In fact many University courses are strongly vocational and do have all the components to fit the student for a future career — medicine is one of the earlier examples. It is also possible within this framework to satisfy the specification laid down in Holte. The Srathclyde course is a four year course which contains the appropriate theoretical studies, supervised practical instruction and controlled clinical experience.

The first three years take place on the main campus in special purpose-built accommodation. During these three years the students carry out their theoretical studies and undergo training in the fitting and fabrication of prosthetic and orthotic devices working with "professional patients", that is patients acting as subjects for the students and not being fitted as part of their treatment. The normal University year of about 30 weeks is extended by 10 weeks to accommodate the large instructional element.

The final year consists of 46 weeks of clinical practice, 23 weeks in prosthetics, 23 weeks in orthotics, during which students are exposed to a structured broadening of their prosthetic and orthotic experience under appropriate supervision. In effect they are learning to apply to "real patients" the techniques they learned during the first three years. The clinical placements are undertaken in centres which meet specified criteria and have been inspected and approved for that purpose.

It may be mentioned in passing that the National Centre is housed on campus in some 32,000 square feet (3,200 square metres) of purpose-designed classroom, clinical and workshop space. It has a full time staff of about fifty, including ten prosthetist/orthotists. In addition to the Degree Course, it provides each year about 20 short courses, each of one or two weeks duration, for qualified clinic team members, and also operates, in a local hospital, a clinical service unit which provides for the needs of about 400 amputees and a greater number of orthosis wearers.

The Scottish course is one expression within a national context of the ISPO philosophy for the developed world. Many variants are equally acceptable. However, all courses must contain the elements of theoretical studies, closely supervised practical instruction in both clinical and workshop skills and structured and controlled clinical experience. Any course which does not contain all of these and where they are not all monitored and assessed is inadequate. So far as the theoretical subjects are concerned every course will contain a blend of life, physical and applied sciences to satisfy the diverse requirements of understanding the human body, the device applied to it and their interaction. It is a strongly held personal conviction that one subject may be described as of paramount importance. Mechanics is the study of forces and their effects; biomechanics is the application of mechanics to the human body or, in other words, the study of forces and their effects on the human body. What then is prosthetics and orthotics if it is not applied biomechanics? Any prosthetics/orthotics course which does not have a solid biomechanical foundation is fundamentally flawed.

Although the introduction of new technology, such as computer-aided design and manufacture, may be important for the future, it is no more significant in this field than in many others. The computer is a tool used by many professionals. The undergraduate course must provide the basic theory and principles of practice; it must teach the student to learn and prepare him or her for continued learning throughout a professional career.

It is important to the future of the profession that its development proceeds in what might be described as a normal way. Having established Baccalaureate as the required level of professional qualification, it is only appropriate that some will proceed to higher degrees at Masters and Doctorate level. This is the next step in providing a cadre of individuals who can function at all levels of service, research and education. The National Centre, as part of a continuing programme of responding to the needs of the profession, will this year commence post-graduate degree courses specifically in prosthetics and orthotics.

ISPO and the developing world

A whole series of ISPO meetings and reports since Holte have pondered on the educational needs of the developing world. The first of these in 1974 in Les Diableret (International Society for Prosthetics and Orthotics, 1975), prior to the first World Congress, was a general meeting which attempted to set priorities for ISPO. Entitled, "Needs in Prosthetics and Orthotics Worldwide", it endorsed the Holte Report and emphasised the need for formal long-term degree level courses.

This remains the goal. However, the need in the short-term for compromise has been dictated by the difficulty of fostering educational efforts in the developing world and the need to strengthen and encourage those educational activities which are taking place and influencing a continual raising of their standards.

Of course the use of the term developing world creates the impression of a uniform, homogenous society. It does not take much reflection to realise that Asia, Africa, South America and the islands of the Pacific Rim probably display almost as much disparity within themselves as they do one from the other. They all, however, have crippling diseases which have been eradicated from the industrial world and they all lack resources. This lack of resources led many intergovernmental and international agencies to emphasise primary health care to the exclusion of all else. Where they did think about the needs of the physically disabled they considered they could be met by inadequately trained artisans. This attitude condemned millions to misery and dependence and ignored the consequent enormous cost to society and the individual and his family. ISPO can take considerable credit for influencing the international agencies to change this attitude and to recognise the size of the problem and the priority it deserves.

There are, of course, many conflicting factors. The prosthetist/orthotist in the developing world, like his counterpart elsewhere, needs to understand biomechanics and anatomy, to study materials and how to handle them and to learn the skills of fitting and constructing devices. It could sensibly be argued that with less resources of all kinds, more difficult conditions and probably more difficult clinical problems he needs to be better trained than his opposite number in the developed world. The reality however is that most developing countries cannot yet afford the investment in training to the highest level when this is considered against their many other areas of essential spending. Clearly a compromise is needed to accept the reality of limited resources while at the same time producing a worker who has adequate skills and understanding to permit him to make a useful contribution in the clinic.

A solution, pioneered mainly by GTZ, the German Agency for Technical Cooperation, is the so-called Orthopaedic Technologist. With entry at 10 years schooling, which is the usual requirement for paramedical education in the developing world and a course of three years duration at lower than Degree level, this individual is clearly less well qualified than the graduate of the higher level schools in the industrial world. In an ideal situation he would always work under the supervision of a high-level, professional prosthetist/orthotist. However, his emergence marks a significant step forward in this field. ISPO has adopted the concept of the orthopaedic technologist, adapted, developed and ratified the syllabus and established a system for inspecting and recognising the educational programmes involved.

In discussion with ISPO and others the World Health Organisation has now agreed and recorded (World Health Organisation, 1990) that this is the minimum level at which developing countries should be aiming and recognised that the long term aim should be for the degree level professional. This is a most significant step forward in the battle for the recognition of the importance of this activity.

Of course the clinical problem is also very much different from that in the developed world — the different causes and incidence of amputation, the continuing presence of such diseases as poliomyelitis and leprosy. This has led to the suggestion of a further development from the orthopaedic technologist philosophy. This would be an emergency measure to produce an orthotics technologist or a prosthetics technologist trained in a single discipline with a consequent reduction in course length and therefore cost. This would permit more people to be trained more quickly with a concentration on greatest regional need.

The challenge or the investment

There are two distinct but related challenges in this field, not surprisingly they correspond to the developed and developing world. They are different because the problems and circumstances are so different, but they are related because the developed world needs to be in a position to provide to the latter, support and assistance and teachers.

The challenge in the developed world and the solution are quite straight-forward.

Government is said to be committed to improving the lot of the disabled among us. For many the prosthetist/orthotist is the key figure in the rehabilitation process. The standards and the revelant training needs are known. The necessity is to provide the appropriate numbers of properly trained professionals and that means to provide appropriate training programmes. Many governments do address the problem of ensuring an adequate supply of doctors, nurses and therapists. It is almost unknown for any government to even consider the supply of prosthetist/orthotists.

Many factors contribute to this situation. In some countries the profession itself has been slow to raise training standards, the numbers involved are small making it difficult for smaller countries to set up viable programmes and of course the training programme is inevitably expensive. Unfortunately government departments are increasingly becoming obsessed by cost. In many countries it has become a maxim that, "Cheap is good". This however is cost consciousness which is not the same as sound economics.

Let us consider some of the numbers involved. Even accepting that they are contentious, it is helpful in putting the problem in perspective. For every one million of population there are about 8,000 disabled in need of prosthetic/orthotic services (that is 0.8%, a figure obtained from Swedish studies (Oberg, 1987) and substantiated by other estimates (Office of Population Censuses and Surveys, 1988). It should be emphasised that this is not necessarily the number who will be provided with service. Government policy, the system of health care provision, and the quality of service available, are all likely to reduce the number fitted in comparison to the number who could benefit from fitting. A useful working estimate of the number of prosthetist/orthotists required to treat these patients is one per 400 patients. So for one million population about 20 prosthetist/orthotists are required. Assuming a working life of about 25 years the training system has to feed into the system about 0.8 prosthetist/orthotist per year per million population. The cost of training varies widely but let us consider what these figures might mean in a country like USA with a population of 240 million. There would be 1,920,000 disabled, needing the services of 4,800 prosthetist/orthotists. The schools would have to graduate almost 200 new professionals each year. Without going into the details of the real costing it can be seen that the provision of $20 million per year to fund training would only represent about $10 for each disabled individual. This is a trivial cost compared to the real cost of disability to the individual and society and the potential saving from improved fit through the use of better trained professionals, leading to improved function and savings in adjustment and alteration costs. Against that background it is difficult to understand the logic behind the recent attacks on the internationally respected education programmes in USA and the demise of institutions like the New York University School.

Things are not better elsewhere in the developed world. There are twelve countries in the European Community (at the last count). Only four (Denmark, France, Germany and United Kingdom) have what can even broadly be described as "high level" programmes. This means that there is a population of about 200 million, in the most sophisticated part of the developed world, with educational traditions stretching back for many centuries, where a key member of the clinic team is being, at best, inadequately trained and even in some countries not formally trained at all! The situation on Continental Europe has hardly changed in 20 years.

In the developing world the picture is different and certainly not better. Many crippling diseases which have disappeared in the industrial world are still prevalent. The World Health Organisation estimates that despite the efforts to eradicate poliomyelitis, as many as two million children may still get the disease before the year 2000 (World Health Organisation, 1990). The vast majority of these children could remain free of deformities and able to walk if they were provided with orthoses. The number needing devices is further swollen by those still alive who have contracted the disease over the last decades. A recent very cautious estimate of the number of amputees in the developing countries is about 3.5 million. If it is assumed that a prosthesis may last for three years before replacement, the annual production in the developing world would need to be about 1.2 million. There is a special need for orthopaedic footwear in a group of patients, the largest proportion of which has leprosy. It is estimated that, at present, there are 11–12 million people in the world with leprosy. If only 10% of them need footwear every year, this corresponds to a demand for over one million pairs of shoes.

All of these figures are almost certainly underestimates. They give an impression of the size of the problem. A similar analysis to that used above for the developed world puts the problem in context. The present number of adequately trained prosthetist/orthotists and orthopaedic technologists in the developing world is not known, but is estimated to be less than 2,000. A very conservative estimate of the number of people who need prostheses or orthoses would be 0.5% (c.f. 0.8%) of the population. By the year 2000 the combined population of Africa, Asia and Latin America will be approximately 4 billion — so there will be 20 million people in need of orthopaedic devices (World Health Organisation, 1990). To even have only one professional available to serve every 1,000 patients (c.f. 400) requiring devices would need 20,000 trained personnel — ten times that currently available. The need is simply staggering. The output of all the schools which currently exist anywhere in the world could not even scratch the surface of the problem. There is no sign of any dramatic change in the number of training places available worldwide. Indeed, it seems certain that in the developing world the rate of expansion is less than the rate of increase of the world's population.

The challenge in the developing world is then of a different order. We can claim some success in changing attitudes, in providing good and useful information and in being supportive of the programmes which do exist. The situation, however, is catastrophic and worsening. We must be still more active, more responsive and more "diplomatically aggressive". We must encourage and foster new initiatives and seek innovative and, perhaps radically different, solutions. If we are to make an impact on this problem we must change our rate of achievement. Frankly, what we have done is not enough.

It is suggested in the title of this presentation that education is an investment in everyone's future. There can be no question that, without an investment in training in this field and a dramatic increase in the number of professionals available to practise, for many people the future will have little quality.

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History of prostheses and orthoses in Japan

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Abstract
Until the first contact with European civilization in 1543, prostheses and orthoses were not seen in Japanese medical history. Some physicians and surgeons who studied medicine in the Dutch language understood about prostheses and orthoses before the opening of the country in 1868.

From 1868 to the end of World War II (1945), prostheses and orthoses were influenced by German orthopaedic surgery. From the latter half of the 1960s the research and development of these have been advanced, because of the establishment of a domestic rehabilitation system, international cultural exchange and economic development.

The first contact with European medicine and surgery

While Japanese medicine and surgery had been influenced by China from ancient times, it was not until 1543 that the first Japanese contact with European civilization took place. This was when a Portuguese ship was driven ashore in Tanegashima, a southern Japanese island. It was at this meeting that guns were also first introduced into Japan.

Looking globally, 1543 was the year Vesalius published his anatomical book and the Copernican system was introduced. In the history of Japanese culture 1543 is also one of the most important years.

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After this many Christian missionaries, such as Francis Xavier, introduced European science into Japan. However, from 1639, the Japanese government forbade religious, cultural and commercial exchanges with European countries, due to their anxiety about the propagation of Christianity. Such exchanges were only allowed with China and the Netherlands. Japan's isolation then continued for two and a half centuries. Thus, Japan had already been introduced to European medicine and surgery through the Dutch edition of French, English and German medical books before the opening of the country in 1868 when the Meiji revolution broke out.

Earlier, a very curious high officer of the Japanese government, M. Inoue (1585–1661) had been interested in prostheses. He ordered both an upper and lower extremity prosthesis made of iron from a Dutch physician who was attached to the Dutch trade office in Nagasaki. However, when the physician showed him how to use the prostheses, he was so disappointed with their poor function that he did not pay the cost of 500 Guilders. This story was recorded in the 1656 Dutch Trade Office diary, making M. Inoue the first Japanese to see prostheses in Japan.

The 1649 Dutch edition of Ambroise Paré's complete works was partially translated into Japanese in 1706 by a famous physician, Chinzan Narabayashi (1648–1711).

However, no figures of prostheses or orthoses were seen in the Japanese translation, maybe due to his lack of knowledge about these.

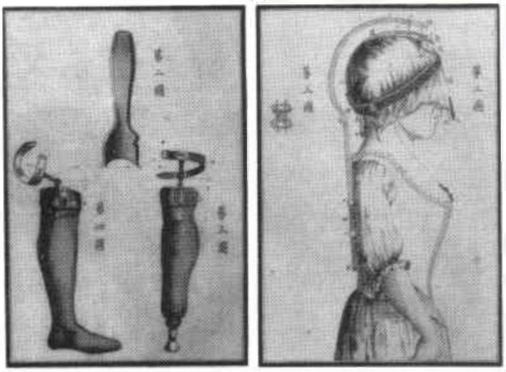

(a) (b)

Fig. 1. Figures in Japanese translation of Plenk's book (1782)
(a) Charles White's below-knee prosthesis.
(b) Le Vacher's scoliosis brace.

The Dutch edition of Institutiones Chirurgicae by the German surgeon Lorenz Heister (1683–1758) was also translated into Japanese by H. Sugita (1763–1833) and G. Ohtsuki (1757–1827). The translation was mainly of the chapters on bone and joint injuries and of amputation.

Although many figures of orthoses were seen in the original book, no figures of these were observed in the translation. R. Sugita (1786–1845) translated a Dutch edition of Plenk's surgical book into Japanese in 1782. J. J. Plenk (1738–1807) was a surgeon in Vienna. Although Sugita did not publish this Japanese edition, in his translation figures of the Charles White's below-knee prosthesis and Le Vacher's scoliosis brace were observed (Fig. 1).

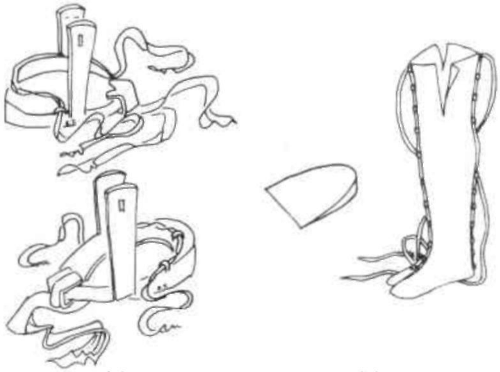

(a) (b)

Fig. 2. Braces in Okuda's book of bone and joint injuries (1835)
(a) correction brace for club foot.
(b) heel wedge and boots for paralytic equinus.

M. Okuda (date of birth and death unknown) published a book in 1835 on the treatment of bone and joint injuries, in which three lower limb orthoses were seen. These details were probably taken from the original book by Lorenz Heister (Fig. 2).

K. Miyake (1817–1873) translated a Chinese edition of a surgical book by Hobson in 1858. B. Hobson (1816–1873) was an English surgeon engaged in missionary work in China, who published his book in 1857 in Shanghai. In Miyake's translation a figure of a wooden below-knee prosthesis was seen (Fig. 3).

Introduction of Palmer's prosthesis and the era of the Meiji Revolution

After a shipwreck in 1850, Joseph Hico (1837–1897) drifted for about 50 days before being rescued by an American ship. He was taken to the United States where he was educated. After his return to Japan he wrote a story about drifting in which he made note of a Palmer's prosthesis seen in the United States. He described how, in the United States leg amputation was performed for a man suffering from a gunshot wound and gangrene of his leg.

Fig. 3. Wooden below-knee prosthesis in Japanese translation of Hobson's book.

After wound healing an artificial leg was provided, enabling him to walk again almost as well as healthy people. Although usually older style artificial legs from Europe were used, he noted that the new Palmer's prosthesis was better, and because of the excellent function of the prosthesis. He showed a figure of it in his book (Fig. 4). S. Ito (1825–1880) translated an operating manual of an American electro-therapeutic machine in 1867, at the end of which was a translation of an advertisement for a Palmer's prosthesis.

From these records, it is probable that Japanese physicians and surgeons who studied medicine in the Dutch language understood the fundamentals of prostheses and orthoses before Meiji Revolution (1868).

In 1867 a famous Kabuki actor, Tanosuke Sawamura III (1845–1878), had his left lower leg amputated by an American surgeon, J. C. Hepburn (1815–1911), who was a missionary surgeon living in Yokohama at that time. At first a puppet-maker, Kiyozo Matsumoto made a below-knee prosthesis, however no adequate socket fitting was available. The following year he had an American below-knee prosthesis from the Selpho Company and appeared again on stage. According to the description he was the first Japanese amputee to use the prosthesis (Fig. 5).

In 1872 the Academy for the Japanese Military Surgeons imported several prostheses from the Netherlands, which were used for medical education (Fig. 6). Although there were records of many war amputees from the 1877 civil war (Seinan War), little was known about any prosthetic service.

In 1986 a below-knee prosthesis was found in an old tomb in the Kagoshima Prefecture. It was a conventional below-knee prosthesis, with a bronze socket, and single axis ankle joint and toes, as well as a thigh corset. Although according to its inscription the tomb was built in 1818, it is questionable whether the prosthesis was made before 1818. Since there were a lot of defeated anti-government soldiers in the civil war in Kagoshima Prefecture, the prosthesis is considered to have been used secretly by one of

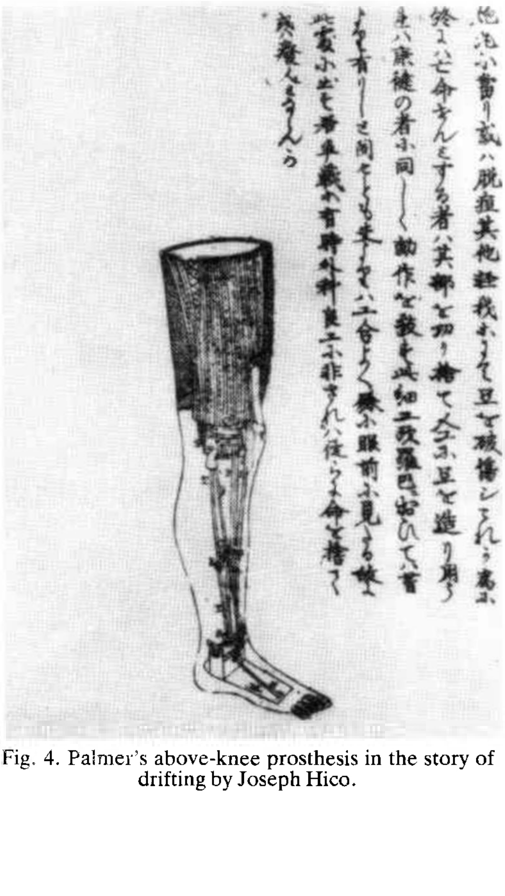


Fig. 4. Palmer's above-knee prosthesis in the story of drifting by Joseph Hico.

Fig. 5. Prosthetic fitting for Tanosuke Sawamura III (1867).

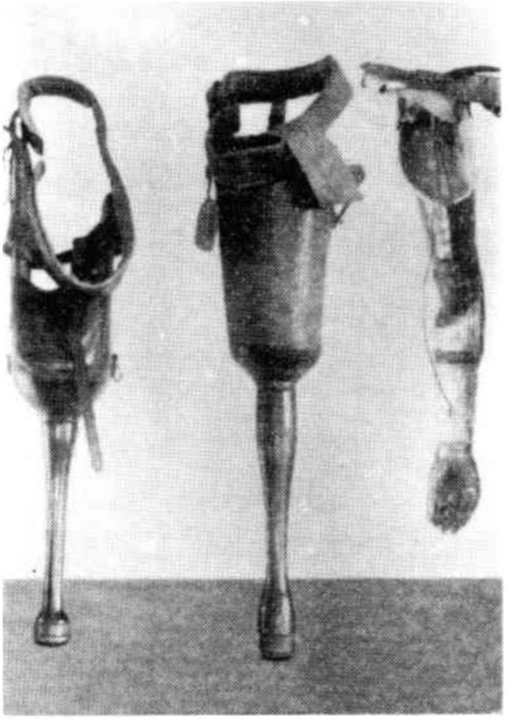


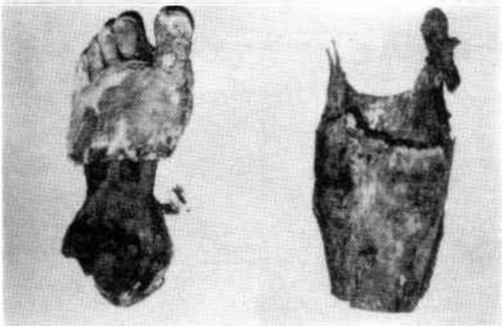
Fig. 6. Prosthesis imported from the Netherlands (1872).

these amputees. This is the oldest prosthesis in Japan (Fig. 7).

A French painter, Bigot, who was in Japan from 1882 to 1899 to study Japanese painting, drew a lot of caricatures about Japanese life, in which prostheses are seen (Fig. 8).

The Russo-Japanese War and World War II

During the 1904–1905 Russo-Japanese War, the Japanese army carried out procedures to produce a prosthesis for an end weight-bearing



(a) (b)

Fig. 7. Below-knee prosthesis found in an old tomb (a) foot. (b) socket.

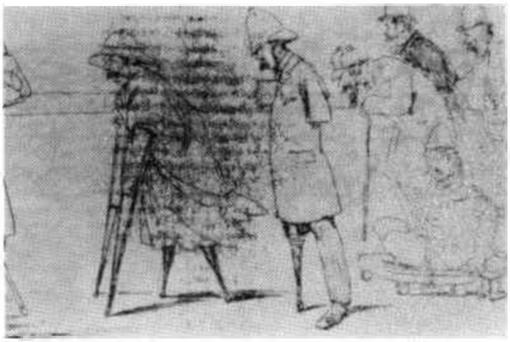


Fig. 8. Caricature by French painter, Bigot "victim of terrorism".

stump, reported by the German surgeon, Hirsch, in 1900. The method was used continuously in Japan until the end of World War II. The Japanese army also developed an upper limb prosthesis during the war, designed by General Nogi, who was very famous because of the capture of Port Arthur. In 1911 the prosthesis was demonstrated by the Japanese

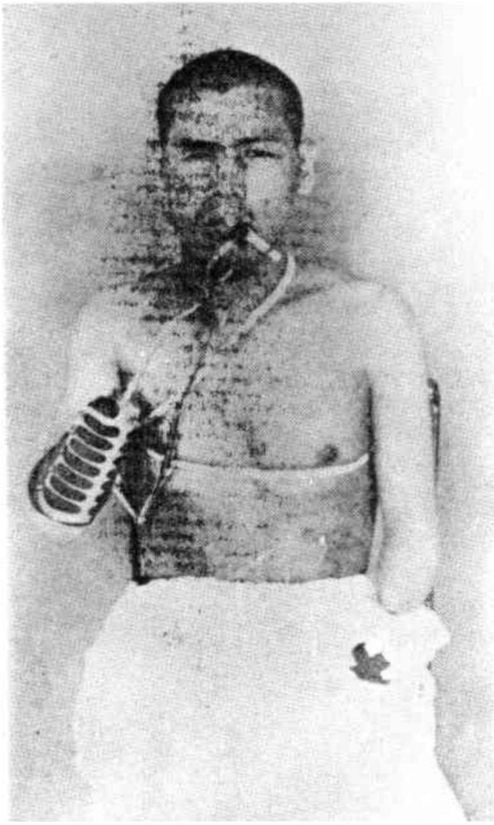


Fig. 9. Upper limb prosthesis designed by General Nogi (1905).

army at the International Hygiene Exhibition in Dresden. Although the precise structure of the prosthesis was described, little is known about its practical use (Fig. 9).

In 1887, the first prosthetic workshop was established by Isematsu Okumura, a dental prosthetist and merchant of medical instruments in Osaka.

The first monograph on prostheses was published in 1902 by Yuichi Suzuki, a right below-knee amputee, who became a prosthetist later, establishing a workshop in Tokyo. The monograph, although not scientific, is comprehensive.

While prostheses and rehabilitation of amputees advanced markedly in Europe and the United States during World War I, few were seen in Japan. However, in 1919 Japan accepted many Czech war amputees who had been engaged in the civil war following the Russian Revolution in Siberia, and they were provided with prostheses by the Japanese government.

As to orthoses, the Hessing-type construction consisting of upper and lower limb braces made of steel and leather, and corsets made of celluloid and leather were popular in Japan until the end of World War II.

From World War II to the present

During World War II the Japanese army developed two kinds of prostheses. One was a lower limb prosthesis named "Iron Leg", which was very suitable for farmers, consisting of an aluminium plug fit socket, locked knee and patten or Dollinger's foot (Fig. 10). The other was a working arm similar to the Tannenberg Arm of Schlesinger (Fig. 11). The ideas at that time were based upon the prosthetic classics, "Kunstliche Glieder" by Hermann Gocht and "Ersatzglieder und Arbeitshilfen" by Schlesinger *et al.*

Due to the shortage of raw materials following World War II, it was very difficult for many amputees and disabled to get prostheses or orthoses. During this period a very simple

Fig. 10. Above-knee prosthesis for heavy workers, Japanese Military (1938).

Fig. 11. Working arm, Japanese Military (1938).

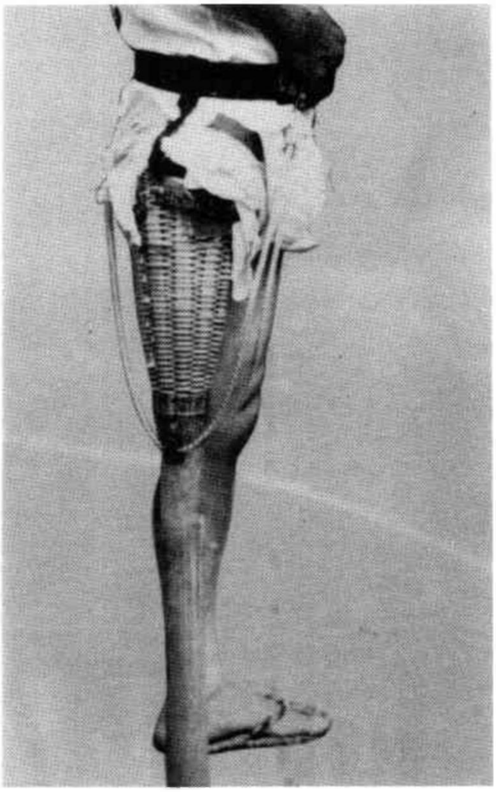


Fig. 12. Above-knee prosthesis made of bamboo (1947).

self-made lower limb prosthesis was seen in the rural areas of Japan, which had a bamboo basket socket and a bamboo pylon (Fig. 12).

As the rehabilitation system, international cultural exchange and economic status developed, Japanese prostheses and orthoses gradually improved. There has been much information from overseas about the quadrilateral socket. patellar-tendon bearing prosthesis, functional and electric arm and other devices. The quadrilateral socket was introduced by a United Nations instructor in 1955. From the latter half of the 1960s, research and development has taken place in myo-electric arms and endo-skeletal prostheses. There has been standardization of components, and the development of education systems for physicians and surgeons. The qualification of prosthetists and orthotists and improvements in the limb fitting service have occurred.

These efforts encouraged the Japanese members of ISPO to offer to host the V World Congress in Japan. In November 1989 the V World Congress of ISPO was held in Kobe, Japan, the first time this Congress had been held in Asia.

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A new model of plastic ankle foot orthosis (FAFO (II)) against spastic foot and genu recurvatum

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Abstract
A plastic ankle foot orthosis (AFO) was developed, referred to as functional ankle foot orthosis Type 2 (FAFO (II)), which can deal with genu recurvatum and the severe spastic foot in walking. Clinical trials were successful for all varus and drop feet, and for most cases of genu recurvatum. Electromyogram studies showed that the FAFO (II) reduced the spasticity of gastrocnemius and hamstring muscles and activated the quadricep muscles. Gait analysis revealed a reduction of the knee angles in the stance phase on the affected side when using the FAFO (II). Mechanical stress tests showed excellent durability of the orthosis and demonstrated its effectiveness for controlling spasticity in comparison with other types of plastic AFOs.

Introduction

Although the usefulness is recognised of plastic ankle foot orthoses (AFOs), which are developed to suit the Japanese life style (taking off shoes in the house and putting them on out of doors), they manage severe spastic drop foot (Shamp, 1989) and genu recurvatum with difficulty.

A newly designed plastic AFO, is proposed, termed the FAFO (II), which is made of 3 mm thick polypropylene. This orthosis is designed to deal with spastic drop foot and genu recurvatum, and its effectiveness is studied using gait analysis and electromyogram studies.

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Materials and methods

Fabrication

The major characteristics of the FAFO (II) are shown in Figure 1. The plaster cast for the FAFO (II) is taken in five degrees of ankle dorsiflexion. Figure 2 shows the method for determining the amount of heel lift. The patient

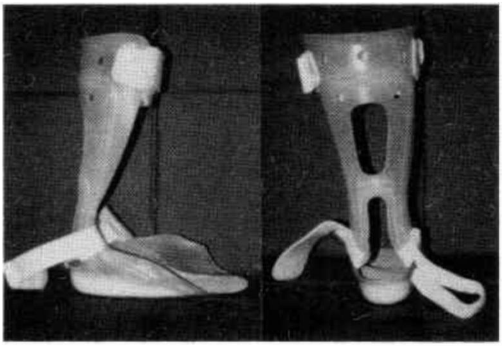

Fig. 1. Anterior and lateral views of FAFO (II).

Fig. 2. Measuring of the amount of heel lift.

stands in the parallel bars in a relaxed condition and takes a step forward with the sound limb. In this position, the distance of the heel of the affected side above the floor is measured to determine the amount of heel lift required. The trim line of the ankle part of the FAFO (II) is determined by measuring the strength of spasticity (Fig. 3). The minimum force to inhibit genu recurvatum is estimated using a spring scale, with the affected heel lifted by the pre-determined amount. Curves of the dorsiflexion moment of the FAFO (II) previously obtained by measurement (Fig. 4) are used to select the appropriate line (Fig. 5). Each curve represents the characteristics corresponding to a trim line identified according to the distance from the back of the sole piece to the anterior border of the posterior fenestration. Trim lines from 5 to

Fig. 3. Measuring lower limb spasticity.

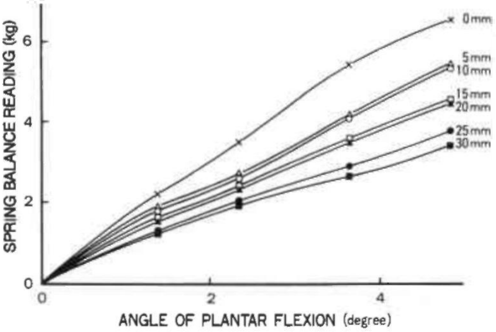

Fig. 4. Dorsiflexion moment in relation to plantar flexion for different trim lines.

30mm by 5mm intervals are illustrated in Figure 5. The positive model is modified by an additional anterior inclination of five degrees of the upper calf part so that the orthosis will push the calf anteriorly and correct the recurvatum position. An ankle strap inhibits the posterior parts from opening during plantar flexion and holds the ankle joint in the orthosis, without inhibiting dorsiflexion. The corrugation of the posterior and lateral parts of the orthosis resists the plantar flexion moment of the spastic foot. The FAFO (II) has a bridge in the posterior

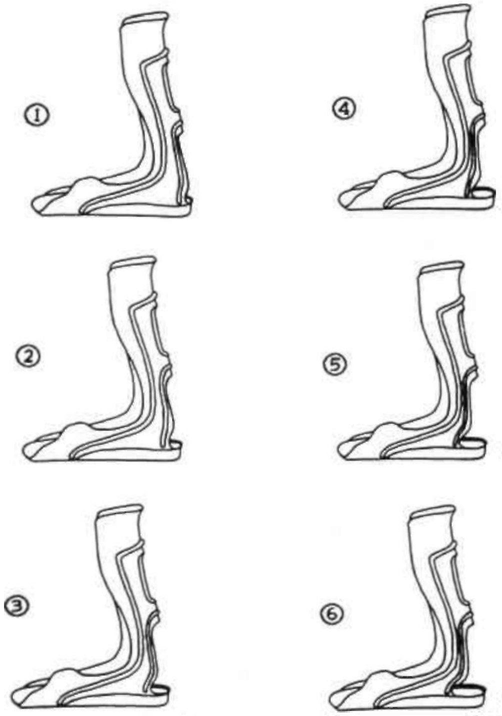

Fig. 5. The trim lines of the posterior ankle area of the FAFO (II).

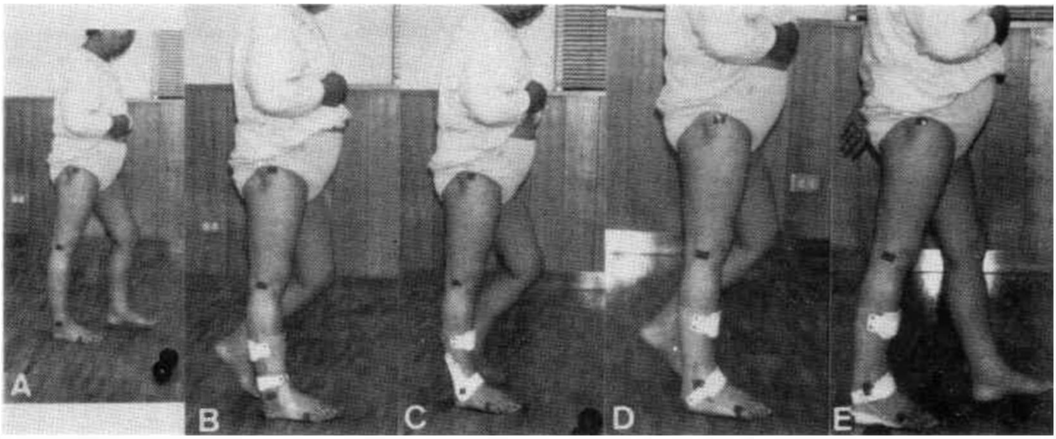

Fig. 6. Case 1 (74 years old, right hemiplegic woman), bare foot in (A) and wearing Yunoko (B), hemispiral (C), shoehorn (D) and FAFO (II) (E).

fenestration which stiffens it and reduces the rotational movement of the orthosis at the ankle and resists ankle plantar flexion. The heel lift in the orthosis reduces the spasticity of the calf muscle. Holding the first metatarsal bone corrects the varus foot in the swing phase.

Clinical trials

Thirty-nine patients, consisting of 26 males and 13 females whose average age was 58 years (4 to 75), attended the orthotics clinic from October 1988 to December 1989. All patients had severe spasticity in their lower limbs according to Shamp's rating (Shamp, 1989). They were considered appropriate for the FAFO (II). No other type of AFO was prescribed during this study.

Diagnoses of the patients were as follows; 34 cerebral vascular attacks (CVA), 4 spinal diseases, and one other. A total of 41 feet were fitted with the FAFO (II). The major symptoms of these patients were 23 genu recurvactum (in stance phase), 28 varus feet and 39 drop feet (in swing phase).

Three CVA patients who suffered from hemiplegia and displayed genu recurvatum in the stance phase and varus and drop foot in the swing phase were selected and each fitted with four different types of plastic AFOs. Figure 6 shows one case (74 year old right hemiplegic woman) fitted with the chosen devices — (A) bare foot, (B) Yunoko (Asayama, 1989), (C) hemispiral (Lehneis, 1974), (D) shoehorn (Sarno, 1971), and (E) the FAFO (II). Their gait was analysed and electromyograms made of their quadriceps, gastrocnemius, tibialis anterior and hamstring muscles to estimate spasticity and muscle activity during walking, under the conditions of wearing the various AFOs and also without any device fitted.

The gait of each patient at a comfortable speed was recorded by video camera and analysed by a computerised motion analyser (Sony, Japan). The knee ankle in the stance phase, gait speed and stride length of the sound side were calculated.

To test the durability of the orthosis a bending fatigue test was performed. The concentration of the stress on the orthosis was checked by brittle lacquer test.

Results

As a general observation it was seen that for the 39 patients wearing the FAFO (II), varus and drop foot were corrected in all cases. Genu recurvatum correction was effective in 21 of the 23 patients who displayed the condition.

The gait of the 3 CVA patients was analysed bare footed and when wearing the four different plastic AFOs described above. Figure 6 gives a subjective impression that the FAFO (II) displayed the best correction of genu recurvatum (Fig. 6E). Figure 7 shows the ratio of the knee angle at mid-stance (Fig. 7A), the gait speed (Fig. 7B) and the stride length of the sound side (Fig. 7C), when wearing the various AFOs, to the values obtained in bare foot walking. The values are given separately for each case and are identified as (1) Yunoko orthosis (2) hemispiral orthosis, (3) shoehorn

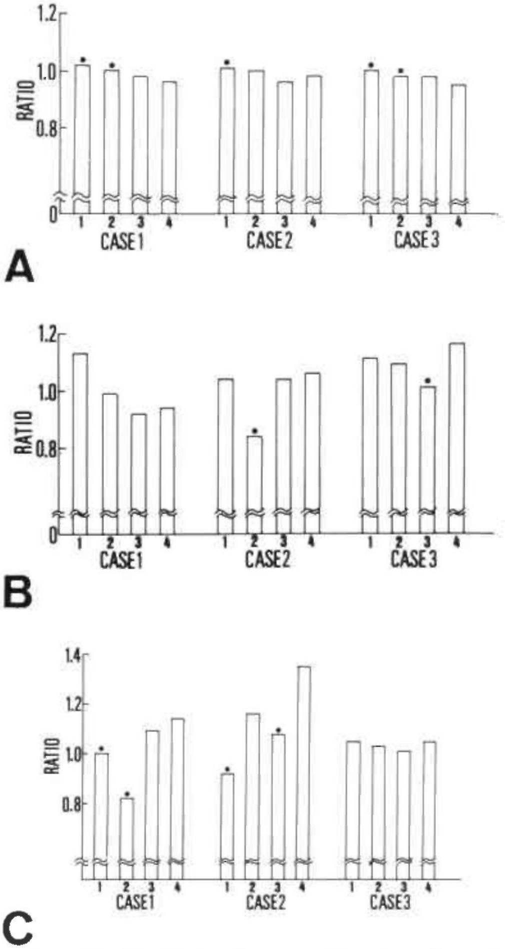

Fig. 7. The ratio of the knee angle (A), the gait speed (B) and the stride length of the sound side (C) in comparison to values obtained in bare foot walking. Measurements are displayed for Yunoko (1), hemispiral (2), shoehorn (3) and FAFO (II) (4).

orthosis and (4) the FAFO (II) orthosis. An asterisk (*) indicates that results are statistically significant $p<0.05$. The FAFO (II) produced the greatest reduction in knee angle in two of the three cases (cases 1 and 3) while the other orthoses did not have much effect. In two of the patients (cases 2 and 3) a higher gait speed was measured when wearing the FAFO (II) and in all cases this orthosis produced the greatest increase in stride length. These results appear to indicate greater stability or confidence when wearing the FAFO (II) than the other orthoses fitted.

The illustrative case in Figure 6 had suffered from right hemiplegia for 5 years. Figure 8 shows the ratio of her integrated

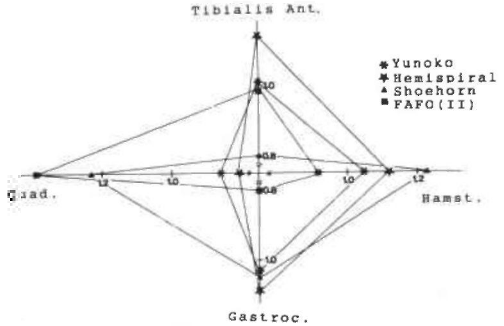

Fig. 8. The ratios of the integrated electromyogram of the same patient when wearing four different AFOs.

electromyogram when wearing each of the devices to the values obtained in bare foot walking. The greatest reduction in activity of hamstrings and gastrocnemius was displayed when wearing the FAFO (II) and this was accompanied by the greatest increase in quadriceps activity. These measurements suggest that the FAFO (II) reduced the spasticity of gastrocnemius and hamstrings while activating the quadriceps muscles.

Figures 9 shows a brittle lacquer test of the FAFO (II). Stress concentration is observed in the ankle joint area. Fatigue testing (Fig. 10) was carried out on the FAFO (II). the ankle

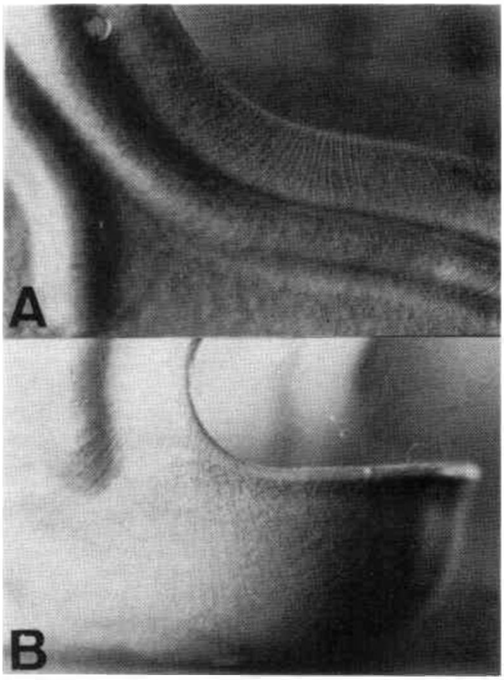

Fig. 9. The brittle lacquer test of the FAFO (II) showing stress concentrations.

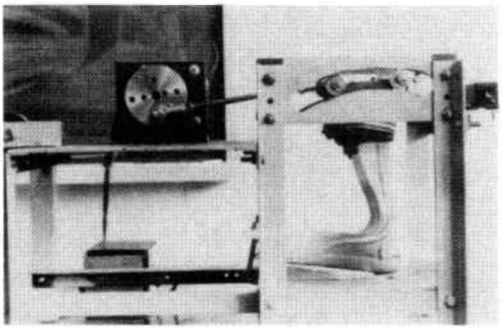

Fig. 10. The fatigue test of the FAFO (II).

was dorsiflexed to 13° at 143 cycles per minute. Three millimetre long cracks occurred in the calcaneal area of the orthosis after 5.05×10^6 cycles.

Discussion

The FAFO (II) is theoretically designed to deal with severe spastic foot and genu recurvatum. The fabrication of the orthosis is based on this design and not an empirical model. The FAFO (II) was analysed during clinical trials and mechanical studies. The orthosis was designed for relatively severe spastic patients who could not be corrected by conventional plastic AFOs. In this study it is established that the orthosis satisfied this aim mostly by reducing spasticity and stabilising the affected lower limbs. However, two patients with genu recurvatum could not be corrected. These two patients had some problems. One of them had a long-standing genu recurvatum thus the habitual pathological gait could not be corrected by the orthosis. The other had insufficient heel lift to reduce calf muscle spasticity. Prior to this present orthosis, some tone reducing orthoses have been reported (Sussman, 1979; Zachazewski, 1982; Bronkhorst, 1987). However, comprehensive studies have not been performed on these orthoses.

The side effect of the heel lift provided by the orthosis should be studied in respect of the need for corresponding limb length correction of the sound side to improve the gait pattern. In the Japanese life style, the heel raised shoe of the sound side must be removed so the limb length discrepancy will be emphasised. However the increased stability of the affected limb provided by the orthosis improves walking ability in the house without correcting limb length discrepancy.

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Patellar band for patellofemoral disorders: results and indications

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Abstract

In patellofemoral disorders, some cases respond well to conservative management thus the authors' initial treatment is conservative. The Patellar Band (PB) was reported previously (Nakamura *et al.*, 1987). Since then the indications for the band have been investigated. Sixty four patients treated by the PB without operative treatment were classified into eight groups. The Severity of Dysfunction (SOD) was assessed by three grades. The First Grade is dull pain after walking or running for a long distance, the Second Grade is sharp pain on climbing up and down stairs, the Third Grade is a feeling of insecurity. The grouping was as follows: Group Ia — plica syndrome with First Grade of SOD and Ib with Second Grade of SOD. Group IIa — chondromalacia with First Grade of SOD and IIb with Second Grade of SOD. Group III — maltracking patella with patellar pain on flexion. Group IVa — subluxation or dislocation of patella with no previous history of patellar symptom and IVb — recurrent dislocation. Group V — degenerative change of the patella. The PB has been proved to be most effective in Groups Ia, IIa and IVb although it is beneficial in half the cases in Groups IIb and III. The subluxation of the patella was partially reduced without recurrence of dislocation during sports activity and the feeling of insecurity was relieved by the PB. The overall results were not related to age or activity level of the patient. The indication of the band for painful knees was not clearly determined in this study. In all operated cases, it was effective for postoperative instability after lateral release of the retinaculum.

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Introduction

In patellofemoral disorders, two main problems are pain and instability of the knee. The origins of these disorders may be from the plica of the synovia, haemodynamic abnormality of the patellar spongiosa, subchondral bone in chondromalacia of the articular cartilage or subluxation or dislocation of the patella on extension of the knee which may be attributable to increased Q-angle and sulcus angle. The maltracking patella may be attributed mainly to contractured retinaculum and lateral tilt of the patella which cause pain on flexion due to excessive pressure on the lateral facet. The severity of dysfunction in this disorder should be determined before treatment. The authors developed the Patellar Band (PB) in co-operation with the Nakamura Brace Company (Nakamura *et al.*, 1987). Since then the PB has been used all over the world. In this paper, the results are reported of conservative treatment by this band and an attempt is made to determine the indications for its use.

Method

Patient group

Some 64 cases were available for a follow-up

Table 1. Age distribution.

Age	Numbers
10–19	13
20–29	6
30–39	3
40–49	7
50–59	18
60–69	17
Total	64

study over the past 8 years. Their age distribution is shown in Table 1.

Score scale

The scores were obtained by subtracting the total points allocated to each item from 50 before and after application (Table 2). The items consisted of pain, instability, severity of dysfunction and physical findings.

Severity of dysfunction (SOD)

It is important to determine by close interview with the patient which dysfunction is the main problem.

First Grade — dull pain appears after walking or running for a long distance which is ascribed from low grade pressure on the surface for a long period or/and repetitive stretching and oedema of the plica.

Second Grade — sharp pain appears on kneeling or going down the stairs which is due to high grade pressure on the articular surface of chondromalacia patellae, occasionally being accompanied by synovitis or bursitis.

Third Grade — feelings of insecurity and pain which are due to subluxation and maltracking of the patella.

Table 2. Score scale.

Pain		
none		(0)
mild —	dull pain, after sports or work	(−5)
moderate —	constant pain on motion	(−10)
severe —	severe pain and limited range of motion	(−15)
Instability		
giving way or locking		(−5)
insecurity or fear of dislocation		(−15)
dislocation and history of dislocation		(−15)
Severity of dysfunction (SOD)		
First Grade —	pain occurs on a prolonged walking	(−2)
	a prolonged bent knee position	(−2)
Second Grade —	pain occurs on going down stairs	(−2)
	on squatting	(−2)
Third Grade —	instability occurs on running or jumping	(−2)
Physical findings		
synovitis		(−2)
apprehension sign		(−2)
facet tenderness (medial or lateral)		(−2)
plica sign		(−2)
quadriceps atrophy		(−2)

Classification of the cases

Group Ia (n=5) — Plica syndrome, First Grade of SOD

Ib (n=0) — Plica syndrome, Second Grade of SOD

In the arthrography, suprapatellar and mediopatellar plicas are demonstrated.

Group IIa (n=11) — Chondromalacia, First Grade of SOD

IIb (n=8) — Chondromalacia, Second Grade of SOD

Tenderness is elicited on the facets of patella, Retinacular contracture and arthroscopic findings are positive.

Group III (n=12) — Maltracking patella, tilting of the patella on skyline views.

Sponge sign is positive. SOD is Second or Third Grade.

Group IVa (n=0) — Traumatic dislocation.

IVb (n=1) — Recurrent dislocation, no definite trauma. Apprehension sign is strongly positive with some roentgenographic abnormalities.

Group V (n=27) — Osteoarthritis of the patella, early degener-ative change without varus deformity.

Criteria of results

Excellent — the score at follow-up ranges from 46 to 50, no pain and normal activity including sports:

Good — the score ranges from 40–50. Occasional discomfort or mild pain. Pain much relieved and subsides by application of the band for a few days if it recurs:

Fair — the score ranges from 30–39. Slight relief of pain is obtained, although surgical treatment is required in some cases:

Poor — the score is less than 29. No relief of pain is obtained.

Table 3. Duration of application (n = 64).

RESULTS	AVERAGE (months)	S.D.
EXCELLENT	9.08	11.04
GOOD	7.33	11.07
FAIR	3.12	2.25
POOR	1.80	1.17

a few days~48 months
(Average 5.2 months, S.D. 6.52)

Degree of activity level

First degree — housewife, deskworker, only enjoying sports:
Second degree — student, belonging to sports circle:
Third degree — outdoor worker, sportsman, obese patient.

Decision on prescription

The patients who have the First and Third Grades of SOD were asked to climb up and down the stairs at the clinic. If they felt comfortable and had some relief of pain with stability at that time, the PB was prescribed.

Instruction to patients

During the first week the PB should be applied for about 2 hours in the morning and 2 hours in the afternoon with a break between. Complications include redness of skin, dermatitis or sweating problems.

The following weeks it should be applied during the daytime or during activity of sports or working.

In periodic application for osteoarthritis it should be applied during the painful period. If the patient feels comfortable he may remove it after the pain subsides until there is recurrrence of the pain.

Table 4. The overall results in each group.

GROUP	EXCELLENT	GOOD	FAIR	POOR
I A	4	0	1	0
II A	8	3	0	0
II B	2	2	3	1
III	5	2	5	0
IV B	0	1	0	0
V	3	8	9	7
Total	22	16	18	8

Table 5. The results in each decade of age.

	Excellent	Good	Fair	Poor
10~19	8	3	2	0
20~29	3	1	2	0
30~39	2	0	0	1
40~49	2	3	2	0
50~59	5	4	5	4
60~69	2	5	7	3
Total	22	16	18	8

Contraindications

It should not be applied until synovitis of bursa or hydrops of the knee subsides. Occasionally pain around the knee may originate from the lumbosacral region in which case the PB is contraindicated.

Results

The duration of application ranged from a few days to 48 months, averaging 5.2 months. Table 3 lists the results against the average duration of application.

The average scores were 35/50 (before application/at follow-up) in Group I, 25.2 (range from 22 to 28)/47.2 (from 42 to 50) in Group IIa, 23.0 (from 21 to 26)/42.6 (from 24 to 50) in Group IIb, 22.8 (from 19 to 26)/43.0 (from 37 to 50) in Group III, 15 (from 14 to 16)/ 46 (from 42 to 50) in Group IVb.

Table 4 displays the results obtained in the different Groups.

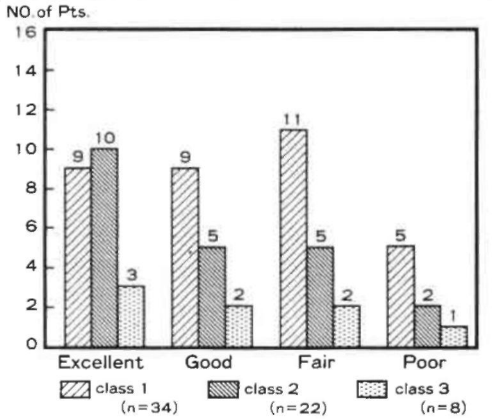
The best results were obtained in the age groups of less than 20 and more than 50 (Table 5).

In the First Grade of SOD, satisfactory results were gained in 15 out of 18 cases (83%), Fair to Poor accounted for 3 cases (17%) (Table 6). In the Second Grade, Excellent to Good constituted 14 out of 31 cases (45%). In Fair to Poor there were 17 cases (55%). In the Third Grade, Excellent to Good there were 9 out of

Table 6. The results in each grade of SOD.

	I	II	III
EXCELLENT	10	7	5
GOOD	5	7	4
FAIR	2	11	5
POOR	1	6	1
Total	18	31	15

Table 7. The results in each degree of activity level.



15 cases (60%), and in Fair to Poor 6 cases (40%).

Activity level was divided into three classes (Table 7). In Class I, Excellent to Good showed 53%, and Fair to Poor 47%. In Class 2, Excellent to Good represented 68% and Fair to Poor 32%. In the Class 3, Excellent to Good showed 63%, Fair to Poor 37%.

Discussion

The patients with recurrent subluxation of the patella have worn the patellar band initially during the daytime for 2 to 4 years and then only during sports activities because insecurity of the patella almost subsides although apprehension signs remain. In Groups I, II and III, they wear the device only during sports activity. In Group V, the osteoarthritic patients wear the device during painful period, for example, they wear it for 5 to 7 days and may remain painless without application for the rest of the month.

The authors considered that in the most cases with suprapatellar plica as in Group Ia, complete relief of pain might be obtained, but in plica mediopatellaris, although some relief might be obtained surgical removal was eventually required in most cases. In the knees with pain and swelling, there was no effect obtained by the PB although it was effective after subsidence of synovitis. In Group III, it was very effective in those patients who complained of mild pain which subsided but most wished surgical treatment.

In Group V of more than 50 years old, the PB showed slight to moderate relief of pain in less active patients.

SOD should be decided by close interview with the patients, since the PB is most effective

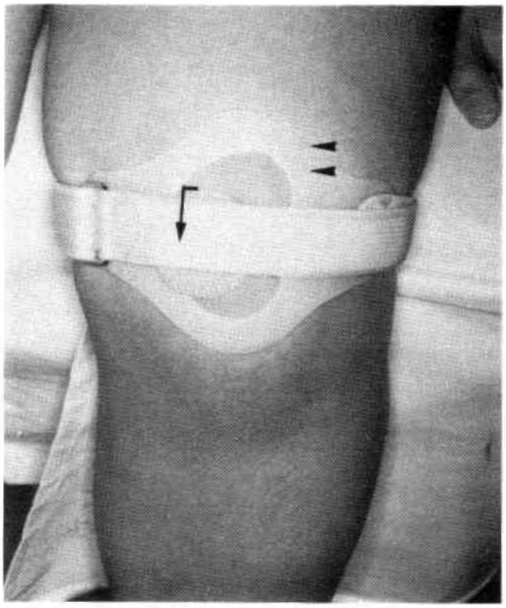


Fig. 1. The patellar band of modified type was applied to a 16 years old girl of Group IVa. This band consisting of semi-lunar cut-out of silicon and patellar pad relieved her feeling of instability since use of conventional type was not effective.

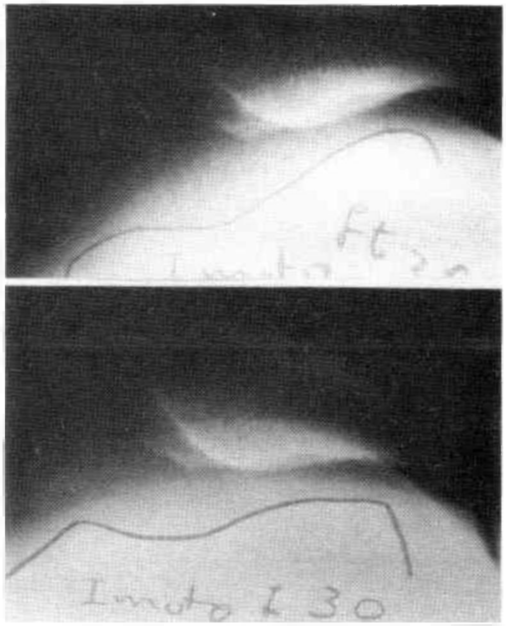


Fig. 2. 26 years old with recurrent dislocation of bilateral knees since 13 years old. (Above) The roentgenogram indicates skyline view in 30° of flexion without PB. (Below) Skyline view with PB.

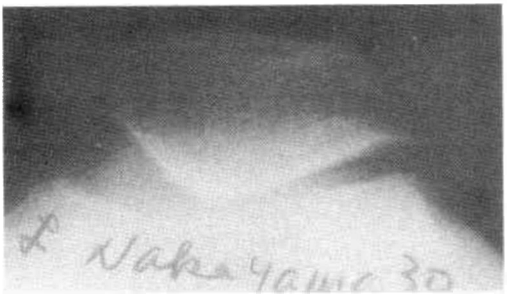


Fig. 3. 62 years old male in Group V. The skyline view revealed sclerotic bone change of the articular surface of patella. Pain was relieved by its application for a few days and subsided for the rest of the month without it.

in the First Grade. Dull pain or stiffness of the knee may occur from a repetitive low pressure burden on the cartilage for a long time. In this situation, the PB may relieve abnormal impact by realignment of the patellofemoral joint. In the Second Grade pain prevails over instability so its effect was almost 50%. Lateral release may relieve pain although instability increases to some extent postoperatively and the PB holds the patella in the groove so that patients notice improved stability of the knee on walking. After removal of suture, the PB has been worn in all patients who have received lateral release of the retinaculum. In the third grade of Group IV, anxiety of dislocation is relieved by wearing the PB although eventually most of them have been treated surgically except for two cases.

In regard to the degree of activity there is no definite interference by the patellar band. Some volley ball players or baseball players use the PB successfully during sports activity.

The band should be applied to those patients who have mild pain of First Grade of SOD and insecurity in patellofemoral disorders and minimal joint laxity due to cruciate ligamentous injury and impaired sensation around the knee. It is beneficial in relieving pain and gaining stability on walking and kneeling.

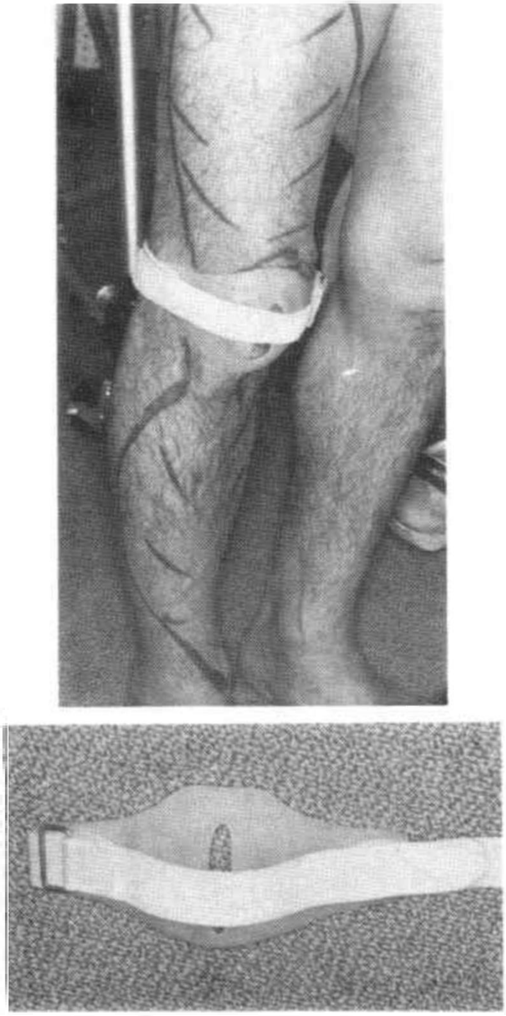


Fig. 4. 53 years old male with injury of lumbosacral plexus found possible to kneel easily by its application. (Above) Shaded area indicates impaired sensation, (Below) Special type of PB.

Summary

1. The PB was most effective in Groups Ia, IIa and IVb but in Groups IIb, III and IV only half of the cases were effective.
2. The subluxation of patella was partially reduced without subsequent dislocation on skyline view of 30° flexion.
3. Its effectiveness was not related to age or activity of the patients.
4. Feeling of insecurity and giving way were relieved in most cases, but the indication of this band to painful knees was not clearly determined.
5. In all operated cases, it was effective for postoperative instability after lateral release of the retinaculum.

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A Swedish knee-cage for stabilizing short below-knee stumps

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Abstract

Stump length is an important factor in attaining successful prosthetic rehabilitation in below-knee (BK) amputees. Stability of the stump-prosthesis complex is impaired in the case of a stump shorter than 10 cm. Thus, fitting a prosthesis to a BK amputee with a stump which is very short often requires the use of different prosthetic techniques. In this work, the authors suggest the use of a Swedish knee-cage attached to a conventional patellar-tendon-bearing prosthesis as an alternative solution in the case of a short BK stump. Objective evaluation was performed by an analysis of gait and the foot-ground reaction forces. The results obtained indicate an improvement in all the measured parameters resulting from the modified stump-prosthesis complex.

Introduction

When the stump of a below-knee (BK) amputee is very short, the horizontal and longitudinal dimensions are similar. In such cases, the stump acquires a round shape and becomes unstable inside the prosthetic socket. A short stump inside a conventional patellar-tendon-bearing (PTB) prosthesis is often unstable during ambulation. Instability of the stump-prosthesis complex even during short ambulation creates shear forces with resulting pain, blisters or friction sores.

A basic mathematical model of such a stump was described by Nissan (1977). The problem of instability, especially evident in the mediolateral direction, can be resolved by some technical methods in current use. The first of these is a thigh corset with side-bars attached to a conventional PTB prosthesis. Such a construction creates an upper extension to the prosthetic socket. The stability of the stump is achieved by means of the forces applied by the corset to the amputee's thigh. Secondly a supracondylar PTB prosthesis may be provided. The proximal extensions of the socket's lateral borders create an effective lengthening of the prosthetic socket and add mediolateral stability to the stump. A third solution was proposed by Seliktar *et al.* (1980) using a posterior shutter which deepens the posterior wall of the socket. This shutter can be pushed down during sitting and it is pulled upwards by a rubber band during walking.

In this work the authors propose an alternative solution to the problem. A pre-fabricated Swedish knee-cage (SKC) is used, attached to a conventional PTB prosthesis. The SKC was first described in 1968. It is a device employing a three-point pressure system constructed originally for controlling hyperextension of the knee during ambulation in patients with a Charcot joint deformity. It was assumed that when added to the PTB prosthesis improved stability in the mediolateral and posterior directions could be accomplished. Analysis of gait and foot-ground reactive forces was performed to evaluate the subjects' performance objectively.

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Table 1. Subjects' characteristics.

Subjects	Age	Sex	Stump length (cm)	Affected side	Amputation (years)
C.A.	69	M	9	left	45
G.A.	51	M	8	right	16
K.E.	40	M	6	right	3
A.I.	28	M	10	left	11
S.B.	42	M	9	left	6
K.A.	43	M	9	left	16

Subjects and methods

Six BK amputees volunteered to participate in this investigation. All had a stump length of 10 cm or less, measured by x-ray. Characteristics of the subjects are presented in Table 1. All had been visiting the outpatient clinic frequently, complaining of severe stump pain, recurrent pressure or friction stump sores and a sensation of instability of the stump-prosthesis complex during ambulation. Current prosthetic mechanical solutions for prevention of stump instability were found to be ineffective. Therefore they were all fitted with a SKC attached to their own conventional PTB prosthesis.

The SKC consists of two plastic coated aluminium side bars connected posteriorly by a semicircular horizontal bar (Fig. 1). When attached to the prosthesis socket rim, it provides the stump with mediolateral and posterior stability, both during standing and ambulation (Figs. 2 and 3). For evaluation of the SKC+PTB prosthesis combination, analysis of gait quality was performed using two methods. First, by measuring gait parameters as suggested by Mizrahi *et al.*, (1982). Time-distance and speed were measured by a 5 m long electrical contact system installed within a 10 m walkway. Stance-phase time, stride distance and velocity were all measured.

Secondly, the foot-ground reaction forces were measured (Mizrahi *et al.*, 1986). For this purpose, a force measuring system consisting of two "Kistler" Z-4305 platforms were used. The foot-ground reaction forces (Fig. 4) in the vertical (Fz), anteroposterior (Fy) and mediolateral (Fx) directions were

Fig. 1. Swedish knee-cage.

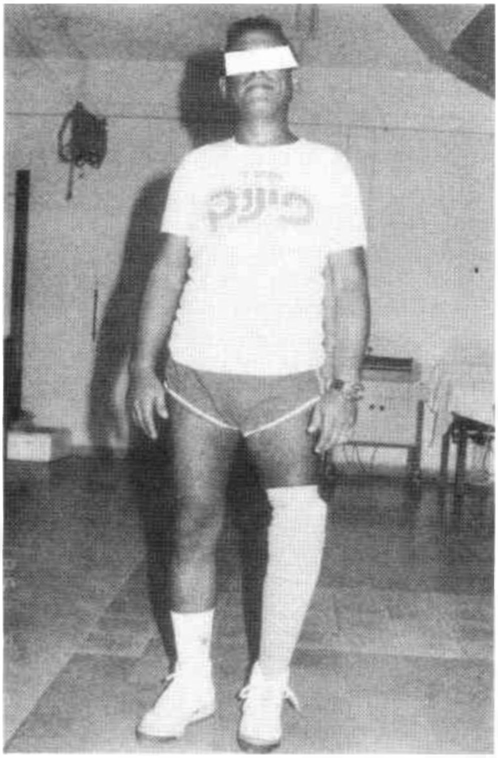

Fig. 2. Severe lateral instability of the stump-prosthesis complex during standing.

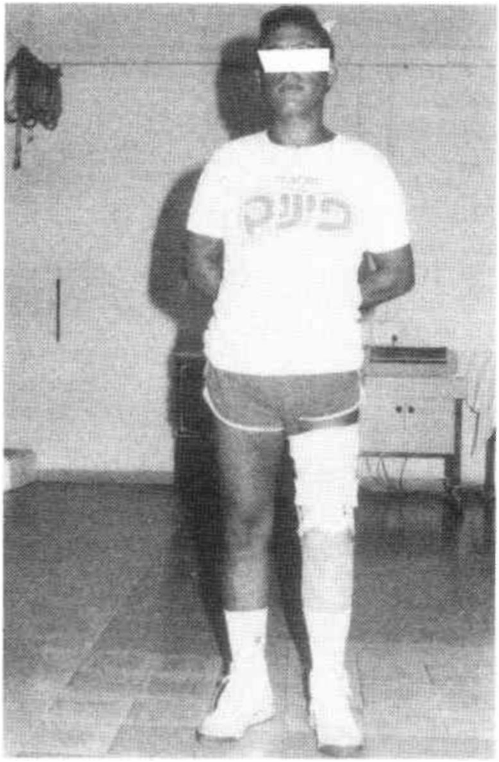

Fig. 3. **Excellent alignment of** the lower limb achieved when using a SKC attached to a conventional PTB prosthesis.

simultaneously monitored for both limbs. Signals from the electrical contact system walkway and from the "Kistler" force plates were routed to an on-line IBM PC and analysed. The subjects were tested in a random order, while ambulating with conventional PTB prosthesis only, and with SKC+PTB prosthesis combination. Each test was composed of 3 trials. The subjects rested for at least 15

Table 2. Overall mean results of gait parameters. Note also percentile improvement in gait quality obtained with PTB+SKC prosthesis.

Parameters	PTB Prosthesis	PTB+SKC Prosthesis	Improvement
Stance phase* (sec)	0.49	0.20	145%
Stride distance (cm)	80	114	45%
Velocity (m/min)	30.3	48.3	59%

*(Expressed as mean difference between left and right leg stance phase.

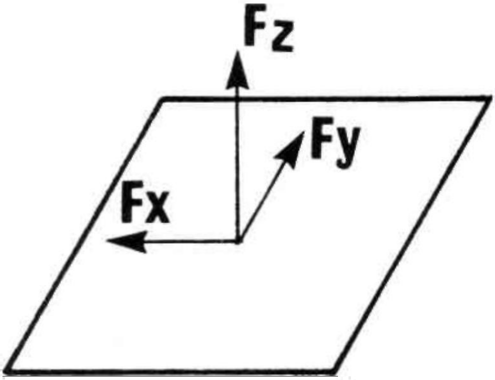

Fig. 4. Schematic diagram of the "Kistler" force plates and the measured variables.

minutes between each trial. The results presented were the average obtained for all subjects.

Results

Three different parameters of gait were analysed (Table 2). The results presented were the averages obtained for all 6 subjects. The differences between sound and amputated leg stance time, obtained by separately measuring for the sound and amputated legs, were 0.49 seconds while walking with the PTB prosthesis only and 0.20 seconds with the PTB+SKC complex. Stride length improved from 0.80 to 1.14 m. Speed of ambulation improved from 30.3 to 48.3 m/min.

Symmetry between limbs foot-ground reaction forces, expressed in percentages, are detailed in Table 3. Complete symmetry is obtained whenever the acting forces are of equal magnitude, 50% in each leg. Symmetry improved in all measured forces while ambulating with the PTB+SKC complex. Asymmetry in the mediolateral force (Fx) decreased to only 1.6%, the anteroposterior force (Fy) asymmetry decreased to 15% and the vertical force (Fz) asymmetry became only 6.9%.

Table 3. Percentile representation of the foot-ground reaction forces as divided between legs during ambulation.

Force	PTB Prosthesis		PTB+SKC Prosthesis		Improvement in symmetry
	R	L	R	L	
Fx	57.7	42.3	51.6	48.4	7.7 → 1.6
Fy	71.2	28.8	65.0	35.0	21.2 → 15.0
Fz	58.4	41.6	56.9	43.1	8.4 → 6.9

Discussion

Stump length is the major factor determining stability of the BK stump inside the prosthetic socket and consequently the quality of gait. Although amputation surgery is a constantly improving process, there are still cases where it is not possible to construct a sufficiently long BK stump. Even though an unduly short BK stump might create prosthetic problems, it is still advisable to make efforts to save the knee joint. The presence of the knee joint provides the amputee with proprioceptive information, a better equilibrium and most of all, a lower energy demand in ambulation (Waters *et al.*, 1976; Huang *et al.*, 1979; Isakov *et al.*, 1985).

From the point of view of the rehabilitation team, an amputee with a short BK stump is still a prosthetic challenge. A firm stump inside the prosthetic socket is very important for preventing stump pain, sores and scars. In fact, a successful fitting of a prosthesis for amputees whose stumps are shorter than 10 cm is difficult. The different mechanical techniques used in attempting to create a good stump-socket adaptation and stability sometimes fail.

In this study, the SKC+PTB prosthesis combination has been evaluated as the suggested technical solution in cases of a short BK stump. The results in 6 patients demonstrated an improvement in all the measured gait parameters. Differences between the stance time of both legs decreased by as much as 145%, the mean stride length improved by 42% and the speed of ambulation improved by 59%.

Symmetry in foot-ground reaction forces between both limbs also improved when using the SKC+PTB prosthesis. These forces tend to be equal in both limbs in the normal subject. Improvement was noted in all the three force directions measured.

As compared to a corset, the SKC is less cumbersome, more aesthetic, does not interfere with the knee joint range of motion, is light-weight, and easy to fit. A better stump stability allows an improved control during each step, together with a better gait performance. Therefore, in cases of a short BK stump, the combination of SKC+PTB should be considered as an alternative technical solution.

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Mathematical modelling and field trials of an inexpensive endoskeletal above-knee prosthesis

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Abstract
The swing-phase motion of the shank of an above-knee prosthesis has been modelled mathematically. An inexpensive endoskeletal prosthesis was designed using the Jaipur foot and conduit pipes with a hinge joint for the knee. Results of field trials and the modelling indicate that a very simple above-knee prosthesis can give near normal gait at "normal" walking speeds on flat surfaces. The swing of the shank is most sensitive to the timing of toe-off.

Introduction

The conventional above-knee (AK) prosthesis poses two major problems for amputees in many low income countries. The usual pelvic suspension system, with its metallic hinge joint at the hip, does not permit abduction and external rotation which is essential for cross-legged sitting on the floor. The rigid thigh and leg pieces of the exoskeletal limb strike against each other when attempting full knee flexion and so the amputee cannot squat. In normal squatting full knee flexion is made possible because the soft tissues of the thigh and knee can be pressed and flattened against each other. Since a Western amputee does not usually assume this posture, the knee joints of most prostheses do not cater for full knee flexion.

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The Jaipur AK limb was therefore designed to permit these postures so essential to the Indian life style where floor sitting is a social norm. The rigid metallic hip joint was replaced by flexible leather straps for suspension, allowing freedom of movement in all directions; a posterior elastic strap was strategically located to tighten when sitting cross-legged, thereby keeping the socket pulled up snugly against the stump.

To permit squatting, the endoskeletal concept was utilised. The soft foam covering of the prosthesis can flatten when pressed during full-knee flexion. A new design of knee joint was designed. It not only allowed for full knee flexion but also had an offset hinge to provide alignment stability during the stance phase of walking. An additional locking system was provided as a safety measure. It may be emphasised that the endoskeletal concept was not used as a labour saving device but primarily to allow amputees to squat.

Aluminium sheet was used to fabricate classical quadrilateral sockets and conduit steel pipes for load bearing. The offset single-axis knee-joint and the Jaipur foot (Sethi *et al.*, 1978) are fixed to conduit pipe using a shrink fit technique.

A saucer-shaped aluminium alignment disc is fitted at the top and a static alignment is secured by placing this disc below the socket and temporarily brazing the two together at a few points. The patient is then made to walk and adjustments in alignment are made if required. Once a satisfactory fit and alignment

Fig. 1. Amputee fitted with Jaipur above-knee prosthesis without its foam covering.

are obtained, the alignment disc is securely welded to the socket. A foam covering and a special latex treated cloth cover is then used to provide a proper shape to the limb with a waterproof tear-resistant skin which can withstand the rough exposure of a rural environment. A patient fitted with a Jaipur AK Prosthesis is shown in Figure 1.

The theoretical limits of performance of this AK prosthesis were evaluated with the help of a mathematical model for the swing-phase and limbs were fitted to 200 amputees for field evaluation. (This work was done at the Jaipur Centre.)

Mathematical modelling

A number of studies (Maillardet, 1977; Mena *et al.*, 1981; Mochon and McMohan, 1980) have shown that an unconstrained pendulum can approximate the swing-phase motion of the shank since muscles do not play a significant role except in the initial and final stages of the swing-phase (Eberhardt *et al.*, 1968; Maillardet, 1977; Mena *et al.*, 1981). Therefore in this study a mathematical model based on pendulum motion was used to simulate the swing-phase of the prosthesis under different conditions. The objective of the study was to determine the optimal location of the centre of gravity of the prosthesis and also its limitations under different conditions of walking. For the purposes of this analysis the use of the Jaipur Foot and mild steel conduit pipes were taken as given (Fig. 2). The nominal mass of the shank and foot was 1.4 kg. It was assumed that extra mass could only be added along the shank of the prosthesis and a limit of 1.5 kg was fixed for this extra mass M so that the total mass would not exceed 3.0 kg.

The shank was assumed to behave like a pendulum free to rotate about the knee joint. It was also assumed that the prosthesis from the knee downwards was a rigid body which moves through space in the swing-phase under the influence of gravity and a specified trajectory of the knee. The trajectory of the knee was obtained from the literature (Radcliffe, 1976) for "normal" gait on level ground at 95 steps per minute at a speed of 1.1 m/s.

It was assumed that the amputee can move the stump like a normal person hence providing a "normal" knee trajectory for the prosthesis. Then the equation of motion (Langrangian) for the shank in the swing-phase with a frictionless knee-joint can be shown to be

$$\ddot{\theta} = - \frac{Wr}{I_o} \left[\ddot{Y} \cos\theta + (\ddot{Z}+g) \sin\theta \right]$$

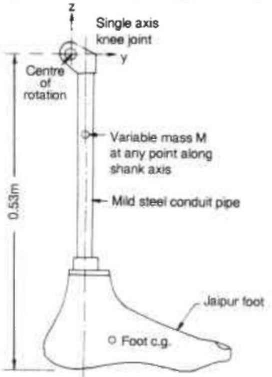

Fig. 2. Lower leg of a simple above-knee endoskeletal prosthesis with single axis knee joint. Mass of leg with M=O is 1.4 kg.

where the terms specified are defined as:

g = The acceleration due to gravity

I_o = Moment of inertia of the shank and foot at the centre of the knee joint about hinge axis

W = Total mass (shank + foot + variable mass M)

r = Distance of centre of gravity (of shank and foot) from the centre of the knee joint

y, z = Cartesian co-ordinates, y-horizontal, z-vertical

Y, Z = Displacements of the knee along y (forward) and z (upward) directions

$\ddot{Y}, \ddot{Z}$ = Accelerations of the knee along y and z directions

θ = The flexion-extension angle of the shank with respect to the vertical, positive in anti-clockwise direction

$\ddot{\theta}$ = Angular acceleration of the shank.

Polynomial curves were fitted to the knee displacement data using a least square technique and integration of the above equation was done numerically using the Merson's form of the 4th order Runge Kutta method. All computations were done on an ICL 2960 computer.

In order to check the sensitivity of shank motion to friction at the knee joint a few calculations were made assuming different values of the coefficient of friction. The effect of friction was found to be negligible for values of coefficient ranging from 0 to 0.4. This is so because the diameter of the pin is very small and so the moment generated by the mass of the limb is much larger than the moment due to friction.

Therefore, for all other analyses in this study the knee joint was assumed to be frictionless. No knee-stop was provided in the model and so the shank was free to assume a hyper-extended position. Each calculation was terminated at the time of expected heel-strike. Shank position was determined by calculating the shank angle with the vertical at different points in time from toe-off to heel-strike.

Results

The shank motion was found to be very sensitive to the value of angular velocity and instantaneous values of vertical acceleration of the shank at toe-off.

The motion of the shank was less sensitive to the location of the centre of the mass. Given the constraints of the geometry of the prosthesis and limitations on maximum allowable mass, it was found that only small variations can be made in the swing-phase motion by altering inertial properties alone.

However, these findings indicate that at "normal" walking speeds on level ground the

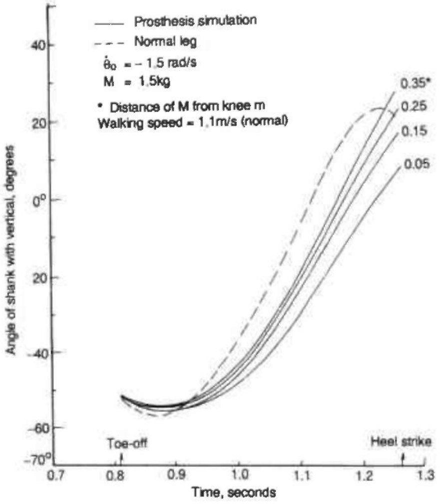

Fig. 3. Effect of angular velocity at toe-off on motion of shank.

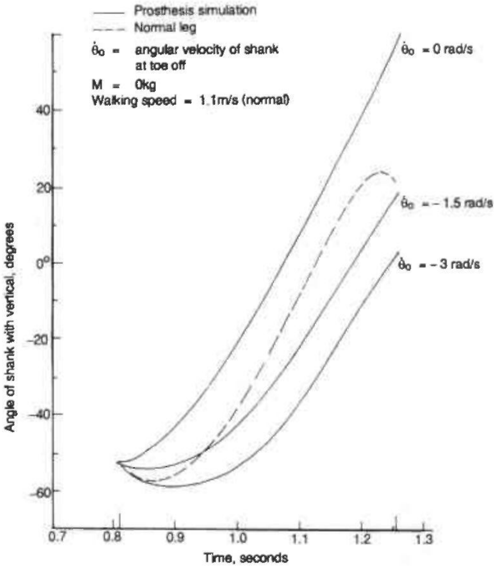

Fig. 4. Effect of position of centre of gravity of prosthesis shown by shifting the point mass M along the shank axis.

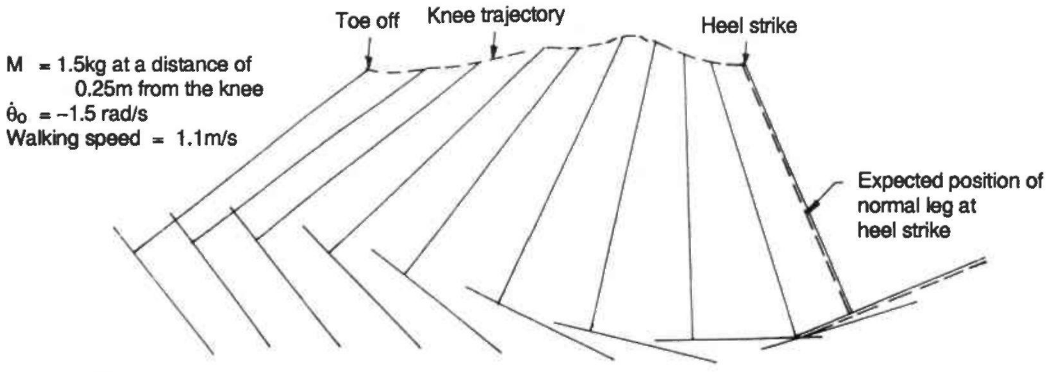

Fig. 5. Prosthesis reaches the correct position at heel-strike if the timing of toe-off is correct.

shank goes through the gait phase owing to ballistic motion alone. This shows that minimal muscle activity is needed to swing the shank during walking at constant normal speeds. This ballistic motion would have to be controlled by much greater muscle activity at other speeds. This explains why energy consumption is so low at "normal" walking speeds.

Figures 3-8 show the successive positions of the prosthesis in swing-phase. These stick diagrams give the impression that the amputee can trip in mid-swing. This is because: (a) The hip trajectory of a "normal" person has been used. Amputees, presumably raise their hips slightly for the prosthesis to clear the ground surface. (b) In the case of normal persons there is movement at the ankle which allows them to clear the ground. This has not been simulated as our interest is mainly in the role of the free swing of the shank.

The results show that for a given mass, geometry and location of centre of mass of the shank the walking speed cannot be varied very much. Within allowable limits of these parameters, "normal" gait can only be obtained if walking speeds are kept around 1.1 m/s to 1.2 m/s. Results are shown in Figures 3 to 8.

Clinical observations

Over 200 such limbs have been followed up for over three years and while problems are being faced with regard to the durability of the knee joints, the amputees seem to be pleased not only because they can squat but because the limb is much lighter. Many amputees who were earlier using the exoskeletal limb were provided with the endoskeletal version and most of them preferred the latter.

The alignment stability provided by the offset knee joint makes them feel so secure that most of them do not require to lock the knee when walking on a level surface. There is observed a remarkably improved swing-phase after a little practice. The stride length and speed of walking

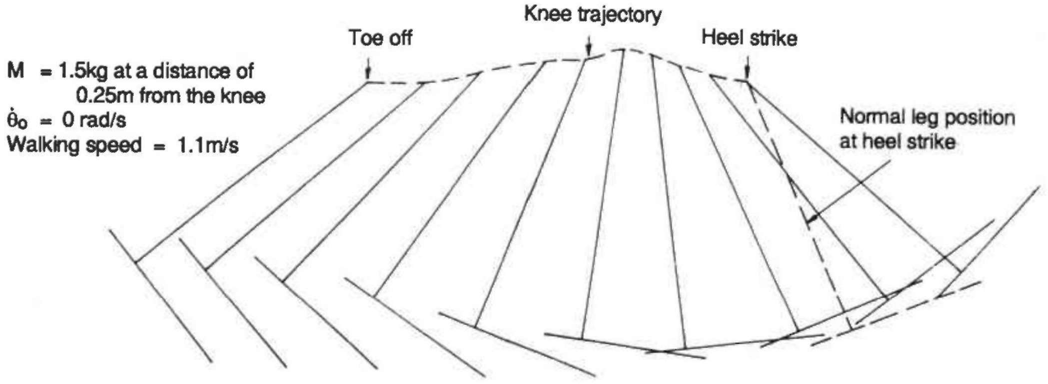

Fig. 6. Prosthesis reaches correct heel-strike position far too early if prosthesis lifted even a little bit early at toe-off.

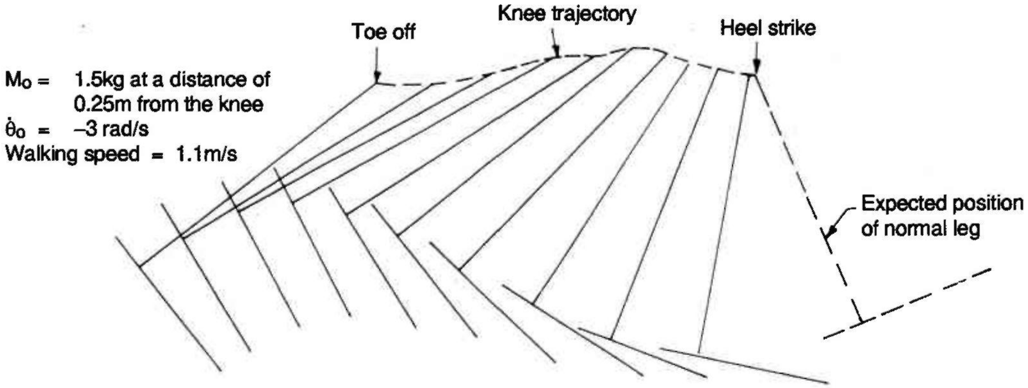

Fig. 7. Prosthesis does not reach correct heel-strike position in time if toe-off is delayed by a fraction of a second.

is adjusted to an optimum level to provide a near-natural gait. Altered speeds of walking do pose problems. Since there is no friction at the knee, the leg continues to swing till it abruptly comes to a halt with an audible snap. The temptation to add friction etc. was resisted in order to retain a basic simplicity and a low cost. These are important considerations in low income countries.

Discussion

It is slowly being recognised that poor amputees from rural areas in India do not avail themselves of rehabilitation services unless the period of stay at a limb fitting centre is of small duration and the prosthesis provided does not need frequent repairs. The AK prosthesis described above is made from locally available materials and can be fitted in a relatively short time.

The results above indicate that at average walking speeds it is possible to optimise the swing-phase of the shank by an appropriate location of the centre of mass and by controlling the timing of the toe-off so that the shank can swing into the right position for heel-strike. The finding that the timing and inclination of the footpiece at the toe-off phase of the prosthesis largely determines the swing-phase characteristic is interesting. Most amputees seem to learn this after a variable period by trial and error, but this observation can be built into the gait training progamme with considerable advantage.

If the mass of the footpiece is reduced then it would be easier to shift the location of the centre of mass by shifting a weight along the shank thus allowing for alterations in walking speed. Therefore it should be feasible to design a simpler alternative to the use of more

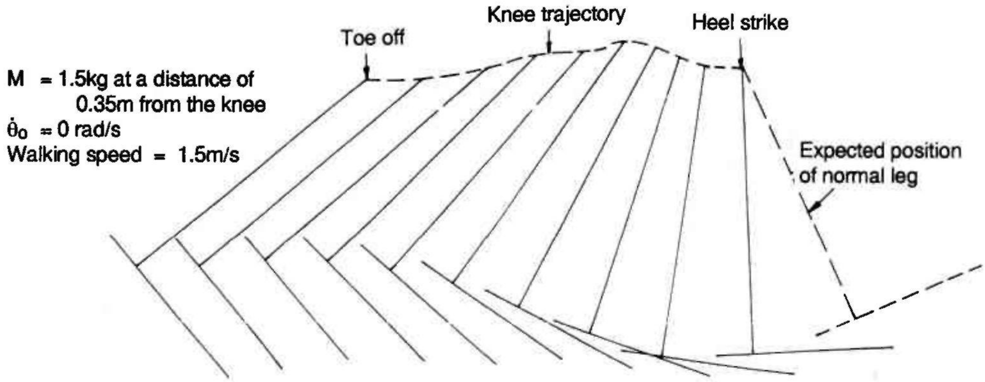

Fig. 8. Prosthesis does not reach correct heel-strike position in time if walking speed is higher than normal (36% greater in above example).

complicated and therefore more expensive knee mechanisms. Further studies seem to be called for to exploit this finding so that an AK prosthesis more suited for the rural populations of India can be developed.

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Rehabilitation after amputation for vascular disease: a follow-up study

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Abstract

Rehabilitation of one hundred and twenty eight patients with lower limb amputation performed for vascular disease from 1979 to 1987 was assessed. Arteriosclerotic occlusive disease was the most frequent cause of amputation (85.9%). Sixty seven patients (52.3%) were diabetic. Early and late results were analysed. For long-term follow-up evaluation, Univariate method of Kaplan-Meyer product limit was employed. Multifactorial analysis was used to assess factors influencing mortality. On immediate evaluation of rehabilitation with a prosthesis 85.2% of patients were successfully fitted. On long term evaluation 47.8% of below-knee and 22.1% of above-knee amputees were alive and using the prosthesis full time at five years of follow-up (p=0.0026). Opposite limb preservation at five years was 69.5% for diabetics and 90.2% for non-diabetics, respectively (p=0.0013). Survival rate at five years was 42.4% for diabetics, and 85.0% for non-diabetics (p=0.0002). On multifactorial analysis diabetic patients showed a risk of late mortality six times greater than non-diabetics. In conclusion rehabilitation after vascular amputation is feasible in a large number of patients, despite a limited life span. Diabetes represents a major risk factor both for life and for the opposite limb. Knee preservation is an important factor for better rehabilitation.

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Introduction

Rehabilitation after amputation due to vascular disease presents special features that make this group of patients particular. Advanced age, associated diseases, and vascular involvement of the opposite limb are examples of these peculiar conditions. The fate after vascular amputation is not well known in terms of rehabilitation possibilities and life span of this population (Chilvers and Browse, 1971; Weaver and Marshall, 1973; Harris *et al.*, 1974; Jamieson and Hill, 1976; Finch *et al.*, 1980).

The objective of this study is to assess rehabilitation in respect of walking capability, when using a prosthesis, according to the level of amputation, as well as to analyse the influence of diabetes mellitus in long term patient survival and contralateral limb preservation.

Patients and methods

From August 1979 to August 1987, 128 consecutive patients with lower limb amputation due to peripheral vascular disease were evaluated. Ninety nine were male (77.3%) and 29 female (22.7%). The age distribution is shown in Table 1. The median age was 62 years. Sixty seven patients (52.3%) were diabetic. Arteriosclerotic occlusive disease was the most frequent cause of amputation (85.9%).

One hundred and seventeen patients were unilateral amputees (91.4%), and 11 were bilateral (8,6%). Of the unilateral patients, 65

Work done at the Limb Preservation and Fitting Centre of São Paulo, São Paulo, Brazil.

Table 1. Age and sex distribution

Age	Sex M	Sex F	Total	(%)
0–9	1	0	1	0.8
10–19	2	0	2	1.6
20–29	2	1	3	2.3
30–39	4	2	6	4.7
40–49	9	2	11	8.6
50–59	23	3	26	20.3
60–69	35	14	49	28.3
70–79	20	7	27	21.1
80–89	3	0	3	2.3
Total	99	29	128	100.0%

(55.5%) had amputation below the knee, 40 (34%) above the knee, 10 (8.5%) through the knee, 1 had a Syme and 1 a Chopart amputation (0.8%). Among patients with both limbs amputated 5 (45%) were bilateral below-knee (BK), 2 (18%) were BK on one side and above-knee (AK) on the other, 2 (18%) were bilateral AK, 1 (9%) had Syme bilaterally and 1 (9%) was BK on one side and transmetatarsal on the other (Table 2).

Distribution according to age group (Table 3) and amputation level showed correlation with diabetes (Table 4).

Patients were referred to the rehabilitation centre only after amputation for initial evaluation. No patient had ever used a prosthesis before. Prosthetic fitting was attempted after medical and physiotherapeutic treatment in all the 128 cases. This was done in the specialised centre in a team approach, including one vascular surgeon, one orthopaedic surgeon, physical therapists, co-ordinating nurse and prosthetic technicians.

Immediate results were analysed in terms of restoration of bipedal gait. Outcome was assessed by personal interview with patients or by relatives' information in case of death. No patient was lost to follow-up. At the last consultation (average follow-up of 24.6 months) patients were classified according to the use of a prosthesis in three categories: non-wearers, partial wearers and fulltime wearers.

Table 2. Distribution according to amputation level.

Level	Frequency	Percentage
Below-knee	65	50.8%
Above-knee	40	31.3%
Through-knee	10	7.8%
Syme	1	0.8%
Chopart	1	0.8%
Bilateral	11	8.6%
Total	128	100.0%

Table 3. Diabetes related to age group.

Age group	Diabetes No	Diabetes Yes	Total
<50 years	20 (74.1%)	7 (25.9%)	27 (21.1%)
>50 years	41 (40.6%)	60 (59.4%)	101 (78.9%)
Total	61 (47.7%)	67 (52.3%)	128 (100%)

Xc^2=8.27819; p=0.004

Table 4. Level of amputation related to diabetes.

Level	Diabetes No	Diabetes Yes	Total
Below-knee	29 (39.2%)	45 (60.8%)	74 (57.8%)
Above-knee	32 (59.3%)	22 (40.7%)	54 (42.2%)
Total	61 (47.7%)	67 (52.3%)	128 (100%)

Xc^2=4.26867; p=0.0388

The Kaplan-Meyer product limit test was used for univariate analyses (Campos-Filho and Franco, 1988). Survival prognostic risk factors were investigated by multivariated analysis (Campos-Filho and Franco, 1990). For cross-tabulations the chi-square method was used.

BK (65 patients) and AK (40 patients) amputees were compared regarding prosthetic use on long term evaluation using the Kaplan-Meyer life table method. For this functional evaluation a successful event was defined as being if patients were alive and using a prosthesis full time (Table 6) or alive and using a prosthesis partial time (Table 7) at time of last follow-up.

Table 5. Immediate results of rehabilitation.

Level	Prostheses fitted No	Prostheses fitted Yes	Total
Below-knee	6 (8.9%)	61 (91.1%)	67 (52.3%)
Above-knee	8 (20.0%)	32 (80.0%)	40 (31.3%)
Through-knee	1 (10.0%)	9 (90.0%)	10 (7.8%)
Bilateral	4 (36.4%)	7 (63.6%)	11 (8.6%)
Total	19 (14.8%)	109 (85.2%)	128 (100%)

Table 6. Summary of survival and prosthetic use full and partial time of below-knee and above-knee amputees.*

variable	categories	number of patients	mean time on use of prosthesis (months)	proportion using prosthesis	
				3 years	5 years
level	BK	65(61.9%)	60.1± 4.9	77.4	58.0
	AK	40(38.1%)	45.5± 5.9	55.4	38.6

*Kaplan-Meyer product-limit estimates.

Table 7. Summary of survival and prosthetic use full time of below-knee and above-knee amputees.*

variable	categories	number of patients	mean time on use of prosthesis (months)	proportion using prosthesis	
				3 years	5 years
level	BK	65(61.9%)	52.2± 4.9	63.7	47.8
	AK	40(38.1%)	32.0± 4.5	41.3	22.1

*Kaplan-Meyer product-limit estimates.

Table 8. Summary of survival data* for 128 patients with lower limb amputation caused by peripheral vascular disease observed between 1979 and 1987.

variable	categories	number of patients	mean survival time (months)	proportion surviving (%)	
				3 years	5 years
sex	male	99(77.3%)	93.5± 12.6	73.5	61.3
	female	29(22.7%)	95.4± 22.1	80.2	67.3
age	<50	26(20.3%)	100.4± 5.4	93.3	93.3
	50–65	54(42.2%)	66.9± 6.4	68.0	60.5
	>65	48(37.5%)	61.8± 6.6	73.4	51.3
associated disease	diabetes	67(52.4%)	55.6± 5.5	61.8	42.4
	others	61(47.6%)	86.4± 4.5	89.4	85.5

*Kaplan-Meyer product-limit estimates.

Results

Ambulation with a prosthesis was initially achieved by 85.2% (109/128) of all patients. These rates for unilateral amputees were: 91.1% (61/67) for BK (including one Chopart and one Syme amputation), 80% (32/40) for AK and 90% (9/10) for through-knee. Bilateral amputees were initially successful in wearing a prosthesis in 63.6% (7/11). These patients were: 1 with Syme's amputation bilaterally, 1 with transmetatarsal on one side and BK on the other, 4 with BK bilaterally, and 1 with AK bilaterally. These results are summarised in Table 5.

Survival and prosthetic use rated as full time or partial time at 5 years was 58.0% for BK and 38.6% for AK (p=0.045), as shown in Table 6.

Survival and prosthetic use rated as full time at 5 years was 47.8% for BK and 22.1% for AK (p=0.0026), as shown in Table 7 (Fig. 1).

General survival rate at the end of five years was 42.4% for diabetics, and 85.5% for non-diabetics (p=0.0002) (Table 8). On multifactorial analysis diabetic patients showed a risk of late mortality six times greater than non-diabetics (Table 9). Opposite limb amputation occurred in 9% (11/117) of patients with unilateral amputation. This incidence was

Table 9. Cox regression model data for death risk estimation on diabetics and non-diabetics.

Parameters	Model: unifactorial	Model: multifactorial
Regression Coefficient	1.5351	1.5950
Standard Error	0.3938	0.4275
Likelihood Ratio	18.456	38.248
Score	1	6

Table 10. Summary of opposite limb preservation* for 117 patients with unilateral amputation observed between 1979 and 1987.

variable	categories	number of patients	opposite limb permanence (months)	patients with opposite limb preservation (%)	
				3 years	5 years
associated disease	diabetes	67(52.4%)	67.5± 6.7	78.2	69.5
	others	61(47.6%)	87.1± 3.9	100.0	90.2

*Kaplan-Meyer product-limit estimates.

higher in the diabetic group (p=0.0013) (Table 10).

Discussion

Peripheral vascular disease is the leading cause of amputation in many western countries (Mooney *et al.*, 1976; Christensen, 1976; Fleurant and Alexander, 1980; Liedberg and Persson, 1983). Elderly, atherosclerotic patients usually with associated diabetes is the pattern frequently observed (Cameron *et al.*, 1964; Steer *et al.*, 1983; Most and Sinnock, 1983; Liedberg and Persson, 1983; Falkel, 1983). Despite the fact that in some series (Mooney *et al.*, 1976) diabetes has been related to amputation in younger age, in this study it was prevalent over the age of 50 (Table 3). Furthermore, due to the more distal arterial involvement, it has been observed that the level of amputation may be lower in the diabetic population (Kihn *et al.*, 1972; Burgess and Marsden, 1974; Kacy *et al.*, 1982). This was also observed in this series, as is seen in Table 4.

Rehabilitation has been studied in terms of immediate and late results. For immediate results, success was considered as being

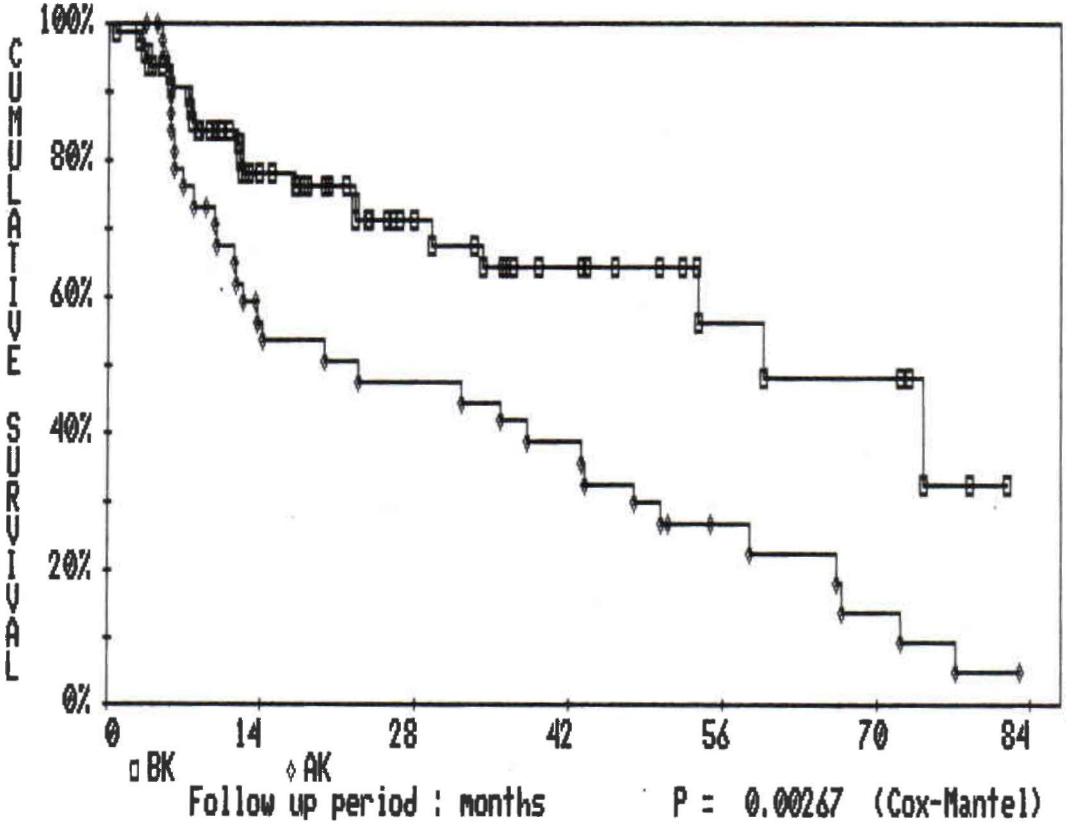

Fig. 1. Survival and prosthetic use/level.

achieved when a prosthesis was fitted, and a patient attained an independent gait at the end of initial treatment. By this measure 85.2% of all patients reached this condition (Table 5).

Late evaluation comparing BK and AK amputees, the most significant groups, showed better results on survival and prosthetic use full or partial time for BK amputees (Table 6). This difference was emphasised when only full prosthetic use was considered (Table 7), pointing out the limitations imposed on AK amputees and the importance of knee preservation.

Survival comparison between the diabetic and non-diabetic populations showed a significant statistical difference ($p=0.0002$) highlighting diabetes as a risk factor. This observation prompted also a multifactorial analysis, relating diabetes with a six times higher mortality risk (Table 9).

Applying the same cumulative survival method for the preservation of the opposite limb of unilateral amputees, diabetic patients also had more contralateral limb amputation. This has also been reported by others (Bodily and Burgess, 1983).

In conclusion, rehabilitation after amputation for vascular disease is associated with limited life span, but it is feasible and rewarding in a large number of patients. Diabetes is a major risk factor for both survival and limb preservation. Prosthetic fitting is frequently achieved, restoring the gait and mobility conditions essential for normal living. Knee preservation is an important factor for better rehabilitation.

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Cause of death of lower limb amputees

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Abstract
A study was carried out on the cause of death of 100 lower limb amputees who had been admitted to the Dundee Limb Fitting Centre, Tayside, Scotland for prosthetic management or wheelchair training. A comprehensive database has been established in the Centre for 25 years and the database is updated regularly. The date of death was collected and recorded. One hundred sequential deaths were investigated to review the cause of their death and compare this with the recorded causes of death for the Tayside population for the year of study. Ninety three per cent had an amputation for vascular related causes, with 73% having a below-knee amputation and 17% above-knee. Heart disease was the most frequent recorded cause of death (51%) of the amputee whereas only 28.1% of the Tayside group died from this pathology ($p<0.01$). Carcinomatosis was reported as a cause of death in 14% of the amputees and 23.5% of the Tayside group. Cerebrovascular disease caused death in 6% of the amputees and in 12.3% of the Tayside group (both $p<0.01$). These findings confirm earlier suggestions that vascular amputees die from heart disease more often than the general population.

Introduction

Peripheral vascular disease (PVD) is the commonest cause of amputation in the western world. The incidence varies from 27% to 85% (Kerstein *et al.*, 1974; Malone *et al.*, 1979). Between 30% and 50% of these PVD patients in addition have diabetes mellitus and many also have other concurrent medical problems. Troup (1976) reported that up to 75% of primary amputees admitted to the Dundee Limb Fitting Centre (DLFC) had at least one other significant pathology.

It is well recognised that dysvascular amputees have a reduced survival as compared with their age related peers. It has been found in a Dundee population that median survival of lower limb amputees was 4 years over a 25 year period, whereas the survival of their peers was greater than 10 years (Stewart *et al.*, 1992).

The cause of the early demise of the lower limb amputees has not frequently been reported but is likely to reflect the aetiology of the amputation. This study reviews the cause of death in patients with lower limb amputations. Previous reports Kallero (1981) and Lindegar (1984) indicated an increased incidence of myocardial problems in these patients as being the commonest likely cause of death. This study confirms that finding.

Method

Tayside operates a comprehensive amputee service with 98% of the amputations being performed in one surgical unit by two teams. Patients are transferred to the DLFC within one week of amputation for prosthetic management or wheelchair training. About 3% of the amputees die prior to admission to the DLFC and a further 6% are considered unfit for either prosthetic management or wheelchair training and are discharged back to the referring hospital.

All patient records are kept in the Centre and are updated regularly.

Prospective information on all primary amputees admitted to DLFC has been recorded, over a 25 year period initially on specially designed charts (1965 – 1981) and

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subsequently on an enhanced data sheet. The information is transferred to an Olivetti M24 PC using dBase III+ (1985).

The 9% of amputees described above who were not admitted, were excluded from the study.

The date of death of the amputee is collected and recorded as a routine procedure, for accurate maintainence of records.

The record of the cause of death of 100 sequential deaths was obtained from a variety of sources including the family doctor attending the deceased during the last illness, the hospital doctor who was responsible for the terminal care or from the Tayside Health Board Primary Care Division. The cause of death was linked to the patient file in the database.

Information from the Registrar General for Scotland was also obtained relating to cause of death for the Tayside population for 1987, the year of the study. Results of these two groups were studied and compared.

Results

Table 1 shows the 100 DLFC patients, the cause of amputation and the level of amputation.

Table 2 shows the comparative causes of death in the 100 DLFC patients and the Tayside group. Some 51% of the DLFC group had a death related to heart disease whereas only 28.1% of Tayside group died from this pathology ($p<0.01$).

Cerebrovascular accident was significantly less in the DLFC cases ($p<0.01$) Carcinomatosis was only recorded in 14% of DLFC patients whereas in the Tayside group the incidence was 23.5% ($p<0.01$).

Bronchopneumonia led to the death of 13% of the DLFC group whereas in the Tayside group this pathology caused the death of 5.4% ($p<0.01$).

Table 1. Causes of amputation and final level of amputation achieved.

Causes		
PVD non diabetic	—	61
PVD with diabetes mellitus	—	32
Tumour	—	4
Other	—	3
Level of amputation		
Hindquarter	—	1
Above-knee	—	17
Through-knee	—	3
Below-knee	—	73
Symes	—	1

Average age at amputation — 70 years.

Table 2. Cause of death — Tayside (1987)

	Tayside group	DLFC group
Myocardial infarction	25.2%	42% } 51%
Other heart disease	2.9%	9% }
Carcinomatosis	23.5%	14%
Cerebrovascular accident	12.3%	6%
Pulmonary disease	10.2%	5%
Bronchopneumonia	5.4%	13%
Peripheral vascular disease	0.5%	5%
Septicaemia	0.2%	3%
Renal failure	1.0%	1%
Hypoglycaemia	0.9%	1%
	79.5% (4111 cases)	1 operative mortality (100 cases)

(Source for Tayside group — Registrar General Scotland 1987).

Table 3 lists the median survival of DLFC cases as 3 years 9 months which was further divided into PVD (without diabetes mellitus) 3 years 10 months, and 3 years 5 months for those with diabetes mellitus (p not significant).

The survival of those dying with myocardial infarction 41% of PVD without diabetes mellitus and 46.9% of those with diabetes mellitus was 2 years and 11 months from the time of amputation, whereas those dying of bronchopneumonia was 5 years 11 months.

The survival of the above-knee (AK) amputees in this study was only 1 year 8 months whereas below-knee (BK) patients survived 4 years 0 months.

Table 4 lists the causes of death in the DLFC group with PVD, with and without diabetes

Table 3. Survival times for the 100 amputees.

Mean survival overall	3 yrs. 9 mnths.
PVD	
(61 cases — non diabetic)	3 yrs. 10 mnths.
(32 cases — diabetes mellitus)	3 yrs. 5 mnths.
Survival of patients dying with:—	
Myocardial infarction	2 yrs. 11 mnths. (25 of 61 patients (41%) with PVD) (15 of 32 patients (46.9%) with DM)
Bronchopnuemonia	5 yrs. 11 mnths.
having had:—	
Above-knee amputation	1 yr. 11 mnths.
Below-knee amputation	4 yrs. 0 mnths.

Table 4. Cause of Death in the Amputee whose amputation was a result of vascular disease.

Cause	PVD non diabetic		PVD with diabetes mellitus	
	Numbers	%	Numbers	%
Bronchopneumonia	9	14.8	4	12.5
Myocardial infarction	25	41.0	15	46.9
Cerebrovascular accident	3	4.9	3	9.4
Carcinomatosis	7	11.5	2	6.3
Congestive cardiac failure	3	4.9	5	15.6
Peripheral vascular disease	4	6.6	1	3.1
Renal failure	1	1.6	—	—
Septicaemia	3	4.9	—	—
Hypoglycaemia	—	—	1	3.1
Respiratory disease	2	3.3	—	—
Pulmonary embolism	2	3.3	1	3.1
Aortic an.	1	1.6	—	—
Op. death	1	1.6	—	—
	61	100	32	100

mellitus. It shows that the incidence of myocardial infarction and bronchopneumonia was unrelated to the cause of amputation.

In addition smoking habits were only recorded in 34 cases, 44% of these admitted to smoking, 56% denied it. No significant difference in survival time between the smokers and non-smokers was found.

Discussion

This paper reviews the cause of death in 100 amputees who had been admitted to DLFC for prosthetic management or wheelchair training. The cause of the amputation in this group is similar to those reported elsewhere (Kerstein *et al.*, 1974; Murdoch and Donovan, 1988) and the levels of amputation reflect the effectiveness of the Tayside Amputation Service with a high level of BK amputation as compared with AK (Table 1). Comparison between the cause of death of the amputee group and the Tayside group revealed significant differences.

In the DLFC group 51% were reported as having a cardiac related terminal event whereas only 21% of the Tayside population had a similar event. This significant difference can only be explained by the widespread nature of the vascular related underlying pathology (93%) leading to amputation (Tables 1 and 2).

More than 30% of patients admitted to the DLFC had clinically established cerebral vascular disease (Stewart, 1985), but only 6% of this DLFC group died of cerebral vascular accidents as compared with the Tayside group where the incidence was 12.3% (Table 2).

The low incidence of cerebrovascular accident as a cause of death in the amputee group may be related to the natural history of PVD and diabetes. The myocardium is particularly vulnerable to the patholoIgies (MacPherson and Feely, 1990), which may lead to earlier demise from myocardial infarction leading to the high incidence of this terminal event in the amputee group.

Neoplasia is a rare cause of amputation. The incidence of amputation related to neoplasia was 4% in this study, in comparison to reported incidence of 1–2% in other studies (Jain and Stewart, 1989).

However it is surprising that only 14% of the DLFC group had carcinomatosis as the reported cause of death in comparison to the Tayside group in whom this terminal pathology was recorded as 23.5%, a significant difference ($p<0.01$).

Bronchopneumonia was recorded in 13% (13 cases), as opposed to 5.4% of the whole population ($p<0.01$), this high incidence may be related to the general frailty and lack of activity of the amputees who have been shown to be less active than their peers (Stewart, 1985).

Although similar incidences of death by myocardial infarction and bronchopneumonia was found in PVD patients with and without diabetes, it was noted that congestive cardiac failure featured slightly more in diabetic patients (Table 4).

Survival of the group was only 3 years 9 months with differences between the vascular cases without diabetes and those with diabetes who appeared to have a shorter, although not statistically significant, survival time.

Survival of AK patients was remarkably less than that of the BK which is in keeping with findings reported in other publications. This difference might be explained by considering that an AK amputee has more widespread disease than the patient requiring a BK amputation, and thus the patient may have severe involvement of major organs (Table 3).

It is important to emphasise that none of the study cases had a post-mortem examination and it is possible that bias towards the amputee with a past medical history of vascular disease may lead to a higher incidence of cardiac related causes being recorded on the death certificate by the certifying doctors. The policy of only conducting post-mortems in a very few cases in the community also means that the figures from the Tayside group also reflect the doctors' opinion based on clinical grounds as to the cause of death rather than laboratory evidence. This provides a satisfactory comparison between the two sets of data. As stated before are based on clinical evidence rather than pathological evidence.

Acknowledgements

Acknowledgement is due to Mrs. M. Copland who spent many hours collecting the cause of death information and to Mrs. F. Clark for typing the script.

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Prosthetics and Orthotics International, 1992, 16, 133–136

Revision of amputation stumps in Dodoma — Tanzania

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Dodoma Regional Hosptial, Tanzania

Abstract

The records of Dodoma Orthopaedic Department, Tanzania were reviewed for the period July 1986 to December 1990 in order to identify the reasons for revision surgery. A total of 26 patients required revision surgery. Two main groups were identified. In the first group 4 patients had a higher level of amputation because of gangrene. In the second group 22 patients had revision surgery because of other stump defects caused by technical mistakes when carrying out the original amputation, or other complications.

Introduction

An amputation is not a final act in itself, but a prelude to the long rehabilitation process that aims to overcome the disability of limb loss. The surgeon should prepare a stump that is suitable for limb fitting, as part of the rehabilitation process.

The records of Dodoma General Orthopaedic Department from July 1986 to December 1990 have been reviewed in order to identify the reasons for revision surgery. The series includes cases where the initial amputation was carried out in the Dodoma Orthopaedic Department, and also patients referred from other centres to its Orthopaedic Workshop for limb fitting.

Table 1 shows the total number of limb amputations that have been carried out, during the period under review, at Dodoma Orthopaedic Department which is one of the three Orthopaedic Centres in the country. Dodoma Orthopaedic Workshop is one among the seven workshops that are currently operating in Tanzania and it cares for the population of its central zone. It was established in 1985, with the financial assistance of the Italian Government channelled through an Italian non-Governmental Organisation, C.U.A.M.M. of Padova.

All correspondence to be addressed to F. Franceschi, Orthopaedic Dept., Dodoma Regional Hospital, P.O. Box 1124, Dodoma, Tanzania.

Material and methods

In the period surveyed 26 patients had revisions of the amputation stump, 21 males and 5 females with a mean age of 33, and an age spread from 9 years to 65 years of age.

Thirty operations were performed on 29 stumps; 3 were bilateral amputees, and 1 patient was revised twice. Of the 30 operations, 27 were on the lower limbs; 16 stumps on the left and 13 on the right.

Ten patients came from the Dodoma Orthopaedic Department, 2 from another Orthopaedic Centre, 11 from other Regional Hospitals and 3 from District Hospitals.

The initial amputation had been carried out for road traffic accidents in 10 cases, train accidents in 2, work accidents in 2, 3 for tropical ulcers, 2 for complications after compound fractures, and 3 for wet gangrene. Leprosy, snake bite, too tight a plaster cast and ergot

Table 1. Number of limb amputations by year in Dodoma Regional Hospital.

1986 (2nd semester)	12
1987	34
1988	29
1989	21
1990	27
	Total 123

Table 2. Cause of first amputation in revised patients.

Road accidents	10
Train accidents	2
Work accidents	2
Tropical ulcer	3
Wet gangrene	3
Complications after compound fracture	2
Leprosy	1
Snake bite	1
Tight POP	1
Ergot intoxication	1
	Total 26

intoxication account for the remainder (Table 2).

It has been possible to distinguish two main groups.

The first group of 4 patients had a higher level of amputation because of gangrene of the stump. In this group, 3 had revisions a matter of days after the initial amputation because of gangrene of the flaps. The fourth patient developed gross infection and wound breakdown of his through-knee amputation flaps.

The second group of 22 patients had revision surgery because of other stump defects, caused by technical mistakes when carrying out the original amputation or because of complications. It included inadequate stump length, deformed or misshapen stumps, chronic bone and soft tissue infection and overgrowth of the bone of the stump.

Discussion

Because of restricted means and lack of investigative facilities, amputation levels are decided on purely clinical grounds. In those patients that developed gangrene of the stump, there had been an effort to retain the knee joint, but the selected level was too low. More than 120 lower limb amputations were carried out in the period under review and because of the importance of knee retention the failure rate (3 cases) was regarded as acceptable.

Stump revision to obtain an adequate amputation stump for limb fitting was the principal reason for revision in the series. There is close co-operation between the Orthopaedic Department and the Orthopaedic Technologist in the Orthopaedic Workshop, who referred patients with stumps that gave rise to difficulties.

Poorly formed amputation stumps, including inadequate muscle cover have been responsible for most of the revisions. There would seem to have been an inadequate myodesis, and in delayed suture an inadequate prediction of the level of muscle retraction. Suture of the skin without myodesis resulted in painful subcutaneous bone. In 5 below-knee amputees, the tibial crest at the bone section had not been bevelled, resulting in a painful stump. One above-knee amputee had revision because of redundant fatty skin cover.

Different procedures, including bone shortening, myodesis and soft tissue shaping were utilised in the revisions. The main problems were:

Muscle cover

It would appear that at the initial amputation, inadequate muscle flaps were left, especially in delayed suture which resulted in retraction of the muscles.

This meant that the level of bone section was left too distal. These factors resulted in subcutaneous terminal bone, which caused difficulty in prosthetic fitting. An inadequately covered stump may produce socket sores (Fig. 1).

Stump length

Five below-knee stumps were revised because they were too long, and 2 too short for prosthetic fitting. This resulted from inadequate level selection. There was one below-knee 8 cm stump, which took a year to

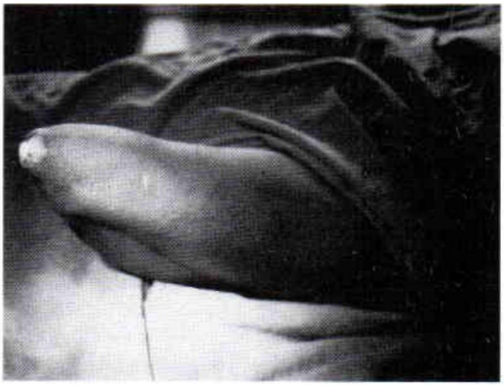

Fig. 1. An above-knee stump for which a procedure of revision has been necessary. The patient was amputated for a long standing leprotic ulcer of his foot. The possibility to perform a through-knee amputation has been overlooked.

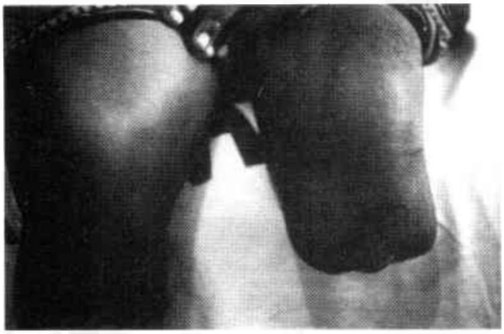

Fig. 2. A short below-knee stump. A through-knee amputation has been found necessary for successful limb fitting.

heal before referral, and which proved too short to be fitted (Fig. 2). If the below-knee stump is short, excision of the fibula is strongly advocated. The possibility of performing a through-knee amputation also has to be considered, instead of struggling with a short below-knee stump that is inadequate for the task. Too short a stump produces a short lever that is inadequate to control the prosthesis, requiring excessive energy and resulting in high local pressures. A below-knee stump which is too long is liable to fracture if the patient falls, and atrophy of the muscles results in an ill padded stump that causes fitting difficulties, and inadequate terminal cover (Fig. 3).

Infection

Nine stumps were revised because of persistent bone or soft tissue infection. Four had osteomyelitis, and sequestrectomy and adequate drainage resulted in healing. Delayed closure of the wound might have allowed the infection to settle down (Figs. 4 and 5).

Fig. 3. An excessively long below-knee stump is going to become, in the long run, a frustum of cone unfit for a prosthesis, due to severe atrophy of the muscles.

Five stumps had soft tissue infection. The removal of silk sutures used to tie the blood vessels resulted in sound healing. The use of silk ligatures in a potentially infected wound is not recommended.

Bone overgrowth

Two revisions in the same 9 year old child were carried out for stump overgrowth.

Training

It would be helpful if the surgeon tailored the amputation stumps to the needs of the prosthetist rather than expecting the prosthetist to adapt his socket to any stump produced. Apart from there being bio-mechanical reasons for prescribing amputations at selected levels, the range of artificial limbs produced by prosthetists in developing countries is limited by working conditions and available

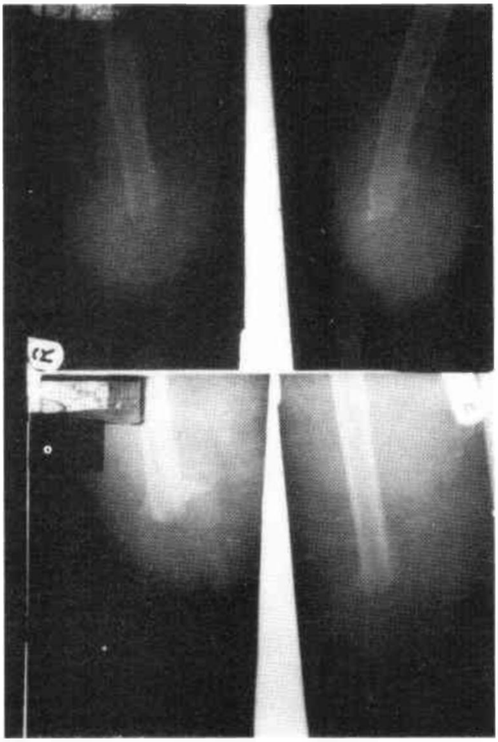

Fig. 4. Chronic osteomyelitis of an above-knee femoral stump. Two small sequestri, visible in the top films, have been removed, as can be seen in the post-operative x-rays.

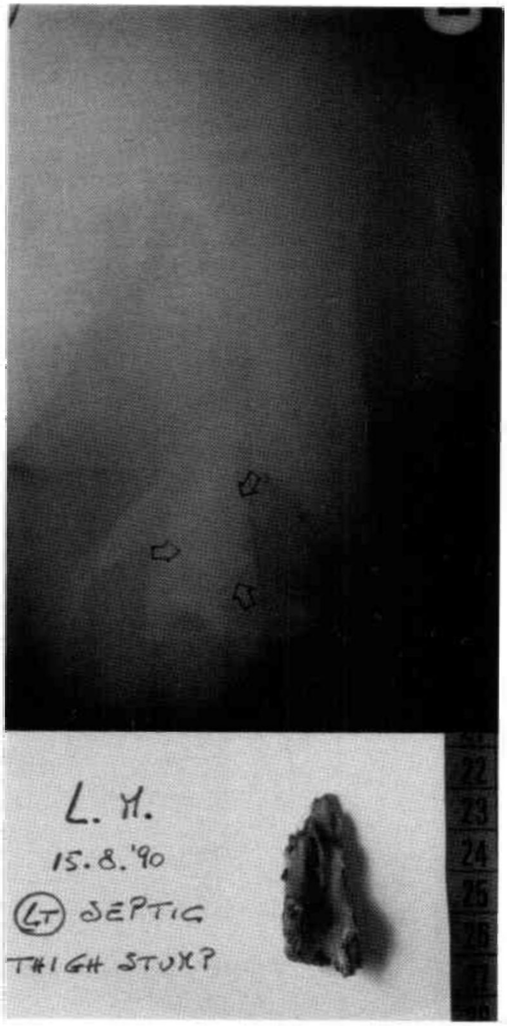

Fig. 5. (Top) The film shows the presence of a big sequestrum near the bone end in this above-knee stump N4. (Bottom) After surgical removal the sequestrum was probably a fragment of a severely comminuted fracture which has been left in situ at the time of first operation performed following a motor accident.

technology. It would thus seem that a knowledge of prosthetics is a requirement in the training of a surgeon who might perform amputations.

Working conditions, sterility in operating theatres and the existing infection of many of the wounds imposes problems. In the case of gangrene many amputations need delayed suture, with delayed fabrication of the stump. At the time of final closure, it is not merely a question of covering the bone, but fashioning suitable muscle and skin flaps.

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Prosthetics and Orthotics International, 1992, 16, 137–139

The geriatric prosthesis as metaphor: a clinical note

H. J. STAM

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Abstract

This clinical note describes a 96-year-old patient who wears a lengthening prosthesis in connection with the shortening of his leg which occurred after osteomyelitis of his left knee at the age of six years. The prosthesis was made and issued to him when he was twelve years old, and had never been replaced. The considerations that need to be made when replacing the prosthesis of an elderly patient are discussed.

In the case described, the prosthesis is replaced by a model that has no fundamental changes from the original. The better fit improves walking considerably and the patient is able to move about safely again using a walking frame.

Introduction

In the Netherlands, the costs of prostheses and orthoses are covered, almost without exception, by health insurance. The patient only needs a note with a short explanation and justification from the rehabilitation specialist or (orthopaedic) surgeon. The average life-span of a KBM-prosthesis, for instance, is two years. Most insurance policies allow for replacement of a prosthesis after two years.

When replacing the old prosthesis of an elderly patient, one is faced with the choice of whether to use new and more modern materials and techniques or ideas in the new prosthesis, or to provide a copy of the old prosthesis.

It is a fact that the older the patient is, and the greater the difference of a new prosthesis from the old one, the more difficult it will be to adapt to the new prosthesis.

The patient described in this report, demonstrates that a two year term before replacement need not apply to every prosthesis and throws light on the considerations to be made when replacing the old prosthesis of an elderly patient.

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Case history

Patient A., 96-year-old man, was referred by his General Practitioner (GP) to a rehabilitation specialist for the first time in his life.

The patient was, for the most part, able to answer questions and describe his own history. His family and GP could complete the information.

Problem

Is the prosthesis still adequate or does it need to be replaced? If it is to be replaced, what are the specifications to which the new prosthesis must comply?

Previous history

The patient developed osteomyelitis and arthritis of the left knee when he was 6 years old. Protracted bed rest and an operation (on the kitchen table) were the main components of the medical treatment.

After healing of the inflammation, an arthrodesis of the knee in a 45° position remained, and in the course of time the growth in length of the left leg was retarded because of damage to the epiphyses.

At 12 years of age the relative shortening of leg length caused by the bent position of the knee and the actual leg length shortening became so great, through the growth disorder, that standing and walking were seriously hampered. He was measured for a lengthening prosthesis and this was made.

During the years in which his body length was still increasing, the prosthesis could be lengthened when necessary by replacing the wooden stilt.

Relevant examination

There are no abnormalities to the upper limbs or the right leg. The hip and ankle joints of the left leg show normal movements for his age. There is atrophy of the lower and upper leg and arthrodesis of the knee joint in 45°.

The patient is able to stand up himself with the help of his arms and to walk about indoors with a walking frame. Walking is, however, no longer safe and the patient feels insecure.

Prosthesis

The patient has a lengthening prosthesis (Figs. 1 and 2) with upper and lower leg cuffs of leather. The frame is made of wrought iron. The shoe rests on a plate under which is fixed a wooden stilt with a rubber cap.

The shoe and leather cuffs are very worn and the fit around the upper and lower leg is no longer sufficient because of atrophy of the musculature.

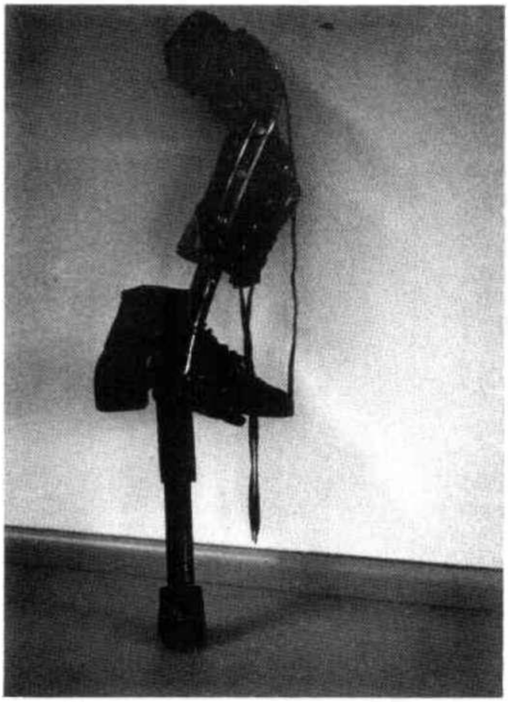

Fig. 1. The lengthening prosthesis.

Discussion

The lengthening prosthesis that this patient received when he was 12 years old, in connection with his shortened leg length, has never been replaced.

In the growth stage it was sufficient to lengthen the wooden stilt and provide a new shoe. Afterwards only occasional repairs to shoe or leather cuffs were necessary and could be carried out by the local shoemaker.

The prosthesis has thus been worn every day for 84 years and this may be regarded as an unofficial world record.

The patient worked all his life as an administrator. He drove a car and motorbike. He is now a widower and has brought up 6 children. He has lived in a residential home for the elderly for six months.

Despite the significant impairment there were very few disabilities and one can hardly speak of a handicap.

When replacing the old prosthesis of an elderly patient, one is faced with making the choice of either changing the design of the prosthesis and/or using new techniques and materials. Will the patient get used to a new prosthesis that is essentially different to the old one? The answer to these questions will largely depend on the vitality of the patient and the type of changes to be made to the prosthesis.

The general advice would be to exercise caution. In this case it was decided, not to

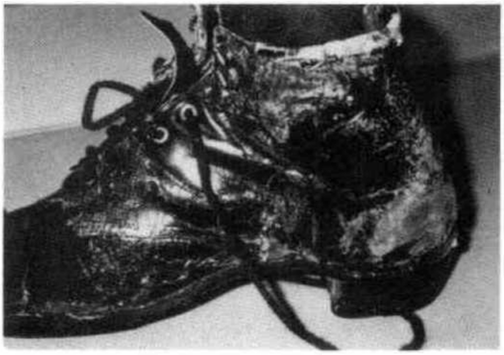

Fig. 2. Details of shoe wear.

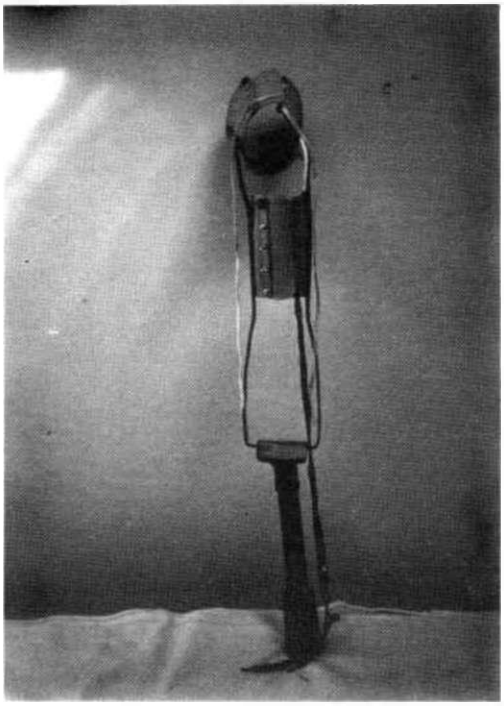

Fig. 3. The redesigned prosthesis.

Fig. 4. The prosthesis in use.

change the design of the prosthesis but to make the prosthesis fit better and be lighter (Fig. 3).

A new metal frame was made on the basis of a plaster model. The leather cuffs with lace-up fastenings were replaced by new ones. A new shoe was made to measure.

It was decided not to fit a rocker bar or artificial foot but to keep the rubber cap.

After receipt of the new prosthesis, the pattern of walking showed objective improvement. It was also a subjective success because the better fit increased the patient's feeling of stability and he was able to move about more safely (Fig. 4).

In conclusion, it can be established that replacement of a prosthesis after 84 years can be useful and desirable, as long as one carefully considers which changes one should make and also which changes one should definitely not make to the new prosthesis.

Prosthetics and Orthotics International, 1992, 16, 140–141

Technical note

Swimming devices for below-knee amputees

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Abstract
Two simple swimming devices that have been successfully fitted to unilateral and bilateral below-knee amputees are described.

Introduction

The value of artificial limbs for recreation is well acknowledged by amputees and therapists alike. Most below-knee (BK) amputees swim without any need for artificial limbs. This is not a grêat problem for the unilateral BK amputee. However, not everybody finds swimming with a single leg an enjoyable task due to the difficulties in getting to the water and the slight imbalance in water (LaBlanc, 1983; Saadah, 1987).

To improve the swimming function of such patients a flipper device was provided.

Bilateral BK amputees may be able to swim without any devices but find it difficult to walk up to the edge of the swimming pool. Socket devices have been devised which allow the bilateral amputee to walk to the swimming pool and swim with them on.

The flipper device — for unilateral BK amputees

A simple supracondylar acrylic socket is made in the normal way from the cast taken of the patient's amputation stump. A flipper is fitted to pedilen foam attached to the socket and kept in place by two rivets. A neoprene sleeve secures the socket to the amputation stump. Sometimes a liner is used in the socket for extra comfort but it is not totally necessary.

The overall length of the flipper is made equal to the natural length. However, it may be better to have it slightly shorter to allow more freedom. This can be varied with the length of the flipper. The flipper should be offset laterally to avoid contact with the sound limb. The flipper (Fig. 1) has been found to improve amputees' swimming ability.

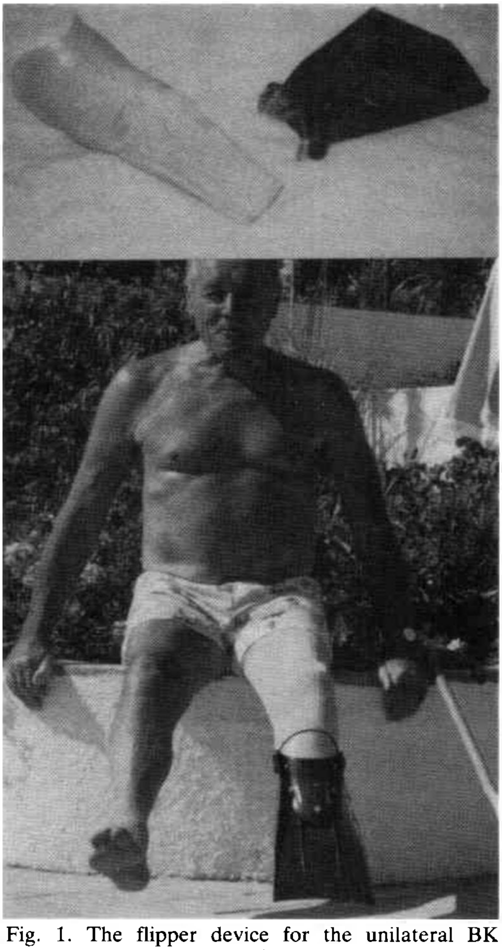

Fig. 1. The flipper device for the unilateral BK amputee.

All correspondence to be addressed to E. S. M. Saadah, Disablement Services Centre, Brighton General Hospital, Elm Grove, Brighton BN2 3EX, UK.

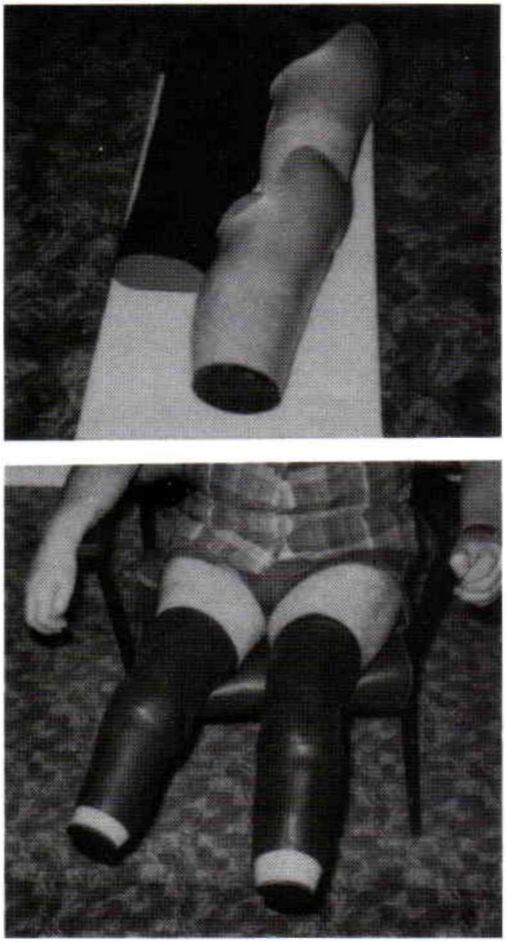

Fig. 2. The socket device for the bilateral BK amputee.

The socket device — for bilateral BK amputees

The bilateral supracondylar devices are made with a socket of glass-fibre reinforced plastic, and a pedilen foam extension which is laminated to a short circular rocker made of rubber. A liner is used in the socket. The sockets are secured to the stumps by neoprene sleeves for security (Fig. 2).

These devices allow the amputee to walk to the edge of the swimming pool with the help of short walking sticks where he can jump into the water with his prostheses on.

Conclusion

The flipper device has been provided to two unilateral BK amputees greatly improving their swimming function. The socket device has been satisfactorily fitted to one bilateral BK amputee.

Acknowledgements

The contribution of Prosthetics (UK) Ltd. who produced these devices is gratefully acknowledged.

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Calendar of Events

National Centre for Training and Education in Prosthetics and Orthotics
Short Term Courses and Seminars 1992–93

Courses for Physicians, Surgeons and Therapists

NC503 Introductory Biomechanics; 19–23 October, 1992.
NC504 Lower Limb Orthotics; 23–27 November, 1992.
NC512 Orthotic Management of the Foot; 7–8 December, 1992.
NC505 Lower Limb Prosthetics; 1–5 February, 1993.
NC502 Upper Limb Prosthetics and Orthotics; 8–12 February, 1993.
NC510 Wheelchairs and Seating; 9–11 March, 1993.
NC511 Clinical Gait Analysis; 28–30 April, 1993
NC506 Fracture Bracing; 10–14 May, 1993.

Courses for Prosthetists

NC218A Ischial Containment Prosthetics; 26–30 October, 1992.
NC205 Above-Knee Prosthetics; 2–13 November, 1992.
NC211 PTB Prosthetics; 1–5 February, 1993.
NC212 Hip Disarticulation Prosthetics; 15–26 February, 1993.
NC218B Ischial Containment Prosthetics; 3–7 May, 1993.

Course for Orthotists and Therapists

NC217 Ankle-Foot Orthoses for the Management of the Cerebral Palsied Child; 21–23 April, 1993.

Course for Rehabilitation Engineers

NC801 CAD CAM; 17–19 November, 1992.

Seminar

NC719 CAD CAM; 16 October, 1992.

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

4–5 September, 1992
International Conference on Experimental Mechanics, Technology Transfer between High Tech Engineering and Biomechanics, Limerick, Ireland.
Information: Conference Secretariat (BSSM 92), Dept. of Mechanical and Production Engineering, University of Limerick, Plassey Technological Park, Limerick, Ireland.

7–11 September, 1992
17th World Congress of Rehabilitation International, Nairobi, Kenya.
Information: The Association for the Physically Disabled of Kenya Headquarters, Lagos Rd., PO Box 46747, Nairobi, Kenya.

8–10 September, 1992
Paraplegia '92, International Forum on Paraplegia, Barcelona, Spain.
Information: BRP, Barcelona Relaciones Publicas, C/Pau Claris, nº 138, 7º -4ª, (Edifici Laietana), E-08009 Barcelona, Spain.

8–11 September, 1992
Autumn Scientific Meeting of the British Orthopaedic Association, London, England.
Information: BOA, 35-43 Lincoln's Inn Fields, London WC2A 3PN, England.

14–18 September, 1992
XI World Congress of The International Federation of Physical Medicine and Rehabilitation, Dresden, Germany.
Information: Prof. Jurgen Kleditsch, Dept. of Physical Therapy and Research, Clinic of Orthopaedics, Medical Academy "Carl Gustav Carus" Dresden, Germany.

17–18 September, 1992
The Science and Technology of Orthopaedic Implants, Glasgow, Scotland.
Information: Prof. J.C. Barbenel, Bioengineering Unit, University of Strathclyde, 106 Rottenrow, Glasgow, Scotland.

27–30 September, 1992
2nd Conference of the European Orthopaedic Research Association, Varese, Italy.
Information: Prof. Ugo E. Pazzaglia, Clinica Ortopedica, 2 Facolta di Medicina e Churugia dell'Universita di Pavia, Ospedale F. Del Ponte, Via F. Del Ponte, 19, I-21100 Varese, Italy.

1–3 October, 1992
4th Meeting of the European Academy of Childhood Disability, Venice, Italy.
Information: Organising Secretariat, CE.S.P.RI., Via Impruneta, 124-50020 Monte Oriolo, Florence, Italy.

7–11 October, 1992
International Symposium on "From Disabled People to Integrated Citizen", Brucoli, Italy.
Information: Studio Santuccio R.P.s.n.c., Via Napoli, 90-95127 Catania, Italy.

15–17 October, 1992
Annual Scientific Meeting of the Australian National Society of ISPO, Canberra, Australia.
Information: Margaret Hodge, ISPO, Prosthetic and Orthotic Dept., St. Vincent's Hospital, Victoria Parade, Fitzroy, 3065, Australia.

26–31 October, 1992
American Orthotic and Prosthetic Association Annual National Assembly, Orlando, USA.
Information: AOPA, 717 Pendleton St., Alexandria, VA 22314, USA.

29 October–1 November, 1992
14th Annual Conference of the IEEE EMBS, Paris, France.
Information: J.L. Coatrieux, Lab Traitement du Signal, Universite de Rennes 1, Campus de Beaulieu, Rennes Cedex, France.

30–31 October
Inaugural Meeting of the European Paediatric Gait Analysis Group, Oswestry, U.K.
Information: Mrs. G.M. Thomas, Orlau Movement Analysis Laboratory, Robert Jones and Agnes Hunt Orthopaedic and District Hospital, Oswestry, Shropshire SY10 7AG, U.K.

7–10 November, 1992
1st International Conference of the Saudi Association for Handicapped Children, Riyadh, Saudi Arabia.
Information: Chairman of the Organising Committee, 1st International Conference of the Saudi Association for Handicapped Children, PO Box 8557, Riyadh 11492, Saudi Arabia.

8–13 November, 1992
Annual Meeting of the American Academy of Physical Medicine and Rehabilitation, San Francisco, USA.
Information: AAPMR, 122 South Michigan Ave., Suite 1300, Chicago, IL 60603, USA.

12–14 November, 1992
ORPROTEC '92, Valencia, Spain.
Information: ORPROTEC '92, Apdo 476, 46080 Valencia, Spain.

21–22 November, 1992
7th National Meeting of the Pakistan Orthopaedic Association, Lahore, Pakistan.
Information: Prof. Naseer Mahmood Akhtar, ORTH-CON-92, Conference Secretariat, PO Box 760, Lahore, Pakistan.

2–4 December, 1992
7th International Conference on Biomedical Engineering, Singapore.
Information: The Secretary, 7th ICBME, 1992, Dept. of Orthopaedic Surgery, National University Hospital, 5 Lower Kent Ridge Rd., Singapore 0511, Republic of Singapore.

8–13 December, 1992
16th Annual Convention of the American Academy of Neurological and Orthopaedic Surgery, Las Vegas, USA.
Information: Dr. Michael M. Rask, 2320 Rancho Drive, Suite 108, Las Vegas, Nevada 89102-3592, USA.

1993

18-23 February, 1993
Annual Meeting of the American Academy of Orthopaedic Surgeons, San Francisco, USA.
Information: AAOS, 222 South Prospect, Park Ridge, IL 60068, USA.

6–7 March, 1993
9th Annual Conference of the Association of Prosthetists and Orthotists, Edinburgh, Scotland.
Information: Mr. W. Dykes, APO Conference Co-ordinator, National Centre for Training and Education in Prosthetics and Orthotics, University of Strathclyde, Curran Building, 131 St. James' Road, Glasgow G4 0LS, Scotland.

28 March–1 April, 1993
Biomedical Engineering Society, New Orleans, USA.
Information: BMES, PO Box 2399, Culver City, CA 90231, USA.

30 March-4 April, 1993
American Academy of Orthotists and Prosthetists Annual Meeting and Scientific Symposium, Las Vegas, USA.
Information: AAOP, 717 Pendleton St., Alexandria, VA 22314, USA.