The Journal of the International Society for Prosthetics and Orthotics

Prosthetics and Orthotics International

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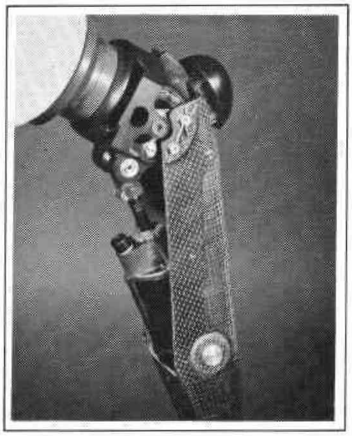

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The Journal of the International Society for Prosthetics and Orthotics

August 1986, Vol 10, No.2

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Editorial

The President

The single event in our triennium which brings our activities sharply into focus is our World Congress. In addition to the marvellous opportunity which it affords for the exchange of scientific information, to learn and to teach and simply to meet old friends and make new, it encompasses the World Assembly and meetings of the International Committee, the retiring and the new Executive Board and our various standing and ad hoc committees.

The Fifth World Congress in Copenhagen was an enormous success in all of these different facets. The success of the scientific meeting was there for all to see and the Society owes a debt of gratitude to the Secretary-General, Steen Jensen and a dedicated group of workers who, over long months of preparation made that possible — even the sun shone on their endeavours. The formal events associated with the Congress are reported in some detail following this editorial — the opening with speeches by the Danish Minister of the Interior, Knud Enggaard and Dr. Piga of the World Health Organisation and an inspiring Knud Jansen Lecture by James Foort of Canada and, later in the week, the World Assembly with the President's Report.

Apparently much less visible to the membership at large were the vital meetings of the International Committee and Executive Boards. "Vital", because these are the business meetings at which the Society's policies and activities are reviewed and tuned and reshaped in accordance with the wishes of the membership. "Apparently much less visible", because through our democratic procedures all have the opportunity to influence the decisions which are made and have access to detailed information through their National Representatives. Of course, the Executive Board has to make decisions and execute them, but its members wish to do so within the framework set by the membership. Copenhagen saw the first full day meeting of the International Committee. This was arranged by the Executive Board, in consultation with National Member Societies, to ensure the widest possible debate on its activities during the preceding triennium and on its plans for the future. These meetings were open, useful and productive.

The reports which follow this editorial display our progress and our vitality and there is no need to repeat them here. We continue to grow, to change and mature. We are not complacent, but I believe we can feel confident that our evolution is in accord with the foundation stone of our Constitution which is "to promote high quality orthotic and prosthetic care of all people with neuromuscular and skeletal disabilities". I am honoured to have been elected as President of this Society. I look forward to working towards the furtherance of these aims. I am deeply conscious, however, that the strength of our Society is the membership and that our continued success depends on your efforts. I look forward to working with you during my Presidency.

John Hughes

Obituary

Wilfred Kragstrup

Wilfred Kragstrup, Honorary Fellow of ISPO and our founding Honorary Secretary Treasurer, died on May 7th, 67 years old. He was a highly qualified Prosthetist/Orthotist as well as a talented organiser. These qualifications, together with his concern for people, especially in the developing world, were recognised by international agencies. The United Nations called upon him to set up an orthopaedic workshop in India, to organise courses in Denmark for students from developing countries and used him as a Consultant. His last international task was the establishment of an orthopaedic workshop in Moshi, Tanzania.

Wilfred was one of the pioneers of ISPO. He was a member of the International Committee on Prostheses, Braces and Technical Aids, the precurser of ISPO. In his own country Wilfred was the undisputed leader in his field. For his services to the handicapped persons in his own country, as well as internationally, he received the Hans Knudsen Award in 1969.

His family, colleagues and friends all over the world will miss him very much.

Erik Lyquist

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Fifth World Congress

Opening Ceremony

The opening ceremony of the Fifth World Congress was held on Sunday, 29th June in Tivoli Variety Theatre, Tivoli Gardens, Copenhagen. The audience of participants and distinguished guests was addressed by:

J. Steen Jensen, Secretary-General, World Congress.
Knud Enggaard, M. F., Minister of Interior, Denmark.
Dr. A. Piga, World Health Organization
John Hughes, Acting President, ISPO.
(on behalf of the President, Ernst Marquardt who was absent through illness).

This was immediately followed by the Knud Jansen Lecture for 1986, delivered by James Foort of Canada. The text of two of the opening addresses by Knud Enggaard and Dr. A. Piga are reproduced below and the Knud Jansen Lecture appears in full as the first paper in this issue of the Journal.

Knud Enggaard, M. F., Minister of Interior, Denmark.

First of all I should like to thank you for the invitation to participate in the opening of the 5th World Congress of the International Society for Prosthetics and Orthotics here in Copenhagen.

It is always gratifying to see a society like this receiving such wide support.

In my capacity of Minister for the Interior and thus responsible for Danish health policy I am particularly pleased that Denmark also takes part in this international co-operation.

The most important goal of the Danish handicap policy has always been to secure the possibility of disabled persons to live a life as normal as possible. And to achieve this a wide range of offers of public assistance is necessary.

The health services are responsible for the provision of the necessary aids. In Denmark about 3,000 people each year need an arm or a leg prosthesis. To all these people it is of the utmost importance that the aids provided by the health care system are of a high quality.

Therefore, continuous research and development are both very important factors. Traditionally, Danish research has been very advanced particularly as regards prostheses and bandages and I hope we shall be able to continue that tradition.

Gradually, as medical and technological developments are achieved, the possibilities of remedying more or less serious disabilities increase. Such possibilities should be exploited.

But we should always make sure that the new technology never replaces human contact. Our enthusiasm and confidence in new aids should not make us forget the patient.

We certainly do not want to help the disabled in such a way and to such an extent that it looks like a deprival of their own capabilities. The recipients of public services should be involved in the procedure as much as possible.

In the Ministry of the Interior we have in recent years received an increasing number of letters from organizations of disabled people and from individuals and we are very pleased with this development. It is always inspiring for the health authorities to receive incentives from people living a daily life with the problems.

I should like to finish my speech by wishing you all a profitable congress and a pleasant stay here in "Wonderful Copenhagen". I hope that the many participants present will get the opportunity to exchange knowledge and experience to the benefit of the patients not only in Denmark but throughout the world.

Dr. A. Piga, World Health Organization

On behalf of Dr. J. W. Asvall, Regional Director, WHO Regional Office for Europe, I want to express sincere satisfaction for our Organization being invited to participate in the opening session of this Congress.

In May 1977, the Thirtieth World Health Assembly decided (Resolution WHA30.43) that the main social target of governments and WHO in the coming decades should be the attainment by all citizens of the world by the year 2,000 of a level of health that will permit them to lead a socially and economically productive life.

In accordance with this Resolution, the representatives of the Member States of the WHO European Region approved in 1980 their first common health policy — the European strategy of attaining health for all and, in 1984, the basic document with the Regional Targets and the indicators to evaluate the progress achieved, with a request to make an up-to-date situation report every second year to the Regional Committee.

Within this strategy, one human basic need is to be able to play a useful role in society and one of the dimensions of the progress in health is to add health to life by reducing disease and disability (as a logical consequence of WHO's definition of health).

It is estimated that there are 450 million disabled people in the world, and that the magnitude of this problem is expected to increase in the future, as a result of the prolongation of life through better health care and emergency services.

Prosthetics and orthotics represent one of the areas in the field of health care that in the last decades has substantially progressed, achieving excellent results and future prospectives, without forgetting an important preventive component, all of this being of paramount importance in the prevention, reduction or elimination of impairments and disabilities, allowing disabled or handicapped people to be happier and socially better integrated citizens.

It is certain that this Fifth World Congress of the International Society for Prosthetics and Orthotics, bringing together so many of the most relevant specialists and scientists around the world, in these fields, will represent a scientific success through the discussions of the most recent advancements, their indications and effectivity.

It is not by chance that Denmark, with its well developed and advanced social and health policies and leader in so many aspects of the biomedical research, hosts this Congress in the beautiful town of Copenhagen where the International Society for Prosthetics and Orthotics was founded.

WHO has a definite interest in the activities of the Society and will also carefully analyze the reports and conclusions of this Congress that, without any doubt, will facilitate the progress towards aims that, from our singular perspectives, all of us share.

Fifth Triennial Assembly, 1986

NORMAN JACOBS
Honorary Secretary, ISPO

The Fifth Triennal Assembly of the International Society for Prosthetics and Orthotics was held on Thursday, 3rd July, in Copenhagen, at the time of the World Congress. In the absence, through illness, of the President, Ernst Marquardt, the Assembly was opened by Past-President, Erik Lyquist. The President's Report was presented, on Ernst Marquardt's behalf, by the President-Elect and offered to the Assembly for comment.

The Honorary Secretary then briefly summarized changes to the Constitution which had been published to the membership in "Prosthetics and Orthotics International" and subsequently approved by the International Committee.

Erik Lyquist then introduced the new Executive Board which had been elected by the International Committee prior to the Assembly. The membership is:—

President:	Prof. John Hughes (UK)
President-Elect:	Prof. Willem Eisma (Netherlands)
Vice Presidents:	Dr. Seishi Sawamura (Japan) Mr. Sepp Heim (FRG)
Fellows:	Mrs. Valma Angliss (Australia) Prof. Rene Baumgartner (FRG) Dr. A. Jernberger (Sweden) Mr. Melvin Stills (USA)
Ex Officio Member	Prof. George Murdoch (UK)
Honorary Secretary:	Mr. Norman Jacobs (UK)
Honorary Treasurer:	Dr. J. Steen Jensen (Denmark)

Professor Hughes then assumed the Chair and briefly addressed the Assembly. Both his address and the President's Report are reproduced hereafter.

A brief presentation was given by Dr. Sawamura informing the Assembly about the Sixth World Congress and Assembly to be held in Kobe, Japan, 12th–17th November, 1989. Following this, the President invited general comments from the Assembly and subsequently formally closed the Fifth World Assembly.

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President's Report

ERNST MARQUARDT

It is my pleasure to present the report of the Society's activities over 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 1500 to 1850 which excludes subscribers to 'Prosthetics and Orthotics International' whose number has increased from 300 to 400 over the period. The Society now has members in 65 different countries which includes 14 strong and active National Member Societies. These National Member Societies' activities provide an important focus for a large precentage of our members and many successful scientific meetings and other events have been held by them each year. Attempts are continually being made to promote the establishment of National Member Societies in other countries but this has met with limited success as it appears that a strong Society can only evolve from within rather than being formed through an outside influence.

Over the past three years the Society has honoured a number of its members. I am delighted to announce that Gerd Khun, Wilfred Kragstrup, George Murdoch, Anthony Staros and Howard Thranhardt have been elected as Honorary Fellows recognising the outstanding contributions that these individuals have made to the Society and to prosthetics and orthotics in general. In addition, Fellowships have been conferred on Cliff Chadderton, Franklin Fay, Frank Golbranson, Lars Hagglund, Sepp Heim, Guy Martel, Gertrude Mensch, Georg Neff, Kurt Oberg, Bjorn Persson, Margaret Powell and Melvin Stills.

During the past three years the Society has attempted to give its members more information as to its activities. A summary of the Minutes of the Executive Board and International Committee Meetings are now a regular feature of 'Prosthetics and Orthotics International'. Additionally, the Society has encouraged the National Member Societies, through their International Committee representatives, to participate in discussions to help guide the Executive Board in its deliberations. To this end a meeting of representatives of the International Committee and the Executive Board was held in Dundee, Scotland in July, 1985 and an International Committee Meeting lasting a full day will be held in association with the coming Congress. These closer links with the members, the National Member Societies, the International Committee and the Executive Board must be maintained and indeed improved in the future.

In order to help communications between the National Member Societies and the Secretariat in Copenhagen, Gertrude Mensch and the Honorary Secretary, Norman Jacobs, have produced a new and expanded version of the booklet which gives information and guidelines for Secretaries and other officers of the National Member Societies. It is the intention that these guidelines be updated periodically so that administrative procedures are well documented and easily followed.

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 period of Presidency started at the Fourth World Congress in London, an event which proved to be a great success in all respects. It is expected that this coming Congress in Copenhagen will prove to be at least as successful with a wide ranging, well planned and innovative Scientific Programme, a comprehensive Commercial and Scientific Exhibition and a very full Social Programme.

It must be reported that the problems relating to the 1980 Bologna Congress have still to be resolved. A series of Court hearings has been held in Bologna with no conclusions in view. This matter has certainly been prolonged by the fact that the Judge who was dealing with the case has been transferred to another district and we are awaiting the appointment of a new Judge so that the hearings may continue.

The next World Congress will be held in November 1989 in Købe, Japan. Plans for the Congress are progressing well under the Chairmanship of Professor Tsuchiya. The Society awaits a response to its invitation to the National Member Societies to submit proposals for the 1992 World Congress.

The financial situation of the Society continues to be healthy as has been displayed in the accounts published in 'Prosthetics and Orthotics International'. During the triennium the membership fee has been changed from $40 (US) to DKK400 because of the large fluctuations in the rate of exchange of the US dollar compared with other currencies. The change was necessary to provide a more stabilized accounting situation as the majority of the Society's expenditure is in Danish Crowns. The membership fee has now remained the same for the past two years and is likely to remain at the same level next year. The Executive Board will continue to attempt to hold down the membership fee and with the growing membership and increasing number of subscribers to the Journal it looks likely that this will be possible.

The Society's healthy financial situation is not altogether due to membership fees and successful events such as the London and Copenhagen Congresses. We should recognise the fact that many agencies give a great deal of support, financial and otherwise, to the Society. SAHVA, the Danish Society and Home for the Disabled, provide the Society with free office accommodation in Copenhagen and have given us an annual grant of DKK75,000. The War Amputations of Canada provide the Society with an annual grant of $5,000 (Canadian). Additionally, many other institutions provide facilities and non-financial assistance to the Society. We are deeply indebted to all these agencies for that generous help.

The Society has continued to collaborate closely with the International Standards Organization (ISO) in the development of standards. In particular we have participated in the activities of ISO Technical Committee 168 on Prosthetics and Orthotics and ISO Technical Committee 173 on Technical Aids and Systems for Disabled or Handicapped Persons. The Society has for the most part been represented by members who have attended these meetings on behalf of their Governments or other agencies, and thus at no cost to the Society.

The Society has endeavoured to promote the philosophy of evaluating new prosthetic and orthotic devices and techniques. Information with regard to evaluation work already carried out is not readily available. A. Bennett Wilson Jr. is attempting to collate, on behalf of the Society, a listing of Centres who are currently conducting evaluation programmes in prosthetics and orthotics together with some details of the work they are doing. Hopefully, such a listing will lead to a greater exchange of information in this field.

The Society is interested in promoting new clinically successful techniques which can improve the physical rehabilitation of the patient. As a result of the interest shown in the above-knee flexible socket the Society organized two courses, one in New York University and the other in the Munksjoskolan, Jonkopping, Sweden for teachers and instructors in prosthetics and orthotics in order that information regarding this technique be disseminated as widely and as quickly as possible.

The Society is also monitoring developments in the field of Computer Aided Design and Computer Aided Manufacture in prosthetics and orthotics. There is no doubt that such developments will have a profound effect on the way that prosthetic and orthotic devices are supplied in the future.

The Society has organized a series of meetings on education during the triennium. The first was held in May, 1984 in Moshi, Tanzania and explored the needs of the developing countries. The second was held in Toronto, Canada in August, 1984 and reviewed the Holte and Strathclyde reports comparing them with present day educational philosophy and practice. Twenty-six out of the 32 identified schools of prosthetics and orthotics were represented at the meeting. The third meeting was held in Jonkopping, Sweden in August, 1985 and examined and recommended standards for education and training in the developing countries. Some 45 participants attended and most of the International Agencies involved with prosthetics and orthotics in the developing countries were represented. The report of the Moshi Meeting has been published and the reports of the Toronto and Jonkopping Meetings are near publication. It should be said that it would not have been possible to run these meetings without the generous support of such agencies as GTZ (Deutsche Gesellschaft fur Technische Zusammenarbeit), the War Amputations of Canada, the Canadian International Development Agency and the Jonkopping County Council amongst others.

The results of these meetings will have a profound effect on establishing standards in education and training in developing countries which will, in turn, greatly improve their services. The Society has since the time of the 1984 meeting, inspected the education programme in Moshi and recognised the Centre there for training and educating orthopaedic technologists, that is mid-level professionals. The Society has also inspected the School in Lome, Togo for the same purpose and the Executive Board is at present considering approval.

The Society has just published a manual for orthopaedic workshops in developing countries, a task coordinated by Sepp Heim. This manual offers suggestions for their planning and installation and covers design, layout and equipment required.

As a result of the interest shown by the Society in the problems of the developing world there has been a wave of interest from individuals of these countries to join the Society and indeed we have attracted many new members from them. However, one matter that still remains a concern is that the level of membership fee is prohibitive to many individuals from these countries. This Society is examining ways to overcome this problem.

'Prosthetics and Orthotics International' is now in its tenth year. It is still being produced in the National Centre for Prosthetics and Orthotics in Glasgow and continues to improve in content and quality. Indeed it has now become so popular that for the past three years it has made a profit for the Society rather than being a drain on its resources. The April, 1985 edition of the Journal was a special issue entirely devoted to Computer Aided Design and Computer Aided Manufacture in prosthetics and orthotics. This issue was under the guest editorship of Professor Ron Davies who is to be commended for the production of such a stimulating volume. It is hoped that further special issues of the Journal appear from time to time highlighting particular problems or developments in our field of interest. The Editorial Board is currently examining the possibility of producing a volume of "Selected Articles" from the Journal.

A new Directory of Members has been produced at the National Centre for Prosthetics and Orthotics in Glasgow and will be distributed to members directly after this Congress. The Society is indebted to Gertrude Mensch and Dick Lehneis for producing a new Fact Sheet on the Society which can be used as a flyer at Conferences and in other situations to provide information to prospective members. An updated constitution was printed in 1984 and distributed to all members.

The Society has continued to further its relationships with International and National bodies. Cooperation with INTERBOR is much closer as a result of discussion and reciprocal representation on both Boards. The President-elect, John Hughes, represented the Society at the last meeting of the INTERBOR Board of Directors held in Turin, Italy in March of this year. Good contact has been established with World Orthopaedic Concern again with reciprocal representation on both Boards. Seishi Sawamura represented the Society at the last meeting of World Orthopaedic Concern in Bangkok in November, 1985. The Society retains its membership of Rehabilitation International and was represented at its World Assembly in Lisbon in June, 1984 by the Honorary Secretary, Norman Jacobs. Margaret Ellis has represented the Society at the last two meetings of ICTA, the International Commission on Technical Aids, the first being held in Lisbon in June, 1984 and the second in Finland in August, 1985. Together with the Honorary Secretary, I attended the last General Assembly of the World Veterans Federation held in Rotterdam in November, 1985. The Society has entered a state of working relations with WHO with a view to establishing official relations with them. The President-elect represented the Society at WHO working group on Systems for Provision of Aids of Disabled Persons held at Skien, Norway in February, 1985 and at a meeting on Information for the Disabled convened by the European Economic Commission in Brussels in January 1985. In addition, the Society remains in contact with the United Nations, the International Committee of the Red Cross, the International Labour

Organization and the Internationaler Verband der Orthopaedie Schutechnik (the International Organization of Orthopaedic Shoemakers), amongst others and is attempting to establish stronger links with them.

The Executive Board has proposed a number of amendments to the Society's Constitution. The first set of proposed amendments is to take account of the way in which the committee structure of the Society has developed over the past decade and also to introduce the concept of Task Officers and ad hoc Committees. It is the feeling of the Executive Board that these will result in a more efficient task oriented organization, if adopted. The second proposed amendment is an attempt to clarify the position of resigning Presidents. The third proposed amendment is simply to ensure that the classes of membership outlined in two separate articles of the Constitution conform with each other. These proposals will be discussed at the International Committee meeting prior to the Congress.

Although I have reported many of the activities of the Society over the past three years, many more are in an advanced state of planning. These include a meeting on Traumatic Amputations to be held in Israel in September, 1987, a joint meeting of the Netherlands, Belgian and German Societies to be held in the Netherlands in October, 1987 and a meeting on Rehabilitation of the Physically Handicapped Child to be held in Heidelberg in October, 1988.

I would like to take this opportunity to thank the Executive Board Members and others for all their help and encouragement during the period of my Presidency. The Society has had a very active triennium during which our numbers have grown; there is better communication between the National Member Societies and the Executive Board; relationships with the International Agencies have improved; and a start has been made in discussing the problems of the developing world.

During the period of my Presidency the nine elected Executive Board Members represented seven different countries and came from three continents. The Executive Board that will take office at the conclusion of the World Assembly will comprise ten members from eight different countries representing four continents. It is with pleasure that I report this widening of the geographical and cultural representation of the governing body. This and previous Executive Boards have continued to attempt to involve more and more dedicated workers to tackle the onerous tasks identified in our Constitution.

We can look forward to the next triennium with great expectations.

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Incoming President's Address

JOHN HUGHES

It is a great honour to me to have been elected to this, the highest office of our Society. It is a task I accept with an awareness of the debt and the duty I owe to those who held it before. I must say I approach it with some sense of awe which only escapes being foreboding because of the confidence I feel in my colleagues in the Board, the International Committee and indeed in the membership at large.

We are still a young Society, but we steadily grow in strength as each Triennium passes. I had the honour to read to you the Report of the Retiring President and that document is a record of solid achievement and progress. Our membership steadily increases, our National Member Societies thrive, and we manage to involve more and more individual members in our activities. It surely must be an auspicious start to this Triennium to be able to report, as I do with pleasure, the formation of a new National Member Society in the People's Republic of China. As our influence spreads, so do we satisfy the aims of our Constitution.

Happily new faces appear in our Board and in our committees. Sadly old friends disappear. It is impossible to mention every name, but it would be remiss not to refer to our sadness at the passing of our friend and Founding Secretary/ Treasurer, Wilfred Kragstrup, such a short time ago. We remember all of them. I am also able to report that the Executive Board has accepted a gracious offer from the Blatchford family to honour the memory of a respected Fellow, Brian Blatchford, by the institution of a Brian Blatchford prize for innovation in prosthetics and orthotics to be awarded at each World Congress and generously funded by the family.

We may look forward to the next Triennium with confidence, but with a strong awareness of the tasks which face us. In still closer collaboration with the International Agencies we will strive to raise standards of training of professionals and treatment of patients. We will seek ways of widening our input in the developing world, both to Government and to the individual worker. We will coordinate and initiate activities over a wide spread of areas already formulated and approved by the Executive Board. We will seek new initiatives in areas of need.

Clearly we already have, here in Copenhagen, a most successful Congress in every sense — scientific and social. We owe our thanks to our Secretary General, Steen Jensen, and his small group of dedicated workers. We are sure an equally successful event awaits us in Japan. I urge you to support our Japanese friends, responding to their requests and most of all by your presence in Kobe.

There is a danger in an event such as this of giving the same message to the same people many times. I will not fall into that trap. I referred to the tasks which face us. They are all within our capability because of the human resource we have available. The strength of our Society is the membership. It is my hope that the work of this Triennium will proceed with the widest involvement of the Board, the International Committee and you the members.

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THE KNUD JANSEN LECTURE

Innovation in prosthetics and orthotics

J. FOORT

Medical Engineering Resource Unit, University of British Columbia

Introduction

As I look back over my 35 years in the field of prosthetics and orthotics research, and consider those years from the point of view of the innovations I have witnessed and participated in, certain insights and influences stand out. They cluster around specific people and projects. Two years in Toronto with Fred Hampton and Colin McLaurin led to the establishment of the Canadian Plastic Syme's Prosthesis, the Canadian Hip Disarticulation Prosthesis, plastic reinforcement of wooden prostheses and conception of the SACH Foot.

The products of ten years at Berkeley with Chuck Radcliffe, Leigh Wilson, Bill Hoskinson, Frank Todd, Jim McKinnon and others, included design of the SACH Foot, the Quadrilateral above-knee (A.K.) socket, the Patellar Tendon Bearing below-knee (B.K.) prosthesis; conception of socket standardization, studies of prosthesis alignment and experiences with modular prosthetics.

Introduction of modular prosthetics to the clinic, development of the electrical alignment unit, use of semiflexible sockets and work on standard sockets and standard cosmetic restorations were experiences of my 8 years in Winnipeg with Ian Cochrane, Doug Hobson and Reinhard Daher.

Invention of Shapeable Matrices, development of Tubular orthotics, development of Computer Aided Socket Design and design of the valgus varus resist knee orthosis are milestones of my Vancouver experiences with colleagues Steve Cousins, Richard Hannah, David Cooper, Carl Saunders and Margaret Bannon over the past 15 years.

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I have appreciated experiences in projects outside my work environment too. The most recent was the cooperation that developed around Computer Aided Socket Design and Computer Aided Manufacturing between the group at UBC and the groups at University College London and West Park Research, Toronto. I am pleased that cooperation is being extended by new initiatives developing between the original groups and others. I speak of these things to convey to you the team basis for developments and the positive effect cooperation between people has on advances in our field.

Those of us who have worked together on various projects functioned best when we recognized and used each others qualities. Among the qualities I am thinking of are drive, curiosity, imagination, persistence, patience, trust, confidence and the ability to share.

To keep sweet reasonableness alive between people, participants have had to review their motives and consider the needs of their associates. How these associates functioned varied.

Some were definite and decisive. Some pondered things over and came to considered views. Some were very competent at the things they were trained to do. Some inspired new ideas on how to solve the problems we worked on. Some were able to take risks easily.

Assertiveness born of clarity of view could sometimes be mistaken for arrogance.

While human relations are never without their problems, all of these people enlarged my capabilities and enriched my work life.

There have been things I loved doing. Other things I have compelled myself to do. My attachment has been to what I believe were keystone projects, projects that had the potential to generate multiple solutions. In addition, they were projects that suited my natural rhythms, abilities and needs, and were championed by colleagues who could fill the gaps in my own abilities. For the most part, the means used to solve problems were traditional engineering coupled to vigorous artisanship. A great deal of self education was involved.

Now we are at a new intersection of events. Many of the problems have been defined but new means for problem solving are at hand. Although engineering and artisan skills are still required, there is a need to reassess our methods in light of the new means so that smooth and effective advances can be made. Re-education and new education are involved.

Factors affecting innovation, on the other hand, will not change. Some already alluded to are:

1. A suitable field for inventing.
2. Colleagues who cooperate, lead and support.
3. A mix of skills and temperaments in the team.
4. People willing to take risks.
5. An environment conducive to study and experimentation.
6. A speculative attitude.
7. Tools and techniques for problem solving.
8. A willingness to reassess methods and means periodically.
9. Appreciation of accumulated skills and knowledge.

In order to develop the theme of innovation in prosthetics and orthotics, I will use a review of the problem of shaping structures that fit against the body for control of forces and movements. Although the emphasis will be prosthetic, the problem is common to both prosthetics and orthotics.

I have organized the presentation around eight propositions which have a bearing on shape management. Factors I have observed as conducive to innovation are interspersed among them.

First proposition: Tissue density is non-homogeneous (1955)

Clinical studies of the quadrilateral socket for trans femoral amputees taught us that the residuum cannot be treated as a homogeneous mass. I believe that an examination of derivation of this proposition in relation to design of the quadrilateral socket will help us to identify some factors associated with innovation and indicate the need for further innovation.

The quadrilateral socket

The quadrilateral socket for AK amputees was brought to the Biomechanics Laboratory, University of California, USA from Germany by Eberhart and his team in 1949. It was assumed to be a suitable solution to prosthetic socket design for the above-knee amputee.

The plan was to examine its characteristics and to test it clinically at the Laboratory. It was studied throughout the 1950s for rational factors that could help to define it. Simultaneously, suction suspension was used, a factor that imposed greater demands on socket design, thereby highlighting problems with the quadrilateral socket.

Difficulties:

Common difficulties encountered included (a) cysts on the residual limbs in areas contacting the medial and anterior brims; (b) formation of horny nodules, or keratin plugs in the ischial-gluteal weight-bearing regions and (c) distal residuum oedema.

Shear forces on tissues where they extended over socket edges were identified as contributing to cyst formation. Oedema was due to proximal wedging effects and to insufficient support of distal tissues. Nodules, or keratin plugs, were traced to high compressive forces which drove small corns inward, building them into pain-producing nail-like structures.

It was assumed by Radcliffe that if the ischium was stabilized on the seat of the quadrilateral socket by means of more positive anterior forces, these difficulties would be overcome. To achieve this, he proposed that soft tissues over Scarpa's Triangle be compressed more positively as compared to harder muscular regions laterally. This led to the inward bulge over Scarpa's Triangle characteristic of present day quadrilateral sockets.

The differential displacement of tissues to effect even loading on the front of the residuum was a new idea that could be applied to any part of the body for force transfer and movement control.

In order to convey the requirements, he depicted the concept in biomechanical terms that practitioners might understand. Thereafter it became common practice to illustrate biomechanical events in this way, encouraging a more systematic analysis of fit and alignment.

Innovative factors illustrated in this include:

10. A person able to derive and champion a new concept.
11. Use of engineering principles for socket design.
12. Confident application of the hypothesized solution.
13. Using a clinical environment for testing it.

The solution helped to reduce the incidence of cysts, keratin plugs and oedema when applied to clinical study amputees.

Practitioners trying to follow the clinical study procedures however, found the information difficult to interpret because it was essentially descriptive. Their difficulties were thought to be due to their failure to abide by the principles. Measurements were made of successful and unsuccessful sockets in order to identify differences that might be responsible. From these might come a more definitive set of instructions for socket design. It was soon apparent however that the dimensions being measured could be the same for sockets that were obviously different. At the same time, successful sockets were observed to appear very similar to one another. This led Bill Hoskinson and I to speculate that it might be possible to standardize quadrilateral sockets.

This is the next proposition:

Second proposition: Socket shapes can be standardized (1957)

Calculations based on hazy ideas and gross assumptions to test the hypothesis that quadrilateral sockets could be standardized indicated that it might require approximately 11,000 one piece AK sockets (5,500 for each side of the body) to provide the range of sizes needed for a system that could be used with no more than small shape adjustments.

At that time, with no computers, storage, selection and distribution would be major problems in practical application.

To arrive at a more favourable format, the hypothetical socket was divided into sections. Attention finally focused on the brim area alone. If the brims were one-piece, only 150 would be required for each side of the body. If all four sides of each brim were adjustable, the number of brims required could be reduced to 3 for each side of the body.

The innovative impulse in this can be seen to follow out of:

14. A problem in strong focus.
15. The search for objective data.
16. A willingness to make assumptions in the absence of facts.
17. A practical objective.

The results of this hypothesis included:

a) establishment of jigs for fitting quadrilateral sockets, notably the Berkeley Adjustable Brims,
b) prefabricated temporary sockets,
c) adjustable sockets for the study of socket design parameters.

The jig fitting method facilitated acceptance of quadrilateral sockets by making the design principles more obvious and the design methods more simple.

Factors that influenced acceptance of jig fitting methods included:

a) the desire for total contact sockets, which could be made easily by this method
b) difficulties experienced in defining the quadrilateral socket shape,
c) the desire to substitute plastic laminates for wood in socket construction, a feature of the brim fitting method.

In this we see how:

18. Converging ideas and overlapping experiences bring innovation to focus.
19. Simplification of methods enhances acceptance.

In spite of these meaningful consequences, the hypothesis on standardization received a hostile response in general. I doubt if many of you will appreciate how heretical it was during the 1960s (and perhaps still is) to suggest that sockets can be standardized. I remember sending a paper based on standardization to an American journal approximately 20 years ago. The provocative title was "Instant Prostheses for Thigh Level Amputees." The editors reply was that there was no space for the article in the journal at the time, and it could not be foreseen that there ever would be!

My comment is this:

20. Negative attitudes toward innovations can either hamper their development or prolong their demise!

While I consider the proposition on socket standardization valid, it may be that every successful shape will be computer banked and standardization will be bypassed. Banking all shapes overcomes obstacles to acceptance of standardization which include:

a) the shape preferences and prejudices that people hold,
b) concern for the population that might be excluded from coverage (i.e. congenital amputees),
c) the lack of objective data.

Adjustable sockets constructed to study design parameters gave information on sensitivity of residual limbs to changes in socket dimensions (1962). There is a need to continue this work in the light of what we now know and need to know.

The adjustable sockets were suggestive of socket modularization, but did not lead to it. New fabrication techniques, an appreciation of the value of socket flexibility as exemplified in the Icelandic Socket and modular shapes in computer aided socket design systems may foster socket modularization.

Data for design could be derived from computer banked shapes and this in turn could lead to the impedance matching of sockets to residual limbs proposed by Ben Wilson and Eugene Murphy once the required data on tissue qualities is available.

Without objective data on tissue qualities to use in design work, modularization will require that intelligent, workable assumptions be made. Following out of that, however, adjustable modular sockets could help refine these assumptions and ultimately be the basis for defining tissue qualities. Finally, with sufficient data available, standardization could be reconsidered. The computer would be used for shape storage and numerically controlled machines for production of the shapes.

I can add other innovation factors:

21. Advances may reduce the need for information, reduce its importance, or facilitate its acquisition.
22. New options precipitate new speculations.
23. Oscillation between various options indicates that we have insufficient data.

So far, I have indicated how the North American version of the quadrilateral socket evolved out of the original German design through clinical studies and how these developments established propositions which I now summarize:

(1) Residual limb tissue density is variable.
(2) Socket shapes can be standardized

An appreciation of the role of the skeletal frame in determining the shape of the quadrilateral socket led to the third proposition.

Third proposition: The bony frame is the basis for socket design (1965)

For example, the triangle defined by the tendon of adductor longus, the ischial tuberosity and the trochanter is the bony frame round which the proximal shape of the AK socket is designed. Deviations from the triangular shape come about because of the need to accommodate the tissue-muscle masses adjacent to the sides of the triangle in a biomechanically compatible way.

The facts of this are most clearly exemplified in sockets derived from hand cast impressions. Lean residual limbs tend to give a shape that resembles the plug fit type of socket. Heavily tissued residual limbs yield a more quadrilateral shape.

This proposition explains deviations from stereotyped socket shapes for any level of amputation. It can be taken into account in standardizing shapes and in adapting standard shapes for shape customization in the computer. It is relevant also in making biomechanical shapes from sensed topographical data. It indicates:

a) why there are limitations in the Berkeley jig fitting method, which utilizes jigs of a single standard form,
b) limitations of standard sockets currently used,
c) what might be done to improve the biomechanical result,
d) why computer aided socket design programs include means for customizing the standard reference shape
e) why reference shape processing of bone geometry is significant for socket design
f) and why we need information on tissue qualities.

The patellar-tendon-bearing BK prosthesis

In my opinion, development of the PTB prosthesis is a good model for this discussion of innovation in prosthetics and orthotics. I will stress the process rather than design in order to emphasize the mechanism of study and motivating factors involved.

Up until the late 1950's at Berkeley, so much time and effort had gone into development of AK prosthetics that there was an uneasy feeling that BK prosthetics had been neglected.

To deal with this, Radcliffe called together a group of knowledgeable practitioners and educators to lay out a plan of attack on BK prosthetics with the researchers. It was agreed that in the studies the researchers would systematize prosthesis design and the educators would disseminate the information. They would also help format the information to be disseminated. The Veterans Administration would require prosthetists to take the courses as a condition for servicing VA clients.

This was a very potent format — one I would recommend for solving other problems, one I wish was being followed in the development and dissemination of CAD/CAM for prosthetics and orthotics.

No formal evaluation component was included. Each group made its contribution. That which would normally be done by evaluators was done directly by the prosthetists who applied the system. In retrospect, I would say that it was a satisfactory way to do it. In fact, considering the rate at which knowledge and means now develop, existing scenarios for evaluation seem more like seaweed around the propeller than a jib full of wind.

I will make another comment. The fascination with statistics on the part of our major funding agency, Health and Welfare Canada, is restricting Canadian prosthetics and orthotics research. In Berkeley, and elsewhere where innovations have advanced our field to a remarkable degree, the sample sizes used in the studies were sub-statistical. Results leading to commitment to adopt the PTB prosthesis rested on multiple fittings on no more than a dozen amputees, each different in various ways.

The results were not expressed objectively so much as procedurally. We knew that our methods were better than existing ones, a fact confirmed by the rate of dissemination and application of the new information.

Competent judgement was substituted for evaluation — and I would add, at no loss.

The PTB prosthesis was essentially assembled from information modules.

A modified form of the German practice of using the patellar tendon as a weight-bearing surface introduced at the original workshop, was adopted. Total contact was already acceptable at the research level in socket design for oedema control and was adopted for use in the BK system. At the same time, Shindler's technique for making Kemblo inserts to line sockets made of hard blocked leather set in wood was adopted. Blocked leather and wood for the socket were replaced by plastic laminates. The SACH foot, now entering clinical application, was incorporated.

Simultaneously, Blevins was making prostheses which he suspended by means of multiple socks with rubber buns stuffed between them and a knee strap. Galdick in San Francisco was making BK prostheses suspended by suction. Woodall was trying condylar suspension by 1962.

This gives you an idea of the many influences at work to give rise to the PTB prosthesis and to stimulate innovation. Much of this information was present in the field but unintegrated.

Summarizing,

24. Innovation is enhanced by coordinated efforts based on shared motives.
25. Informed judgement can be equivalent to evaluation.
26. Information density affects innovation.
27. Accomplishments in one area affect events in another.
28. Practical hypotheses are quickly accepted.
29. Accident also plays a part.

Alignment of trial prostheses at the biomechanics laboratory during checkout of procedures outlined by the review group was done in two steps. The socket-foot complex was aligned without the side joint and corset system in place, and then, upon completion of dynamic alignment of the foot-socket complex, the joint and corset system was added and aligned.

At that time, it was considered hazardous for an amputee to walk for prolonged periods on a prosthesis without the corset and sidejoints in place to protect the knee. No explanation was given as to why some people were able to wear jointless Muley prostheses. When one of our test amputees rebelled at having the corset-joint system added to his prosthesis following successful trials without, the switch was made to what is now the PTB below-knee prosthesis.

Controversy surrounded the PTB initially. Concerns remained that the knee would be damaged. Some critics said that only a few people could be successful PTB users, the majority would require side joints and corset.

Examination of the role of alignment on forces at the knee and application of normal locomotion data led researchers to abandon the myth against jointless prostheses and led to emphasizing the flexed knee gait as an insurance against knee damage.

Factors pertinent to success of the PTB prosthesis seem to have been:

a) a better understanding of how to shape and construct a socket;
b) a better appreciation of the biomechanics of the prosthesis as exemplified by the improved definition of alignment;
c) relating fundamental gait data to the practical situation;
d) the experiences of successful wearers of Muley prostheses,
e) development of the SACH foot;
f) a switch to new prosthesis construction methods;
g) significant simplification of the BK system.

Factors favouring innovation were;

30. The existence of the "Muley" type of prosthesis.
31. Available fundamental information on locomotion.
32. An engineering-artisan approach to solving the problem.
33. Cooperative effort directed toward its implementation.
34. Including the amputees on the team.
35. Using accumulated information.

With regard to the last spur to innovation, I would comment that technologists who are about to do fundamental design work for the production of orthopaedic shoes using computer aided design methods would be wise to take into account what the practitioners can teach them! Much of the information that designers will need resides in the shoe lasts and methods of measurement and last modification used by the practitioners.

Innovations spawned by development of the PTB prosthesis included the air cushion socket, adjustable sockets, transparent sockets, adjustable spring loaded end-bearing sockets, sockets fabricated directly on residual limbs, foam-in-place end pads, suspension from the patellar and femoral condyles and inflatable bladders in sockets.

36. New innovations spawn innovation of variants.

Modular prosthetics

During the 1960s, a major problem, and still a problem to quite an extent in North American prosthetics, was the degree of immutability in prostheses. When there were difficulties, the socket was usually the problem. To replace the socket required major modifications to the prosthesis, even replacement of the entire prosthesis.

In experimental modular-like prostheses however, the option for quick exchange of components existed.

The need and the obvious solution led to the next proposition:

Fourth proposition: Modular structures optimize prosthetic management (1955 —)

The modular-like designs in the research laboratories that foreshadowed modern modular systems did not seem attractive to prosthetists; the Northwestern University BK pylon with alignment and length adjustability built-in and the University of California Polycentric Knee for above-knee amputees are examples.

It was apparent that a comprehensive modular system that overcame whatever obstacles were inhibiting development was needed if the potential advantages were to be exploited. This realisation influenced me to adopt modular prosthetics for clinical use when I went to Winnipeg, Manitoba in 1963. My conviction was that modularizing prosthetics would speed up access of amputees to prosthetic care. It would also help people learn prosthetic practices and would lead to economies.

The emphasis in Winnipeg was on physical rehabilitation in a newly established hospital designed for that purpose. However, the prosthetics clinic was bogged down in wooden leg making practices of the times. Geographic isolation and absence of modern technical resources in prosthetics inhibited change.

I came as an expert. What I proposed for clinical application in fact was experimental. I had worked in an environment linked to innovating and wished to bring the attitudes associated with innovating into the clinic.

The aim was to have a comprehensive and adaptable modular system that included as many prefabricated elements as possible. The system would be used to manage patients with any level of amputation through their full spectrum of care from immediately post surgery to return to community life.

The design process would be evolutionary with the designed system used for what it was good for at every stage of development. A system with the least number of parts would be designed and common parts and tools would be used as far as possible.

A key feature would be rapid assembly-disassembly and reassembly for quick adjustment and socket exchange.

Only a few basic elements had to be designed to manage BK, AK and HD prostheses. All other parts were available or could be adapted.

We tried to make the system suit a basically rural environment so that a person who was distant from services might be able to manage repairs using community resources, including the local hardware store.

This experience illustrates:

37. Integrating what exists in new ways is innovating.
38. Experimentation can be a part of a service system.
39. Problems can be tackled from the users point of view.

The risks that might be involved in adopting a modular system for clinical use seemed small compared to the advantages to be gained in overcoming the bottlenecks affecting amputee rehabilitation.

Results were positive. No amputee had to postpone rehabilitation because of the prosthesis. In fact, it became common for a training prosthesis to be delivered on the day prescribed.

The evolutionary design approach allowed defects in design to be overcome as a means of extending usefulness of the system while it was used for what it would permit. At first, the objective was to keep people walking until the definitive prostheses were delivered. Stage by stage, the system was improved until finally it could be used definitively.

Evaluation proceeded in tandem with design. This circumvented the possibility of incorporating unsatisfactory features into the final design. In my view reaching objectives in this manner must be one option to consider in the interest of economizing on time, costs and effort (I must admit that I would always choose this approach).

Shaped components were a source of problems, especially with the BK amputees. Although standard cosmetic covers had been designed, and also standard socket receptacles to link the sockets to distal components, the sockets themselves were all custom made. This was reasonable for definitive prostheses, but training prostheses require frequent socket changes.

Successes with the AK prefabricated sockets motivated us to develop prefabricated BK sockets in response to the bottleneck experienced.

Nineteen sockets were made for each side of the body.

Use of these sockets taught us that five sizes for each side of the body were sufficient to fit all of the new amputees managed in this way and that one size alone met 50% of the needs. This illustrates other factors in innovating:

40. Previously successful patterns are followed.
41. Every experience is treated as an information source.

We were acutely aware of limitations imposed by standardization. Standardizing can mean that someone is left out unless the standardized item is adaptable. Such implications for the client need to be kept clearly in mind during innovating. That is:

42. A sense of responsibility must influence what is done.

Shape sensing

At that time, obtaining limb shapes by means of a shape sensing method, subject of the next proposition, seemed like a possible solution to the limitations imposed by standardizing.

Fifth proposition: Shape sensing gives data for interface design (1961)

When the idea of automating shape management for the fitting of sockets and cosmetic restorations was first raised in 1960, there was no sympathy for it at Berkeley. In fact there was strong scepticism toward it in the research community when I raised it as a proposal at a meeting of the Subcommittee on

Socket Design of CPRD in 1965. Although I was chairman of the subcommittee, the proposition did not even win a place in the minutes.

43. An innovative idea in its first stages is fragile.

I had discussed shape management by automated means in a letter to Colin McLaurin in June 1961. In practical terms, Frank Todd and I constructed a left side shank model from a right side shank model by means of photographic silhouetting in 1962 and that was all that was attempted until I returned to the idea in 1969.

When the gap between conception and initiation of work is considered, one can appreciate that:

44. Innovators must be patient and persistent.
45. A concept has to be suited to its times for acceptance.

Our first formal attempt to sense shape for prosthetic applications involved use of the shadow moire phenomenon. These studies spanned the period 1972 to 1980. A prosthesis replicated in Vancouver, using the moire technique for sensing the shape and a numerical controlled carver for producing the models, was worn by the recipient for three years.

We were introduced to the shadow moire technique by Dr. Duncan, then Head of Mechanical Engineering at UBC. He was actively engaged in shape processing for ocean bottom survey, boat hull design and machine design purposes.

Using a system that he had built to obtain multiple view photographic contour maps around objects, Steve Cousins and I produced a number of maps and models of residual and intact limbs.

On the basis of this work, Tony Staros established a contract with us to quantify shoe last shapes for the USA Veterans Administration, a forward looking project which we completed in December 1980.

We set up design criteria and had fabricated on principles demonstrated by Dr. Vickers and Doug Dean at UBC Mechanical Engineering Department, a machine that gave a single continuous moire shoe last map.

Saunders forced the system to work by putting the data into the computer point by point. He soon appreciated that quick input of data was necessary if sensing was to be a part of automating prosthetic procedures.

In later studies of what was being done in Japan where considerable expertise in shape processing had developed, he identified the flying spot technique as significant. It offered direct, rapid deposit of data into the computer at an affordable cost.

These experiences taught us to:

46. Look outside our field for information.
47. Go for information where the information density is greatest.

The light streak technique has been adopted at West Park Research Centre, Toronto, Canada, where, by agreement between us, sensing shape has become a central project while we concentrate on manipulating shape.

Because sensed shape is topographical, it must be used in conjunction with tissue quality data or be subjected to manipulation to derive the required biomechanical shape. This weakness in topographic mapping methods for derivation of biomechanical shapes has yet to be overcome.

On the other hand, biomechanical data are inherent in standard shapes and this fact can be the basis for deriving custom shapes. I proposed this concept first during the ISPO course in AK prosthetics held here in Denmark in 1978. (You may recall, that in Winnipeg 50% of new BK amputees were found to fit into a single standard socket size).

This leads us to the general hypothesis of the next proposition.

Sixth proposition: The shapes of all examples of any given anatomical feature or its biomechanically matched representation are sufficiently similar to permit shape matching on a mathematical basis using a standard shape as the reference (1978) and Strathclyde Paper #1, 1984.

That is, you can make a standard shape bigger, make it smaller, make it longer or shorter, make it differentially flatter or deeper in any direction and add or subtract from a particular point any required amount starting with a preconceived shape that serves as a biomechanically relevant core or reference shape.

My UBC colleagues have designed the current CASD (Computer Aided Socket Design) system on the basis of this proposition.

Colleague Dave Cooper has extended its application to derive the shape of bones *in vivo* using external bony landmark measurements.

The hypothesis stems from attempts to standardize sockets and from attempts to adapt sensed shapes to socket design.

The hypothesis does not discount the significance of shape sensing. Shape sensing can be used:

a) to deposit shapes in the computer for further processing; and
b) for defining how a shape should be processed.

Reference shape modelling has elegance. It can be used for internal as well as external anatomical structures and has no adverse effects on the person for whom the shape is being developed. It can be used for other than anatomical features. It can be used in conjunction with other techniques, such as shape sensing. It is, in fact, a concept of general significance.

The next gap to leap is that of constructing the interface with a degree of elegance comparable to that offered for designing it.

This leads to the next proposition:

Seventh proposition: Shapeable matrices can be used to construct biomechanical structures directly (1977)

A shapeable matrix is a structure made up of nodes and links in a format that permits it to be contoured to match a required shape. You may liken it to a flexible lattice that can be made rigid once shaped and be returned to flexibility for re-shaping.

The new emphasis could be on structures that can be assembled in the shape format required and remain amendable for post fitting adjustment. The seating systems developed at the Bioengineering Centre University College London and at MERU are the only examples of shapeable matrices so far.

Design of shapeable matrices grew out of brainstorming sessions led by Steve Cousins when he worked with the team at the Medical Engineering Resource Unit, Vancouver in 1977.

With advent of the Shapeable Matrix, shape management is targetted from two directions:

a) On the one hand, computer graphic techniques for shape management can be used to define the shape.
b) On the other, mechanical matrices can be used to build up the shaped structures directly.

Yet to be achieved is the mating of computer and matrix to allow configuration of the matrix by computer.

The aim should be to develop universal matrix building blocks from which any shape can be constructed. This may lead to modularization of interfaces, or modularization may circumvent development of matrices. If the matrix approach is circumvented, there may be some gains but there will also be losses. The matrix approach is much more fundamental even though design is difficult. Hybrid modular-matrix systems, as proposed by Cousins, may develop as stepping stones to either matrix or modular structures.

This illustrates other factors in innovating:

47. The path to choose is the more fundamental one if an innovation is to be far reaching.
48. Concepts can be combined.

Difficulties experienced with hand assembly and adjustment of miniature shapeable matrices which we have attempted to design for direct use against the body have led us to the eighth proposition:

Eighth proposition: Shape dependent components will be produced by robot constructors

To produce sockets directly by computer controlled robots, while difficult, would set the stage for a manufacturing method that precludes the need for moulds. Such an approach is infinitely compatible with computer aided design.

It is also compatible with the needs in prosthetics and orthotics which are now so heavily dependent on custom made moulds for production of shape determined components.

This view is shared by our colleagues in Toronto at the West Park Research Center where it is proposed to use a robot constructor to make seats.

The dream is that CAD and CAM will become so intimately meshed that the design and fabrication of shaped objects will proceed simultaneously. Also, it will be possible to have raw material managed in a way that will deliver an interface that varies in stiffness according to the way in which materials are delivered from the nozzles held by the robot constructor.

Establishment of computer controlled robot constructors would be as revolutionary in production technology as was the introduction of mass production.

Intermediate steps might include (a) the design of programmeable moulds, or (b) design of matrix elements that can be assembled by computer controlled robots.

When all of this is put together, we can say:

a) Biomechanical shape is determined by bone geometry and tissue quality.
b) Biomechanical shapes can be standardized.
c) Standard shapes can be customized.
d) Shape sensing can capture and classify shapes.
e) Interfaces can be constructed from matrices.
f) Matrices can be constructed by robots.

You may well consider the long and arduous course of actions bringing us to these possibilities. We can mesh them easily on the basis of hindsight. What step could have been omitted, what influences of colleagues on one another done without?

The adoption of matrices, computers, shape sensing, internal and external reference shapes and robot constructors is equivalent to a new date zero for design of shaped components for use in prosthetics, orthotics, and orthopaedics. We come to this as a consequence of the technology that surrounds us or can be envisioned on the basis of what surrounds us. We have merely to take note of it, reassess our problems in the light of it and act innovatively.

An important principle to guide us is to derive solutions that have wide-spread uses. This will help make what we design available to the disabled population. Matrices are like this. They could dim the boundary between prosthetics and orthotics and the boundary between disabled and able bodied persons. Computer aided design already does this. Robotic constructors are likely to have the same affect.
I urge you to this — aim for universal solutions.

Epilogue

I have tried to show how, starting with limited information, some propositions that foster solution of difficult problems have come into focus. The time and effort and innovative skills of many people, some unknown, have been involved. That there are such people with the time and resources to solve problems is a prime requirement. They need to be in environments that are conducive to original thinking.

Persons within or between groups need to be linked to permit complementary problem solving paths to develop. Innovating is not the province of a person or a group but is a flower that grows out of the human garden.

Innovative impulses need to influence not only what and how we design, but how we organize to do so. The need for cooperation and joint involvement in large projects is growing. Fortunately, the technical means are available to foster this. Seemingly separate entities such as standardizing shapes, designing modular systems, sensing shape, manipulating shape, transmitting shapes over the telephone, designing matrices and constructing custom shapes by robots coalesce as lively possibilities for automation of design and production of shaped components for prostheses, orthoses and orthopaedic footwear.

I cannot help but wonder how all of these things might have fared had they been part of an overall strategy fostered by cooperation of all of us engaged in prosthetics/orthotics research over the past few decades.

The necessity is for designers to overcome indifference to colleagues, mistrust, greed and jealousy so that field-adoption of comprehensive systems that can develop from joint efforts will be realized.

I personally feel that copyrighting and patenting are impediments to the free flow of information. Researchers would not be corrupted by the impulse to protect what they innovate in order to derive gain if the social means were available for the work they wish to do. The political problem is to foster mechanisms by which such programmes can be funded and the benefits be directly applied where the needs exist.

As I see it, we must be free of attitudes that keep us bound to our particular institutions. We must discount nationalism and ideologies to become truly conscious of our roles in relation to the world's people. Every person in our field plays some part in this. Manufacturers do when they make quality the factor of significance in their competition. Designers do when they encourage the best things to be used by the various participants in the rehabilitation field regardless of origins. Practitioners do when they stay informed and use what is best in the developing armamentarium. Educators do by trying new things, selecting the best and disseminating information about them. Funding agencies do when they are sensitive to grass roots inputs that identify appropriate objectives for research in support of services. Politicians do when they transcend political boundaries in response to world-wide needs.

These are the sorts of ideals that thoughtful men have brought to us down through the years. An innovative approach to their implementation is to be encouraged.

ISPO is the means by which we keep in touch with each other for furtherance of our common interests. They are the sorts of interests Knud Jensen held for ISPO which he saw as an important element in the evolution of a brotherhood dedicated to the wellbeing of physically disabled people throughout the world.

I appreciate the chance I have had to outline a course of events that illustrates the innovative process, to give you these thoughts through the Knud Jensen lecture and to wish you an inspiring 5th World Congress of the ISPO.

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The relationship of abnormal foot pronation to hallux abducto valgus — a pilot study

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Abstract

Abnormal foot mechanics is the most common cause of hallux abducto valgus. To date no quantitative data regarding the relationship between abnormal foot mechanics and the degree of hallux abducto valgus has been presented. An outline of the abnormal foot mechanics responsible for hallux abducto valgus is described along with a technique for measuring the extent of abnormal function. A common intrinsic abnormality responsible for hallux abducto valgus is described along with its diagnosis and orthotic treatment.

Introduction

Abnormal foot mechanics is the most common cause of hallux abducto valgus (Burns 1979). Until the advent of podiatric biomechanics in the early 1960's abnormal foot mechanics, as an etiological factor of hallux abducto valgus, had received comparatively little attention in the literature. A tendency for a pronated foot to develop hallux abducto valgus has been reported in several papers (Stein, 1938; Galland and Jordan, 1938; Joplin, 1950; Craigmile, 1953). Hofmann (1905) stated that a pronated foot is always associated with, and is always the cause of hallux abducto valgus. Studies describing the incidence of hallux abducto valgus in shod and unshod populations have identified footwear as an important etiological factor (Lam Sim-Fook and Hodgson, 1958; Shine, 1965). Several authors however, have reported that hallux abducto valgus occurs in unshod persons (Lam Sim-Fook and Hodgson, 1958; Shine 1965; Mann and Coughlin 1981). Root et all (1977) suggest that shoes are not a cause of hallux abducto valgus but aggravate the condition and accelerate the onset of deformity in a foot that exhibits abnormal foot mechanics.

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In a review of the literature available no quantitative data regarding the relationship between abnormal foot mechanics and hallux abducto valgus, in shod or unshod individuals, has been presented.

The purpose of this pilot study was to establish a quantitative method of measuring the abnormal foot mechanics associated with hallux abducto valgus. Subsequent work using the established technique would allow quantitative data to be collected and a possible correlation identified between abnormal foot mechanics and the incidence of hallux abducto valgus. An outline of the abnormal foot mechanics responsible for the development of hallux abducto valgus is given. The technique used to determine the magnitude of abnormal foot mechanics is described and an indication for its possible use is suggested. Clinical data regarding the incidence of non-rigid forefoot valgus, the most common predisposing frontal plane forefoot variation, responsible for the development of hallux abducto valgus is presented. The treatment of a non-rigid forefoot valgus condition using functional biomechanical orthoses is described.

Normal foot function

Before describing the abnormal foot mechanics associated with hallux abducto valgus it is necessary to discuss certain aspects of normal foot function.

At heel strike the subtalar joint should be neutral to slightly supinated. At 25 percent of the stance phase the subtalar joint is in a slightly pronated position, unlocking the midtarsal joint allowing adaptation to uneven terrain and providing shock absorption to the foot and skeletal superstructure. At this point the midtarsal joint is supinated from its fully locked position against the hindfoot and the first ray is in a dorsiflexed position. At 50 percent of stance phase the subtalar joint is approximately neutral. At this time the midtarsal joint should be fully pronated and locked against the hindfoot. At 75 percent of stance phase shortly after the heel comes off the ground the midtarsal joint remains locked against the hindfoot and the oblique toebreak, along with plantarflexion of the first ray, allows the forefoot to stay in contact with the ground. Plantarflexion of the first ray is important to allow free dorsiflexion of the hallux. Subtalar joint supination is primarily responsible for stabilizing the first ray during propulsion.

Abnormal foot function associated with hallux abducto valgus

Hallux abducto valgus is generally an acquired condition resulting in subluxation of the first metatarsophalangeal joint. The subluxation of the first metatarsophalangeal joint and subsequent development of a hallux abducto valgus deformity is caused by hypermobility of the first ray during the midstance and propulsive phases of the gait cycle. Hypermobility of the first ray occurs when the subtalar joint remains in a pronated position during midstance and propulsion. Subtalar joint pronation occurring during midstance and propulsion is classed as abnormal. The extent of first ray hypermobility and first metatarsophalangeal deformity is directly proportional to the degree of abnormal subtalar joint pronation. In order for hypermobility of the first ray to produce hallux abducto valgus deformity, it is necessary for the predisposing factor of forefoot adductus greater than 15° to be present. Abnormal pronation produces an abnormal position of the first metatarsal head during propulsion. The first metatarsal assumes a dorsiflexed and inverted position relative to the rest of the metatarsus as the first ray moves around its normal axis of motion. Therefore as muscles attempt to hold the hallux firmly against the ground, the first metatarsal head rotates into a dorsiflexed and inverted position relative to the base of the proximal phalanx. The normal first metatarsalphalangeal joint does not have an axis that allows motion to occur in a frontal plane. When the first metatarsophalangeal joint is forced to move in a frontal plane, contrary to its plane of motion, the joint subluxes.

In addition there is a functional lateral displacement of the sesamoids. Lateral displacement of the sesamoids gives the short flexor apparatus an advantage in an abductory direction and the dorsiflexion of the first metatarsal limits first metatarsalphalangeal joint dorsflexion, enhancing the likelihood of the hallux displacing laterally. Once lateral displacement of the hallux has begun the development of deformity is enhanced by several factors, two of these are: the bowstring effect of the long flexors inserting into the hallux; and the inherent digital abductus.

There are several predisposing abnormalities which cause abnormal pronation. One of the most common of these is non-rigid forefoot valgus (Burns 1977). The majority of these abnormalities inhibit normal resupination of the subtalar joint and maintain the foot in a pronated position throughout the midstance and propulsive phases of gait and therefore may cause the development of either hallux abducto valgus or hallux limitus (Fig. 1).

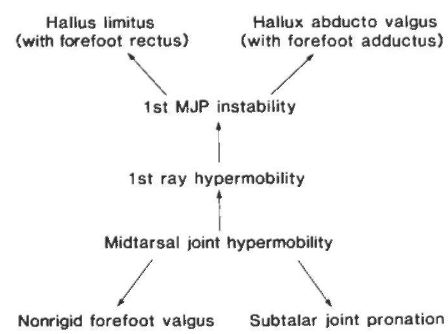

Fig. 1. Flow chart of hallux abducto valgus formation.

Measurement of foot pronation during midstance in an appropriate number of individuals would provide quantitative data to determine whether abnormal pronation was a consistent etiological factor in hallux abducto valgus. It will be remembered from the discussion of normal foot function that the foot should be in a neutral position at midstance.

Introduction to methodology

Vertical displacement of the navicular bone occurs with subtalar joint pronation. The magnitude of the vertical displacement of this prominent anatomical landmark when going from a non-weight-bearing to a weight-bearing stance was selected as a measurement of foot pronation.

Human gait is a highly complex dynamic event involving several anatomic structures both intrinsic and extrinsic to the lower extremity. Gait analysis however, may be simplified by considering static situations. For example the midstance phase of gait can be approximated by one leg static stance (Black and Dumbleton, 1980) the utilization of static equilibrium situations provides a basic understanding for the determination of joint position and the principles behind joint motion.

Even where the dynamic aspects are important a static analysis is usually the first step in the solution of the most involved mathematical and physical problems (Fender, 1962).

For the purpose of this pilot study a foot which displayed the following features in a static weight-bearing situation was designated a pronated foot: the height of the medial longitudinal arch was decreased and the forefoot was abducted on the rearfoot.

Method

Fifteen individuals (10 females, 5 males) aged 19-33 years (mean age 20 years) with varying degrees of hallux abducto valgus (8-32 degrees; mean 16 degrees) were used for the study.

The magnitude of hallux abducto valgus was obtained by the following method.

1. A foot print was obtained for each subject in right foot unipedal stance using an inked pedogram.

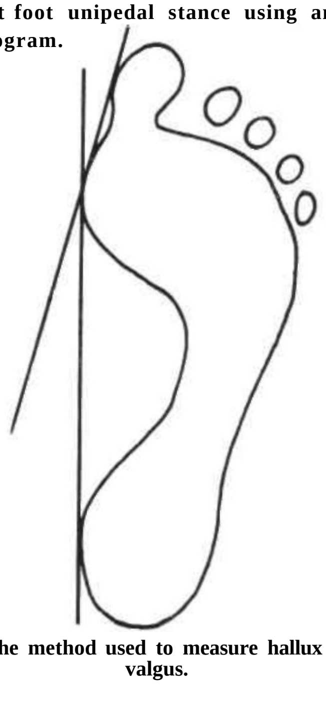

Fig. 2. The method used to measure hallux abducto valgus.

Fig. 3. Palpating the congruity between the neck of the talus and the calcaneus when determining subtalar neutral.

2. On the resultant pedograph the medial border of the foot was represented by a line drawn tangent to the first metatarsal phalangeal joint and the calcaneus.
3. From the tangent point of the first line at the first metatarsphalangeal joint a second line was drawn tangent to the medial border of the hallux.
4. The angle measured in degrees created by these two lines represented the extent of the hallux abducto valgus deformity (Fig. 2).

Navicular differential

The position of the navicular bone was determined with the foot in weight-bearing and non-weight-bearing positions.

The subtalar joint was placed in neutral and the midtarsal joint was fully pronated in the right foot of each subject. Neutral subtalar joint position can be ascertained by palpating the relationship of the head and neck of the talus to the calcaneus just anterior to the melleoli (Fig. 3). Neutral position should be defined as that position at which the subtalar joint is most congruent and neither the medial or lateral heads of the talus can be felt.

The right navicular was identified by palpation and marked with ink. For the non-weight-bearing position the subject was seated in a chair with both feet resting on the ground. Before sitting the subjects assumed their natural angle and base of gait. This meant that the right foot would be viewed in its natural midstance attitude. To obtain the natural angle and base of gait the subjects walked on the spot for approximately one minute at a comfortable pace with eyes straight ahead. They were then commanded to stop rapidly. The resultant position of the feet was taken to represent the natural angle and base of gait.

Without moving their feet the subjects were seated. The chair height was adjusted until both knees were flexed 90°. This ensured that the legs were perpendicular to the ground and the tibiotalar joints were in their neutral position. The non-weight-bearing height in millimetres was measured from the floor "to the ink spot on the right navicular bone. It was decided that placing the ankle joint complex in neutral was necessary to obtain a true indication of non-weight-bearing navicular position; the relationship of the foot to the ground is dependent on the relationship of the hindfoot to the ground. Maintaining the angle and base of gait the subjects then stood and the bipedal weight-bearing height (WB-2) of the right navicular was measured. The height for weight-bearing on the right foot only (WB-1) was then found. As in previous research the difference between the non-weight-bearing and weight-bearing measurements was identified as the navicular differentials (Delacerda 1980 a/b).

Table 1. Navicular differentials in feet with varying degrees of hallux abducto valgus.

Navicular differentials		Hallux abducto valgus
WB-2	WB-1	Degrees
25	27	32
12	18	30
14	18	5
12	16	15
13	15	18
9	14	21
12	14	20
10	13	18
8	13	12
10	12	17
9	12	16
10	12	14
8	12	13
7	9	9
4	7	8

Discussion

The vertical displacements of the right navicular bone of each subject are respresented in Table 1. The WB-1 Navicular Differential was greater than the WB-2 in all fifteen subjects.

The third subject also exhibited a hallux limitus in the right foot. This is because the angle of inherent forefoot adductus can vary from 0°-90°, thus, there is a point at which both deformities may occur simultaneously. In general an abnormal foot with a forefoot adductus angle in excess of 15° primarily develops a hallux abducto valgus deformity, while one with 10° or less of forefoot adductus primarily develops hallux limitus (Root et al, 1977). The abnormal pronation displayed by the third individual primarily predisposed to the development of hallux limitus.

To date, there is scarcely any evidence in the literature to suggest that static and dynamic function of the lower extremity are well correlated. Thus it may be the case that a patient presenting certain appearances during static examination functions entirely differently during walking. It is possible, therefore, that the WB-1 navicular bone displacement measured in an individual could be greater or smaller during walking. This factor was recognised as a limitation of this study.

However with the exception of the third result it would appear that within the limits of this study, abnormal pronation, as determined by the navicular differential at midstance was a consistent factor in the incidence of hallux abducto valgus.

Further study

Further clinical data is being collected in an attempt to establish a significant correlation between abnormal subtalar joint pronation and hallux abducto valgus.

As a control it is hoped to replace both the pedogram and navicular differential methods with X-ray analysis enabling exact measurement of hallux abducto valgus and navicular bone displacement. It would then be possible to determine how accurate the pedogram and navicular differential techniques are as a quick clinical method of measuring abnormal pronation.

Proposed use of navicular differential

In addition to the extent of hallux abducto valgus the speed of onset of this deformity is directly proportional to the degree of abnormal subtalar joint pronation. In this respect a quantitative measurement of a patient's abnormal subtalar joint pronation would provide an objective indication of the urgency, intensity and type of treatment required for that individual.

Abnormal pronation of the foot is one of the most common postural deformities seen in the feet of weight-bearing children (Tax, 1980). In the average individual adult, morphology of the foot is closely approximated by seven to eight years of age. Only a small change in arch height and morphology occurs in the normal foot from eight years of age to full maturity (Root et al, 1977). The abnormal foot function associated with hallux abducto valgus in children is similar to that found in adults. When abnormal pronation, joint hypermobility and subluxation occurs prior to the age of seven it generally retards or stops normal osteogeny and results in severe deformity of the foot. For this reason Tax (1980) states that abnormal pronation should be treated as early as possible using functional biomechanical orthoses.

This paper proposes that the navicular differential technique offers a quick and easy quantitative method of evaluating abnormal foot pronation in a clinical situation.

Forefoot valgus

A forefoot valgus is any forefoot to hindfoot mechanical relationship in which the plane of the forefoot (represented by a line drawn through the plantar aspect of the first and fifth metatarsal heads) is everted relative to a line bisecting the posterior aspect of the calcaneus when the subtalar joint is in a neutral position and the midtarsal joint is fully pronated and locked (Fig. 4, left).

The type of abnormality described above is classed as a frontal plane forefoot variation. Forefoot valgus can be subdivided into two groups; rigid and non-rigid.

Approximately 70 percent of all frontal plane forefoot variations are valgus. This observation is based on a review of the examination of 276 patients representing 552 feet. In this study by Burns (1977) significant frontal plane forefoot variation was found in 56 percent of the feet (309 feet) of these, 70 percent were forefoot valgus (216 feet). Burns also found that 70 percent forefoot valgus were of the non-rigid type. This means that nearly one half of all frontal plane forefoot variations are non-rigid forefoot valgus. Non-rigid forefoot valgus causes abnormal subtalar joint pronation, and therefore can cause hallux abducto valgus.

In a non-rigid forefoot valgus medial loading of the forefoot in a plane perpendicular to the posterior bisection of the calcaneus, causes the first ray to dorsiflex and the midtarsal joint to supinate bringing the plane of the forefoot perpendicular to the heel and unlocking the midtarsal joint relative to the hindfoot (Fig. 4, right).

Forefoot loading similar to that described above occurs during midstance and propulsion creating hypermobility of the midtarsal joint and first ray. The subtalar joint generally functions around a pronated position in this foot type to accommodate the supinated forefoot.

Midtarsal and first ray hypermobility caused by a non-rigid forefoot valgus in a foot with a metatarsus adductus greater than 15° can cause hallux abducto valgus.

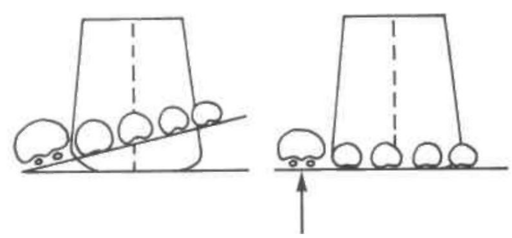

Fig. 4. Left, non-rigid forefoot valgus. Right, the effect of loading the medial aspect of the forefoot perpendicular to the bisection of the heel.

Orthotic therapy

Hallux abducto valgus is commonly caused by abnormal subtalar joint pronation in a foot exhibiting forefoot adductus in excess of 15°. In order to prevent the development of this type of hallux abducto valgus abnormal subtalar joint pronation must be eliminated. In a study involving six individuals both the period of pronation and the amount of maximum pronation were significantly reduced using functional biomechanical orthotic devices (Bates et al, 1979). Root et al (1977) state that hallux abducto valgus deformity can either be decreased or its development arrested by treatment with functional orthoses.

Manufacture of orthosis

A functional orthosis for a non-rigid forefoot valgus comprises a hindfoot post (Wedge) to control abnormal pronation of the subtalar joint and a 2-5 metatarsal bar post to enable equal loading of the forefoot.

A negative slipper cast of the foot is taken with the subtalar joint in neutral positions and the midtarsal joint fully pronated. The positive cast is poured and once dry is removed from the negative. It is then rubbed down with fine sandpaper.

The weight-bearing points of the first and fifth metatarsophalangeal joint are established by gently rubbing the positive cast against the worktop. Marks are then made 1cm proximal to these points which will represent the most distal edge of the orthosis shell. The first and fifth metatarsal shafts are bisected and these lines represent the medial and lateral borders of the orthosis respectively (Fig. 5, left).

One of the most common materials used in the manufacture of functional biomechanical orthoses is Plexidur. This is preheated and vacuum formed to the positive cast. Excess material is removed until the shell of the orthosis conforms to the marks on the positive cast. The shell is then cut back from the medial aspect of the second metatarsal head to a point approximately 1.5 cm proximal to the first metatarsal head (Fig. 5, right).

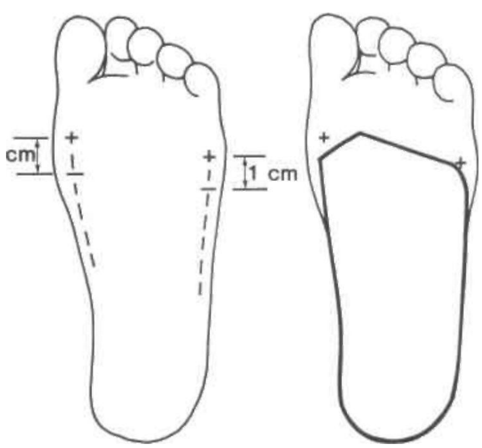

Fig. 5. Left, marking of first and fifth metatarsal heads. Right, shape of finished shell.

Next, the hindfoot post and the 2-5 metatarsal bar post are incorporated into the shell of the orthosis. Before posting the orthosis the shell is secured to the positive cast with zinc oxide tape. Both of these additions are made from acrylic resin. A 2mm thick bar post is placed along the anterior edge of the shell from the second to fifth metatarsal heads.

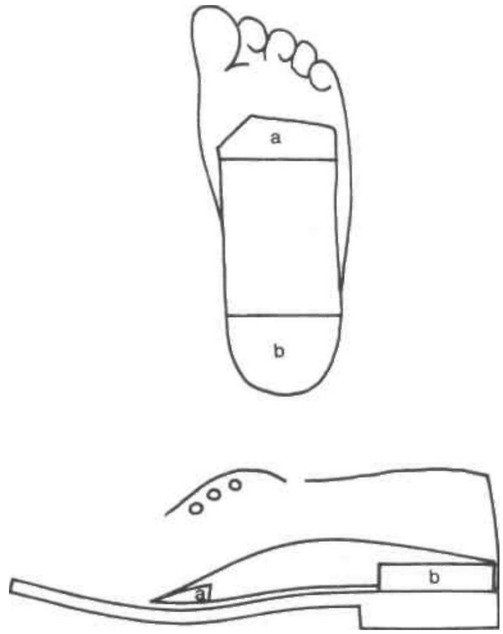

Fig. 6. Plastic shell fabricated as described in text, a) metatarsal bar post, b) medial hindfoot post.

The hindfoot post is applied in the following manner. A quantity of acrylic is placed on grease proof paper on the worktop. The shell is then pushed into the acrylic and angled in the frontal plane raising the anterior medial edge of the device from the supporting surface. The shell is angled 4° and this is checked by placing an angle finder on the dorsal surface of the positive cast. Once dry, excess acrylic is removed with a grinding wheel until the posts conform to the dimensions of the shell. Finally the hindfoot post is given a 4° grind off to allow for normal pronation of the subtalar joint during the stance phase of the gait cycle. A functional orthosis sits in the patient's shoe and is not secured to the foot in any way (Fig. 6). The effectiveness of the orthosis can be augmented by wearing lacing type footwear with a stiff heel counter and shank, and a deep heel seat. The aim of functional orthoses control is to allow the foot to heel strike with the subtalar joint near the neutral position, to pronate for shock absorption and then allow transverse plane rotation of the leg. The pronation must be controlled and limited so that the foot will be in a position from which it can resupinate. By 50 percent of the stance phase of gait (mid-stance) when the subtalar joint is back near its neutral position, the orthosis must maintain the midtarsal joint fully pronated against the hindfoot in preparation for propulsion. By 75 percent of stance phase the foot should be rigid for its use as a lever during propulsion. At this time the orthosis has little effect on the foot as propulsive forces are concentrated distal to the device. The normalization of function which the orthosis provides up to this time allows the foot to be in a position from which adequate propulsion is possible.

The principle of functional orthosis therapy for a non-rigid forefoot valgus is to prevent abnormal subtalar joint pronation. This prevents midtarsal joint and first ray hypermobility during midstance and propulsion and eliminates the development of hallux abducto valgus. Functional orthosis therapy increases the plantarflexion force exerted by the peroneus longus muscle during propulsion thus enhancing first ray stability. In addition a functional orthosis provides stability of the forefoot around the oblique axis of the midtarsal joint.

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A three-quarter type below-elbow socket for myoelectric prostheses

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Abstract

The Muenster and Northwestern sockets have become universally prescribed for below-elbow amputees with myoelectric prostheses. The most attractive feature of these sockets is that they are self-suspending, thereby obviating the need for a harness. The sockets are designed to encompass the patient's whole elbow. Because of the intimate fit, heat build-up inside the socket is a problem. Patients with myoelectric prostheses are denied the benefit of a stump sock. Ventilation inside the socket is almost zero and excessive perspiration occurs. This leads to maceration and skin problems which negatively affect control, comfort and wearing time. This paper reports on a technique whereby the problem of no ventilation is overcome through the removal of the proximal-posterior quadrant of the socket.

Introduction

An attractive feature of the myolectric below-elbow prosthesis is the complete absence of any harness. This factor has been emphasised repeatedly by the many amputees who converted from conventional to myolectric prostheses. The use of externally powered terminal devices together with self-suspending sockets such as in the myolectric below-elbow prosthesis has made the much disliked dual-purpose harness of the conventional prosthesis obsolete. Two major designs for self-suspending below-elbow sockets have emerged and are widely recognized by the prosthetic practitioner today. Named for their places of origin, they are the Muenster and Northwestern type sockets.

The Muenster Socket, originally conceived by Drs. Hepp and Kuhn of the University of Muenster and described by Kay et al (1965) is most widely used for short to medium length below-elbow stumps and is designed to grip the stump in the sagittal plane between the ante-cubital fold and the olecranon fossa. The Northwestern type socket (Billock, 1972) is advantageously employed on long below-elbow stumps and provides suspension through a medio-lateral grip of the stump just superior to the epicondyles of the elbow.

Many variations exist between these two major socket designs and depend on stump length and the individual prosthetist. All aim to meet the same criteria:

a) To provide an interface between patient and device, to receive and contain the tissues of the stump.
b) To provide control over and suspension of the prosthetic device without undue limitations to either comfort or range of motion.
c) To accept the electrodes of the myoelectric control system employed.

These criteria are usually met.

Suspension is usually excellent because of the elbow encompassing design of the sockets. The intimate fit provides the amputee with superb proprioceptive feedback.

The range of motion at the elbow is usually slightly reduced from normal. Whilst this has never been a functional problem, it has sometimes been a cosmetic concern (Gordon, 1966).

A serious and constant complaint about the myoelectric prosthesis is heat build-up inside the socket. This is easily understood when one realizes that the patient, because of the

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myoelectric control, is denied the comfort of a stump sock. Air circulation within the confines of the socket is therefore non-existent. Whilst the internal heat build-up eventually plateaus when the socket becomes a heat sink, the problem of perspiration becomes continually more pronounced. Because of this, many patients report a much reduced wearing time in the summer. In addition, this may well be the major cause for the non-use of myoelectric prostheses in the tropics.

This paper examines the below-elbow socket, and the extent of shrouding it provides, and describes a method to increase effective air circulation without lessening the basically sound design of the socket.

Analysis of the below-elbow socket

An analysis of the socket and its dynamics as part of the below-elbow prosthesis is aided by dividing the socket into four sections while looking at it from a lateral view.

The *first* division to be made is circumferential and divides the socket into a distal and proximal half. The *second* division is axial and in the frontal plane, dividing the proximal and distal halves further into anterior and posterior parts or quadrants as shown in Figure 1. The measure of function contributed by each of these quadrants is quite different as further analysis reveals.

The first quadrant or distal anterior part of the socket transmits the forces generated by flexion of the elbow. It lifts the prosthetic forearm into a position at right angles to the humeral portion of the arm. It thus carries the weight of the prosthesis.

The second quadrant, or distal posterior part of the socket responds to the extension of the stump. It extends the prosthetic forearm and assists in stabilizing activities. Together with the distal anterior part of the socket, it contains the tissues of the stump and becomes the guiding portion of the prosthesis for movements in both the sagittal and coronal planes.

The third quadrant or proximal anterior part contains the socket brim and thus provides suspension of the socket and the prosthesis. It also connects to the distal socket half and therefore secures the socket axially.

The fourth quadrant or proximal posterior part of the socket, however, has apparently no functional value and does not contribute to the quality of the socket in any way.

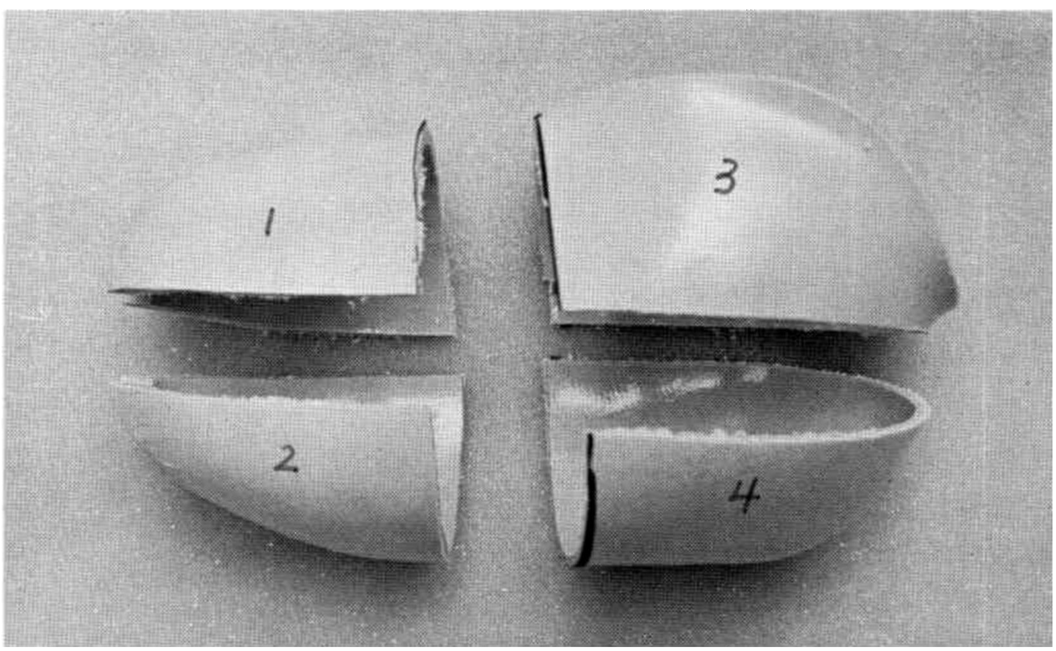

Fig. 1. The first and second quadrants are the guiding portions of the socket; the third quadrant provides suspension and stability; the fourth quadrant is non-contributory.

The three-quarter type below-elbow socket

At the Hugh MacMillan Medical Centre, the area falling into the boundaries of the fourth quadrant is cut away as much as possible as shown in Figure 2. This simple measure successfully removes the most important single complaint about the myoelectric below-elbow prosthesis, which is about excessive heat and perspiration inside the socket. This has been caused by the amputee's tissues being confined in an intimately fitting socket without the benefit of a stump sock. In the new three-quarter type below-elbow socket, ventilation has been greatly improved, therefore the skin of the stump remains dry making for a cooler socket in the summer and a warmer stump in the winter. Skin problems that have previously been caused by maceration are eliminated while comfort and wearing tolerance are greatly improved.

Suspension is also improved because excessive perspiration sometimes causes an otherwise well-fitting prosthesis to slip off. Improvements in performance are seen as well because both slippage and perspiration previously interfered with control.

In addition to these more direct and expected improvements, it has been found that, since the anatomical elbow is now free to move into the cut-out, a definite increase in the flexion range can be observed. In retrospect, it seems that many below-elbow sockets have limited range of flexion due to the restriction at the elbow rather than at the biceps tendon. With the posterior proximal quadrant cut away the socket now shows reduced bulk in the fully extended position and is therefore cosmetically more pleasing. This is seen in Figure 2. In addition, because the elbow is now largely exposed, the patient is able to place the prosthesis quietly down onto a table top.

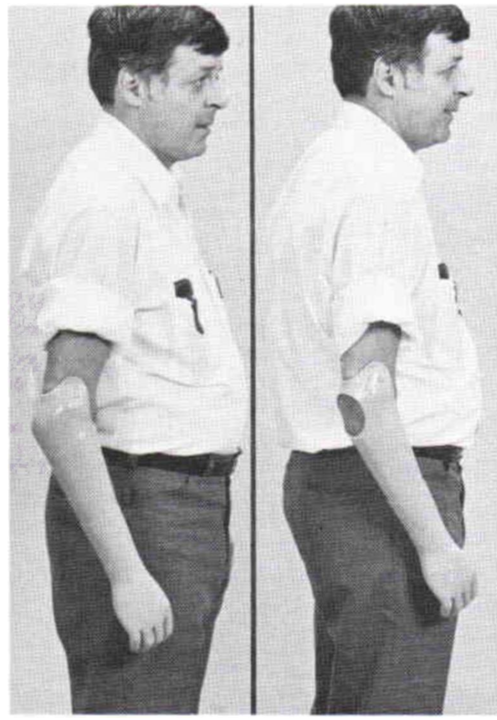

Fig. 2. With the elbow cut away, the socket shows reduced bulk in full extension.

Method of construction

All sockets are made in the normal fashion with no deviation from the usual fabrication procedures. Cutouts may be made as a retrofit. It is worth mentioning that the prosthetist can dispense with the usual modifications made to the positive mould in the elbow area. In cases of users involved in manual labour it may be appropriate to reinforce the olecranon bridge with some extra material, e.g. a couple of patches of nylon tricot to prevent later cracking of the laminate. The actual cutout is made only after having carefully assessed the length of the patient's stump. As a rule of thumb, the cut-out length should not exceed 50% of the axial stump length. If this rule is not followed, the stump may not be contained properly. Before cutting, the outlines of the intended cut-out surface should be drawn on the socket with a grease pencil. Depending on the actual size of the cut-out, a hole can be made with a conical plastic bit* and a router used to gradually enlarge it. In cases of adult patients, the cut-out can be made using a cast cutter. In either case, it is advisable to start conservatively and enlarge the hole gradually. The edges of the cut-out should be smoothed and burnished as are other parts of the socket brim.

Clinical experience

The procedure described above has been used by the authors with excellent results over the past few years on more than 50 patients fitted

*Otto Bock Catalog for Machines and Tools, Conical drill, No. 726W9/20mm.

with myoelectric below-elbow prostheses. The patients involved were both adults and children and were fitted with hard resinous or silicone rubber flexible sockets (Sauter, 1975). No negative side effects were observed.

This simple procedure has proven to be effective in removing the drawbacks of the type of socket used in below-elbow myolectric prosthesis fittings. It has now become standard practice in the powered upper extremity prosthetic programme at the authors' centre. These positive findings have been confirmed by colleagues in other centres.

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Custom moulded plastic spinal orthoses

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Abstract

A review of fifty patients with wide ranging clinical conditions who had been fitted with one-piece moulded plastic spinal orthoses was carried out to determine prescription criteria for these orthoses. The review showed that patients with scoliosis (idiopathic and paralytic), kyphoscoliosis, as well as a selected number of patients with low back pain derive benefit. Patients with kyphosis and localized vertebral body disease are unlikely to gain benefit since they commonly cannot tolerate the excessive skin pressures which occur as a consequence of the corrective and distractive forces applied by the devices.

Introduction

Spinal orthoses are one of the most commonly prescribed types of orthoses delivered in the United Kingdom. A review of prescription practices in Dundee during one year showed that a total of 520 spinal orthoses had been prescribed and subsequently fabricated representing 17 per cent of the total orthotic supply for a district with a population of 180,000 people. Ninety one per cent of these orthoses were fabric supports but the remainder were rigid devices. These devices have traditionally been fabricated from metal and leather but in recent years it has been the practice in Dundee to make increased use of moulded plastic jackets (McDougall and Condie, 1982).

Between 1979 and 1982, a total of 56 patients with a wide range of clinical conditions had been supplied with 66 moulded jackets. Eight of these patients had undergone spinal surgery and 34 had previously worn conventional orthoses such as fabric supports, Taylor braces and Milwaukee braces. Referring clinicians had considered that these conventional orthoses had been inadequate for a variety of reasons and had decided that alternative orthotic provision should be attempted even though the plastic orthoses were often considered to be a 'last resort'. The success of their fittings and the consequent increased clinical demand prompted the authors to undertake a review of 50 consecutively fitted patients in order to improve our understanding of prescription criteria and to assess the benefits of this type of orthotic care.

Description of orthosis

One-piece plastic spinal orthoses are commonly fabricated using vitrathene (Paul, 1970), a derivative of polyethylene*, although polypropylene can also be used (Zamosky, 1978). The fabrication process involves taking a plaster-of-Paris wrap cast of the patient's trunk, from which a plaster model is produced. The force distribution required to be applied by the orthosis upon the trunk is achieved through the rectification of the model (the addition or removal of plaster). A heated sheet of vitrathene is draped by hand around the rectified model and its edges are trimmed when it has cooled. Particular attention is given to the axilla and groin areas. The plastic is flexible in its opened state allowing the patient to don it, but becomes rigid when secured with velcro straps around the trunk. The plastic overlaps over the abdomen (Fig. 1). Sheets of various thicknesses are used depending upon the desired rigidity.

The orthosis is light in weight (typically 0.5 to 1 kg) and is more cosmetically acceptable than

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'Vitrathene' is manufactured by Stanley Smith and Co., Isleforth, England and supplied through North Sea Plastics, Dumbarton, Scotland.

the conventional metal and leather devices (Fig. 2). It is easy to clean and does not absorb perspiration. Vitrathene possesses excellent fatigue properties and its durability typically gives many years of useful function.

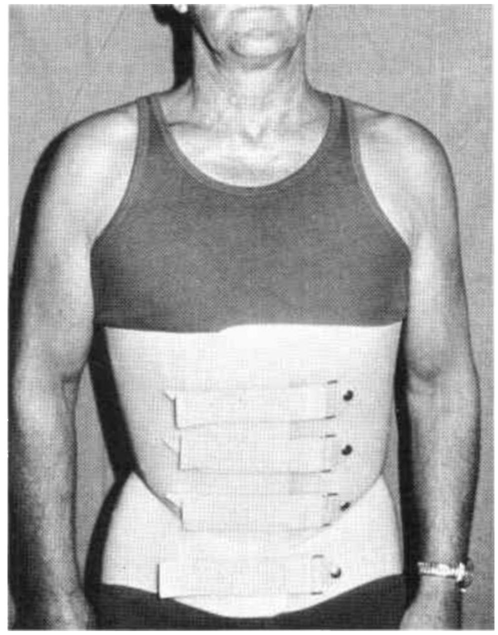

Fig 1. A one-piece plastic spinal orthosis with the proximal edges overlapping on the abdomen.

Review method

The 50 patients selected for the review were taken from a list of sequential deliveries. The mean follow-up time was 25 months following delivery with a minimum period of four months. The review was conducted by interviewing 47 patients and recording the answers to pie-set questions using a specially developed proforma. Relevant personal details, diagnoses, previous forms of treatment, orthotic objectives and results of clinical reviews were noted. The details of a further three patients who had died since delivery of their orthoses were taken from case notes. Decisions on the success or otherwise of the orthoses were made from an assessment of a number of criteria, including the provision of postural support and the relief of persistent pain.

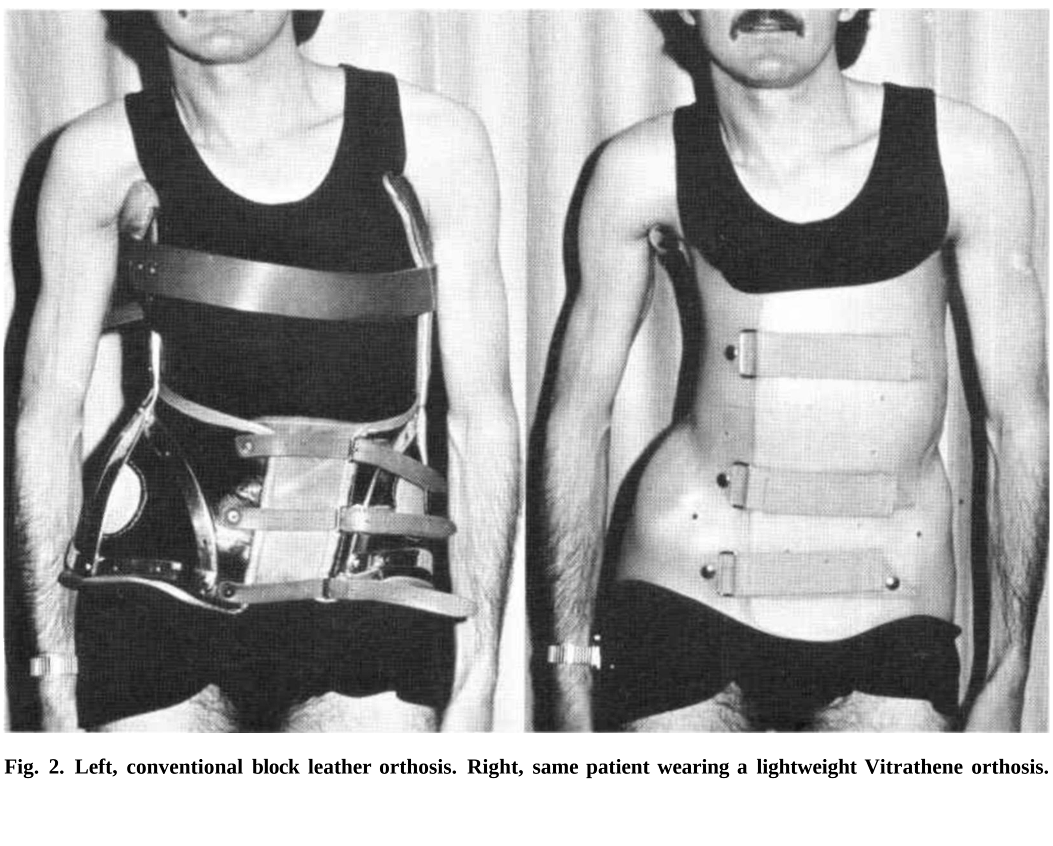

Fig. 2. Left, conventional block leather orthosis. Right, same patient wearing a lightweight Vitrathene orthosis.

Table I. Review summary

Group	Condition	Number of patients in group	Number of successful fittings
1	Spinal deformities		
(a)	Paralytic scoliosis	11	8
(b)	Scoliosis-kyphoscoliosis	10	8
(c)	Kyphosis	6	2
2	Localized vertebral body disease	4	0
3	Low back pain	19	10
	Total:	50	28

Results

The patients were divided into three groups for the purposes of analysis.

The first group consisting of patients with spinal deformities was further sub-divided into three sub-groups (a) paralytic scoliosis, (b) non-paralytic scoliosis and kyphoscoliosis and (c) kyphosis.

The second group consisted of patients with localized vertebral body disease caused by tumours or infection.

The third group consisted of patients with low back pain from various causes and whose orthoses were prescribed principally to reduce pain.

Table 1 summarizes the number of patients in each group, with the results of the review.

Spinal deformity (Group 1)

Paralytic scoliosis (Group IA — II patients)

The application of a three point force system in the coronal plane for patients with scoliosis, typically requires forces laterally on the rib cage under the axilla, contra-laterally on the distal end of the rib cage and thirdly at a point on the lateral aspect of the pelvis immediately proximal to the hip joint. To achieve this force system, it is essential that the orthosis fits closely around the pelvis.

These 11 patients suffered from osteogenesis imperfecta, congenital spastic paraplegia, Werding Hoffmann disease, Duchenne muscular dystrophy, pseudohypertrophic muscular dystrophy, poliomyelitis or spina bifida (Fig. 3).

Eight patients continued to wear their orthoses at the time of the review. Of the three which had been withdrawn, one had been prescribed for a two year old child with spina bifida whom the surgeon subsequently considered no longer needed an orthosis. The second had been prescribed too late for one of the muscular dystrophy patients who was in the latter stages of terminal illness. The third patient who had worn a block-leather orthosis since childhood following the onset of poliomyelitis, preferred this to the plastic orthosis.

One child with spina bifida used the spinal orthosis within a standing frame to improve posture and balance. The patient with osteogenesis imperfecta was the only one in the review who routinely wore his device in bed to assist breathing. Two patients reported intermittent discomfort with pressure on the rib cage and the anterior iliac spine and the review showed that these are areas requiring considerable care in the cast rectification processes.

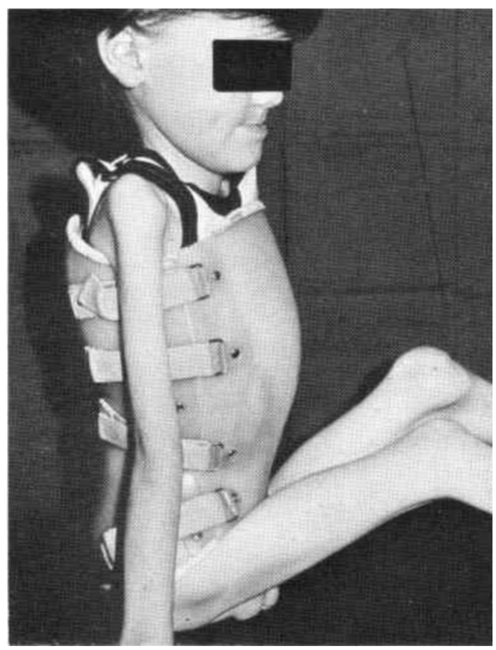

Fig. 3. A one-piece plastic spinal orthosis fitted to a child with muscular dystrophy. Straps have been provided on the lateral side to facilitate donning

Non-paralytic scoliosis-kyphoscoliosis (Group IB — 10 patients)

The majority of patients in this group were adults with degenerative changes secondary to longstanding idiopathic scoliosis but the group also included patients suffering from osteoporosis, cerebral palsy and neurofibromatosis. Eight of the ten patients demonstrated satisfactory results when the criteria of pain relief and improved ability to undertake functional activities such as standing and walking were considered. Six had previously worn spinal orthoses of other types. Patients in this sub-group generally wore their orthoses intermittently.

The two patients who had discontinued use of their devices had done so because of discomfort. One had complained of discomfort when sitting and a further patient had rib impingement on the side of the scoliosis. Their discomfort could not be alleviated by adjusting their orthoses.

Kyphosis (Group IC — 6 patients)

For kyphosis, forces acting in the sagittal plane require to be applied anteriorly on the sternum and pubis and posteriorly in the dorsal region. The application of these forces inevitably requires a full-length device which patients find uncomfortable because of high skin pressures on the sternum and pubis.

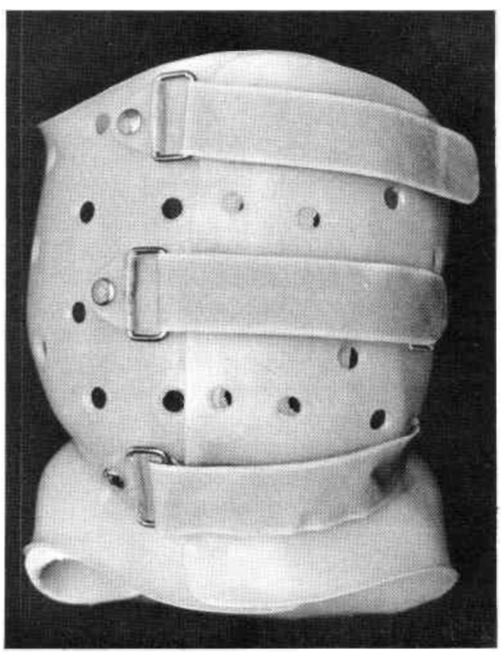

Fig. 4. "Keying-in" of the orthosis around the pelvis is essential for correct fitting. Soft liners may be used for comfort.

Patients with kyphosis did least well with this type of orthosis. Of the six patients within this category, only two had gained benefit. Discomfort was commonly reported especially in the sitting position. For the three patients with osteoporotic crush fractures, adequate corrective forces could not be tolerated.

Localized vertebral body disease (Group 2 — 4 patients)

There were four patients in this group and none achieved a satisfactory result. The group consisted of one patient with haemangioendothelioma of T10, one with Paget's disease of LI and two with local but severe deformity following tuberculosis. It was considered that all these patients needed distraction for pain relief which was not obtainable in the spinal orthoses.

Low back pain (Group 3 — 19 patients)

The aim was to restrict spinal movement for these patients rather than to apply any corrective forces. Considerable care was thus taken to locate the orthosis on the pelvis by moulding deeply into the iliac crests (Fig. 4). The orthosis was also flattened over the abdomen in an effort to influence the intra-abdominal pressures (Morris et al, 1961) although it probably helped more by further restricting movements (Nachemson et al, 1983).

There were 19 patients in this, the largest group in the review. Successful fittings were achieved in ten cases. The prevalence of low back pain in the community prompted the investigators to pay particular attention to this group and the results are summarized in Table 2.

It was significant that seven patients gained satisfactory results with these rigid orthoses when fabric supports had failed. Four patients were unable to wear their orthoses for genuine reasons (Table 2b). Of these, one patient was too frail to be a suitable candidate, the second had respiratory problems and could not tolerate anterior pressure and two obtained better relief with medication.

The assessment and treatment of some patients with low back pain can be notoriously difficult. In retrospect it should have been

Table 2. Results of fitting patients suffering from low back pain

SUCCESSES:			
TABLE 2A			
Osteoarthrosis with referred pain			— 7 patients
Spondylolisthesis			— 2 patients
Compression fractures awaiting fusion			— 1 patient
			Total: 10 patients
FAILURES:			
TABLE 2B			
Osteo-arthritis with compression fracture		L4	Too elderly and feeble
Osteo-arthritis with spondylolisthesis		L3/4	Respiratory problems
Indefinite investigation but considered connected with artereo-sclerosis		—	Preferred simple analgesia
Prolapsed intervertebral disc		L4	Preferred simple analgesia
			Total: 4 patients
TABLE 2C			
Osteo-arthritis	—2 patients	L4/5	Anxiety neurosis
Indefinite cause		—	Hypochondriacal
Prolapsed intervertebral disc		L3/4	Hysterical paraplegic
			Total: 4 patients
Minor osteo-arthritis		L4/5	Malingerer

possible to anticipate failure in four of the remaining five patients (Table 2c). Examination of the complete medical case notes confirmed that four patients had definite psychological problems which directly influenced their low back pain. In all four cases, the diagnoses were made by at least one clinician outside the authors' department. The presence of these adverse psychological factors do not of course exclude the presence of true spinal pathology.

Discussion

The prescription criteria for vitrathene spinal orthoses can be best determined by considering patient groups.

Patients with paralytic scoliosis gain an improved posture, breathing control and outward appearance (Fig. 5) (James, 1977). The results were particularly impressive for four teenagers confined to wheelchairs. All gained more upright positions and were able to use both arms whereas previously they needed the support of an elbow on the wheelchair armrest for support. They reported improved breathing control and increased self-confidence since the presence of the jackets could not be detected under their clothing.

Patients with scoliosis or kyphoscoliosis presenting with secondary degenerative changes, especially the elderly, benefit from using vitrathene jackets for the relief of pain even for part of the day. Intermittent use may be made by a number of patients for pain relief whilst standing and walking. Patients with kyphosis may also encounter pain as a consequence of secondary degenerative changes but this group does least well and these patients commonly complain of excessive skin pressure.

The second group of patients with localized vertebral body disease did not benefit. The distractive forces which are required for these patients cannot be readily applied by the plastic orthoses since intolerable skin pressures are encountered.

It is less easy to foresee the results for the third group of patients, namely those with low back pain. Most patients needing orthotic care are successfully supplied with a fabric support but there are some patients needing a rigid device. Experience has shown that vitrathene orthoses may be of considerable benefit if applied correctly but very careful assessment is necessary before decisions are taken to initiate fabrication.

Patients' views were sought regarding increases in body temperature and perspiration due to the close proximity of the plastic. Fourteen patients reported no discomfort and were quite satisfied although cotton vests were commonly worn to improve comfort. Patients found their orthoses most beneficial whilst standing, a point on which all (excluding wheelchair users) reported favourably. Eight patients who continued to wear their devices reported some discomfort under certain situations such as sitting in soft cushioned chairs. It was observed that patient age, per se, is not a contra-indication to the prescription process and patients with ages ranging from 2 to 83 were fitted.

Summary

The review demonstrated that moulded plastic spinal orthoses have an important role in orthotic rehabilitation. The major advantage of this type of orthosis over conventional types is the facility to provide a more precise force system between the orthosis and trunk to meet the particular prescription objectives for each patient though considerable patience may be needed during the fabrication processes. Patients generally find their orthoses lightweight and easy to clean. Those in the series found that their jackets were easy to apply with the exception of the wheelchair users and the elderly and frail.

Prescription practices in Dundee now reflect the results of the review but experience has shown that it is important to show a vitrathene orthosis to a patient before fabrication commences, to ensure that he or she will be prepared to use one. This is necessary to avoid wasted efforts in device fabrication.

Acknowledgements

The authors wish to acknowledge the contributions made by Mr. D. McDougall, Principal Orthotist at Tayside Rehabilitation Engineering Service, who developed the procedures for fabricating one piece plastic spinal orthoses and who fitted the majority of the patients in this review. They also wish to thank Professor G. Murdoch and Mr. D. Condie who provided helpful comments in the compilation of this paper.

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Biomechanical study on axillary crutches during single-leg swing-through gait

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Abstract

This paper describes a kinetic and kinematic study on axillary crutches during one-leg swing-through gait. The primary objective is to evaluate the interplay of forces at the crutch and body interfaces and to relate them in the understanding of problems associated with the use of axillary crutches. Ten normal adult male subjects with simulated left leg impairment participated in the study. For data acquisition, the VICON kinematic system, a Kistler force plate and an instrumented crutch (with force transducers at the two upper struts close to the axillary bar and one near the crutch tip) were used. Results showed that the peak ground reaction force on the weight-bearing leg during lower limb stance increased by 21.6 percent bodyweight. The peak reaction force transmitted to the arm during crutch stance was 44.4 percent bodyweight. These increased loadings could be detrimental to patients with unsound weight-bearing leg and upper extremities respectively. When the crutches were used incorrectly, 34 percent bodyweight was carried by the underarm. This could cause undue pressure over the neurovascular structures at the axillary region.

Introduction

Axillary crutches are widely used either temporarily or permanently to assist ambulation in various type of locomotor disabilities. They are used for relieving weight-bearing on operated or injured lower limbs and also in some cases of lower limb paralysis for the purpose of ambulation.

The use of axillary crutches however is not without problems. Brooks and Fowler (1964) had reported complications such as axillary artery thrombosis. Rudin and Levine (1951) had observed the compression of the radial nerve by the axillary bar. Jebsen (1967) noted that though sensation is rarely affected by radial nerve compression, motor weakness may become subtly worse. He warned that this may lead to complete paralysis of the triceps and forearm extensor muscles. These adverse effects are usually a result of bearing weight directly on the axillary bar under the arm during crutch walking.

Several papers have been published on various biomechanical aspects concerning the use of axillary crutches. Shoup et al (1974) reported on the kinematics of swing-through gait with both feet landing using axillary crutches. Four normal adult male subjects were used in their study. They recommended three possible design improvement criteria : (a) to minimize the vertical motion of the upper body; (b) to minimize the shock associated with planting of the crutch tips; and (c) to minimize the need for lateral motion of the crutch tips. Stallard et al (1978) observed that during swing-through gait with axillary crutches, the vertical ground-foot reaction forces increased by 24.5 percent body-weight for single-foot landing and 35.1 percent for both feet landing when compared with normal gait. They suggested from their findings that the increased loadings on the lower limbs could be detrimental to patients with unsound weight-bearing limbs and could contraindicate swing-through gait for such cases. Five male and five female normal adult subjects were used in the study. Sankarankutty et al (1979) compared the use of the axillary, elbow and Canadian crutches in relation to the metabolic energy consumption. They found that all the ten normal adult subjects (five male and five female) felt that the axillary crutches were easiest and least tiring to use although higher heart rates were recorded. They pointed out that artificial

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stimulation of the heart is possible when using this type of crutch, since the axillary bar is regularly pressing against the thoracic cage. Wells (1979) found that the kinematics and mechanical energy variations of the two-leg swing-through gait were dependent on both the speed of progression and degree of induced disablement. However, the mechanical energy cost of crutch gait was found to be similar to that in normal gait. Three normal adult male subjects were used in their study. A study by McGill and Dainty (1984) on the kinematics, kinetics and mechanical energy of children's crutch gait, shows the importance of optimal length fitting. Increased energy expenditure and reduced crutch weight-bearing were observed with ill-fitted axillary crutches. Five male and three female normal subjects, ages ranging between 9 and 11 years, took part in their study.

In all the articles reviewed, the use of normal subjects was a common feature. Wells (1979) pointed out that the use of normal subjects in two-leg swing-through gait has repercussions on the results. This is because normal subjects are able to make full use of their legs. Therefore to be more representative of the disabled crutch user, the joints of the normal lower limbs must be immobilized. This may be true in simulating two-leg swing-through gait, especially that of paraplegic subjects. However, in one-leg swing-through gait, the weight-bearing leg of the disabled crutch user is usually capable of normal range of motion and has normal muscle power. Hence, by suspending one of the legs in the normal subject for one-leg swing-through gait, a close approximation of many disabled crutch users can be achieved (Stallard et al, 1978). Furthermore, the advantages of using normal subjects are (1) greater control of parameters, (2) availability and (3) adaptability of test subjects.

Table 1. Physical characteristics of subjects

Subject	Age (yrs)	Height (m)	Body Mass (kg)
ACP	24	1.73	60.6
AEJ	23	1.72	80.5
DHH	24	1.67	53.3
LCA	24	1.74	59.7
LKC	24	1.78	62.0
TBH	24	1.73	61.9
TSC	25	1.72	52.2
TYK	23	1.78	73.5
YCM	24	1.67	47.5
YWK	24	1.76	63.5
Average (σ_{N-1})	23.9 (0.6)	1.73 (0.04)	61.5 (9.8)

The objectives of this study were to firstly describe the single-leg swing-through crutch gait pattern and secondly, to determine the axial forces acting along the axillary crutches.

Materials and methodology

Ten normal male subjects were used in this study. Table 1 shows the physical characteristics of these subjects. Each subject was required to flex the left knee to simulate impairment so that only the right leg was weight-bearing. The right leg was the dominant side of all the subjects. Adequate training in the use of axillary crutches was given by a physiotherapist. The crutch gait pattern used for all tests was the one-leg swing-through gait with two axillary crutches and landing on the right foot.

Prior to the commencement of the gait trial, each subject was given as much practice as he required to ensure that he landed on the force platform with his right foot or crutch. Each gait trial consisted of the subjects:

(i) walking normally at their comfortable speed;

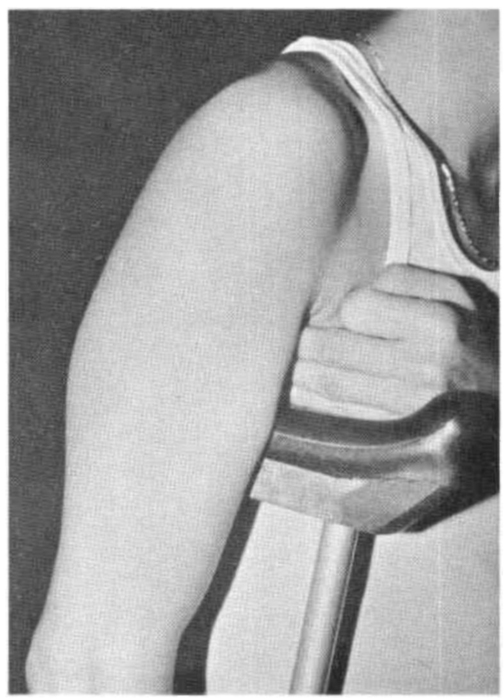


Fig. 1. Correct use of crutch, with a three-finger gap between the axillary fold and bar.

(ii) ambulating with axillary crutches using one-leg swing-through gait at their preferred speed with respect to the following:—
   (a) Proper usage of crutches, that is with the axillary bar three fingers (approximately 50mm) below the anterior axillary fold (Fig. 1)
   (b) Incorrect usage, that is height adjusted so that the anterior axillary fold contacts the axillary bar.

For crutch walking, the ground reaction forces of the right foot and the right crutch were taken on separate runs. For normal walking, only data on the right foot was measured. A run was considered acceptable when the foot or the crutch touched the force plate within its proper limits and that the markers on the body and crutch were visible to the cameras. The resulting representative run was taken as the average over three acceptable runs.

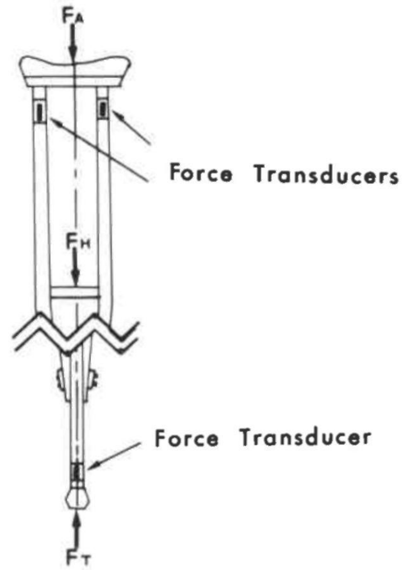


Fig. 2. Lateral view of crutch showing the locations of the force transducers.

Instrumentation

Kinematic data of the one-leg swing-through crutch gait was recorded by a television/ computer gait analysis system, trade-named "VICON" (Oxford Metrics Limited, Oxford, England, U.K.). The three-camera system was used in the ipsilateral study. The ground reaction forces of the foot and the axillary crutch during locomotion were monitored by a Kistler force platform (Type 9281B11).

Uniaxial forces were also measured at three different locations on the axillary crutch on the side of the landing (i.e. right) leg. Stallard et al (1980) had shown that the vertical ground reaction to the crutch on the side of the landing leg was on average greater than the contralateral side. Figure 2 shows the three locations where the strain gauges were installed, that is near the crutch tip and the two upper struts of the crutch, close to the axillary bar. The instrumented crutch was calibrated and the three sets of strain gauges were found to respond linearly. The overall error of the force measurements was less than 3 percent. The strain gauges were connected to a 6-channel TML Type DT6A dynamic strain meter (Tokyo Sokki Kenkyojo Co. Ltd., Shinagawa-ku, Tokyo, Japan 140) and the results were plotted on a 6-channel chart recorder.

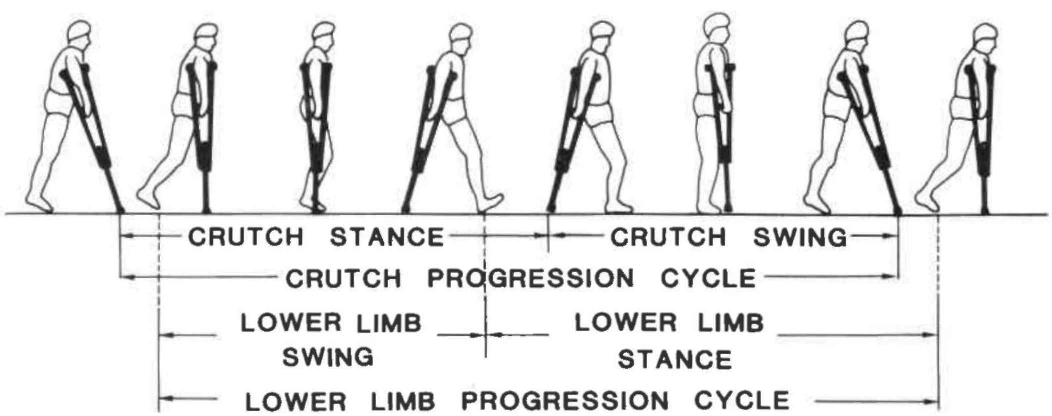


Fig. 3. Gait phases in swing-through crutch gait.

Table 2. Temporal gait data of normal walking and swing-through crutch gait.

	Normal level walking		One-leg swing-through crutch gait			
			Lower limb progression cycle		Crutch progression cycle	
	Range	Average	Range	Average	Range	Average
Stance phase % cycle	59–62	61 (0.9)	69–76	72 (3.0)	52–57	55 (1.6)
Swing phase % cycle	38–41	39 (0.9)	24–31	28 (2.8)	43–48	45 (1.5)
Average speed of progression m/s	1.22 (0.09)		0.73 (0.12)			

Brackets indicate 1 standard deviation (σ_{N-1})

Results and discussion

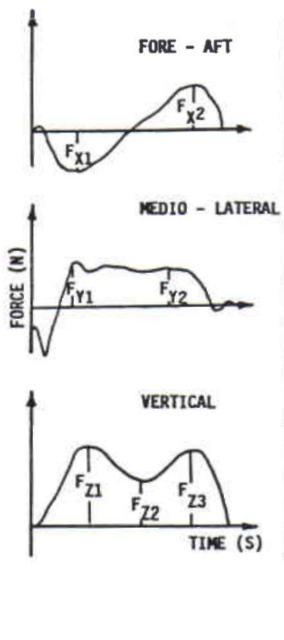
Figure 3 illustrates the different gait phases during swing-through crutch gait. Table 2 shows the measured temporal details of the gait phases in normal level walking and the swing-through crutch locomotion.

In normal walking, the average stance phase of 61 percent and swing phase 39 percent are in agreement with those reported by other investigators (Murray et al, 1964). The average cycle duration was 1.12s. The cadence ranges from 106-112 steps/min. and the average speed of walking was 1.22m/s. This represents a much slower walking speed than that reported by Murray et al (1964) for the similar age and height groups. The significance of these differences is being pursued in another study.

In the one-leg swing-through crutch locomotion, the average lower limb stance phase was 72 percent and swing phase was 28 percent. The average cycle duration was 1.66s. Wells (1979) observed that as the degree of disablement increases, the proportion of time spent in double support increases and lower limb swing phase decreases. In this study, the lower limb swing phase decreased by 11 percent as compared to the normal gait. Furthermore, it was found that in swing-through gait the supporting lower limb spent on average 0.82s in single leg stance, this is twice as long as in normal walking. The average crutch stance was found to be 55 percent and swing phase was 45 percent of the crutch progression cycle. The average cycle duration was 1.82s. The average speed of progression was 0.73m/s.

Table 3 gives a comparison of the average

Table 3. Ground - foot reaction forces of the right leg during normal walking and the right "unaffected" leg during swing - through crutch gait.



		Normal walking Average (σ_{N-1})	Swing through gait Average (σ_{N-1})	Significance level P
Fore – aft shear (% B.W.)	F_{X1}	16.8 (4.5)	24.2 (7.0)	‹0.02
	F_{X2}	19.4 (3.4)	17.5 (4.8)	N.S.
Medio – lateral shear	F_{Y1}	6.6 (1.3)	5.3 (2.7)	N.S.
	F_{Y2}	5.3 (1.6)	0.8 (1.2)	‹0.01
Vertical force (% B.W.)	F_{Z1}	106.8 (8.4)	128.4 (11.7)	‹0.01
	F_{Z2}	74.3 (10.3)	84.2 (8.2)	‹0.05
	F_{Z3}	106.7 (9.8)	101.2 (5.3)	N.S.

ground reaction forces of the right foot during normal level walking and swing-through gait. The Student's 't' distribution test was used to evaluate the statistical significance of the results. Differences between averages were considered as significant at $P<0.05$.

At early lower limb stance of swing-through gait, the fore-aft shear ($F_{x}1$) was 7.4 percent bodyweight higher than that obtained for normal gait and the vertical force ($F_{z}1$) was 21.6 percent bodyweight higher. Figure 4 illustrates these increases clearly in the force vector plots. It should be noted that the speed of progression during the crutch gait was much slower than that of normal walking.

Andriacchi et al (1977) have shown that in both normal and abnormal gait there exist either linear or quadratic relationships between various gait parameters and the speed of walking. Wells (1979) observed that by increasing the speed of progression from 0.43 to 0.98 m/s during crutch gait, the range of motion of the lower limbs also increased; the shank excursion increased by approximately 25° and the thighs increased by 10°. Furthermore, the stride length also increased, from 0.75 to 1.2m.

As cited earlier, Stallard et al (1978) have also reported similar increases in the vertical force ($F_{z}i$), although the speed of progression was not stated. Nevertheless, they cautioned against the

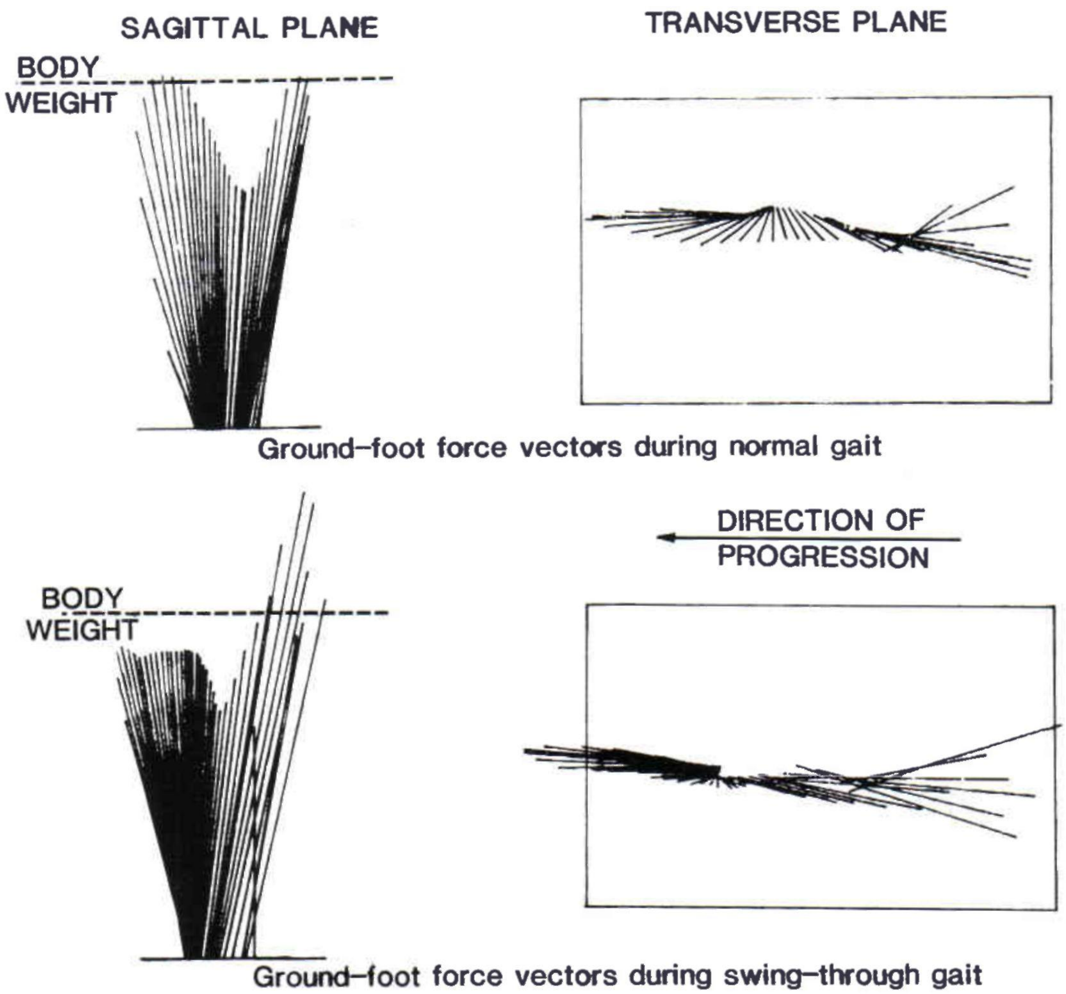


Fig. 4. Typical ground reaction force vector plots of the right leg during normal walking and the right "unaffected" leg during swing-through crutch gait. (Subject LCA).

use of swing-through gait for patients with an unsound weight-bearing limb.

At late lower limb stance of swing-through gait, the fore-aft shear (F_{x2}) and the vertical force (F_{z3}) showed no significant difference when compared to normal gait. However, the medio-lateral shear (F_{y2}) decreased significantly from 5.3 to 0.8 percent bodyweight.

Figure 5 shows the typical pattern of forces developed on the axillary crutches during the swing-through gait when used (a) incorrectly and (b) correctly. When the crutches were used incorrectly, (a) both the upper struts of the crutch were subjected to compression although the forces on the anterior strut showed a much higher magnitude than the posterior. In proper usage, (b) the posterior upper strut of the crutch was subjected to tension while the anterior strut was in compression during crutch stance phase. Table 4 gives the peak forces on the upper half of the body and the crutch tip for both proper and incorrect usage.

In proper usage, the palm experienced a peak force of 44.4 percent of the body weight. This means that both the hands, wrists and forearms virtually bear the whole body weight during the swing-through gait. Therefore, care must be taken in recommending swing-through gait with axillary crutches for patients with weak upper extremities. It could have detrimental effects on the upper extremities and furthermore increase the tendency for these patients to lean on the axillary bar for weight-bearing during gait. This incorrect method of usage will give rise to high reaction forces acting under the armpit. A peak force of 34 percent body weight has been determined. This force could be a contributing factor to crutch paralysis and thrombosis of the axillo-brachial artery through prolonged misuse. Therefore, patients have to be trained not to lean on the axillary bar for weight-bearing.

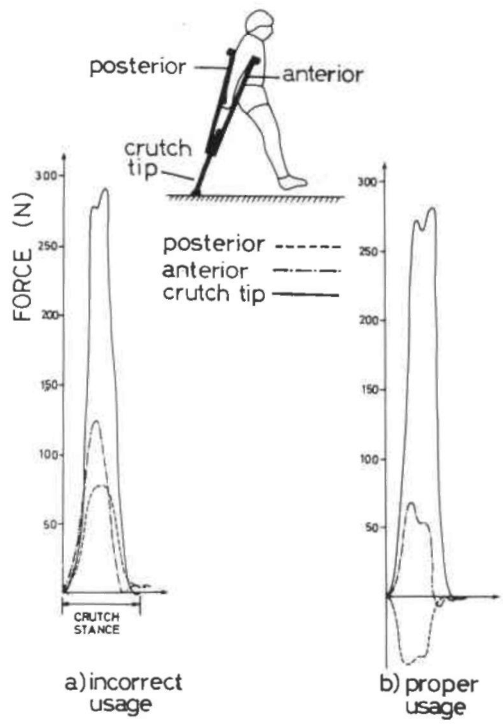


Fig. 5. Uniaxial forces measured along the axillary crutch length during swing-through crutch gait in (a) incorrect and (b) proper usage of crutches (Subject LCA).

An electronic biofeedback device has been designed and developed for use in training for crutch walking. It simply detects and warns the patient of weight-bearing on the axillary bar. The device utilizes the strain gauges mounted on the upper stuts of the axillary crutch to monitor the load transmitted through the axillary bar. An empirical value of 15 percent body weight was set as the threshold, any magnitude measured beyond this value will produce an audible output. This value was found to be reliable in

Table 4. Reaction forces transmitted through the axillary crutch during correct and incorrect usage of crutches.

Forces at: (% body weight)	Correct usage		Incorrect usage	
	Range	Average (σ_{N-1})	Range	Average (σ_{N-1})
Axillary bar FA	2.5 – 9.5	5.0 (2.6)	25.6 – 40.7	34.0 (5.7)
Handgrip FH	40.0 – 47.6	44.4 (2.6)	10.9 – 26.1	17.4 (5.9)
Crutch Tip FT	49.3 – 54.4	51.2 (1.7)	50.9 – 54.8	53.2 (1.5)

detecting incorrect usage. The audio feedback allows the patient to make the necessary adjustment.

Conclusion

The study has shown that in one-leg swing-through crutch gait,

(i) The average limb stance and swing phases were 72 percent and 28 percent respectively; the average crutch stance and swing phases were 55 percent and 45 percent respectively.

(ii) The peak vertical component of the ground reaction force on the weight-bearing leg during lower-limb stance was 21.6 percent bodyweight greater than in normal walking. This could prove detrimental to patients with unsound lower limbs.

(iii) The peak reaction force transmitted to the arm during crutch stance was 44.4 percent bodyweight which could be harmful to patients with weak upper extremities.

(iv) If crutches were incorrectly used, a high compressive force of 34 percent bodyweight was found to be acting on the underarm. An electronic device has been designed and developed to help in monitoring the proper use of axillary crutches.

Acknowledgements

The authors wish to thank Mr. E.J. Ang, Mr. C. P. Ang, Mr. S. Rajaratnam, Miss Belinda Teng and Miss P. L. Tan for technical assistance. Thanks are also due to Miss T. M. Mak and Mr. S. H. Tow for the illustrations and Miss Zaidah for the secretarial assistance.

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Simplified, low cost below-knee prosthesis

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Abstract

Problems are encountered in using standard prostheses in developing countries, especially when the prostheses need repair and the amputees cannot come back to the workshop. Very simple, low cost and durable prostheses can solve this problem. The solution described has worked well with villagers in some rural areas of Thailand, where the inexpensive prosthesis permits walking bare-foot and through water and mud.

Introduction

The first standard prosthetics and orthotics workshop was set up in Thailand at the Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok in 1960. The detail of its operation was published in the Orthopedic and Prosthetic Appliance Journal more than 20 years ago (Kijkusol, 1962).

Because the machines and materials provided by UNICEF at that time were very modern (from Otto Bock, Germany), and the expert (Mr. Werner Wille from UNTAB) who came to help for 3 years was also highly experienced, the appliances produced met international standards. They were very popular among the disabled. During the Vietnam War American servicemen and civilians were successfully fitted.

The need to simplify

After a time, when we surveyed the appliances of our clients we found that, although most of them were satisfied with their standard

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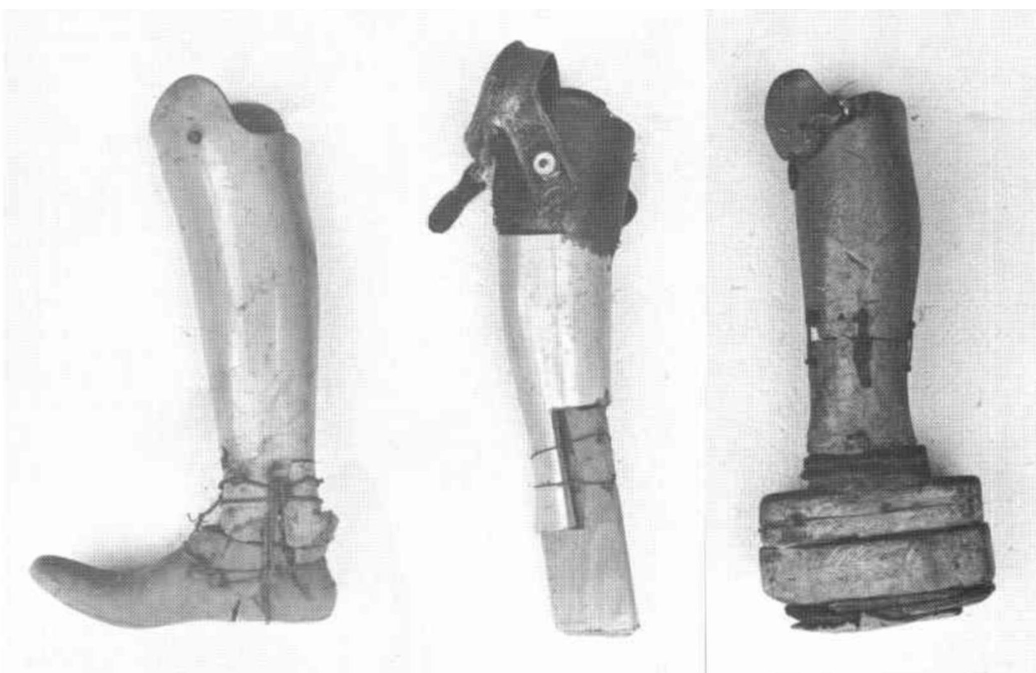

Fig. 1 Repairs carried out by amputees on their own prostheses.

prostheses, many were faced with problems of repair or renewal. This was both on financial gounds and in relation to returning to the workshop in Bangkok (some live as far as 1,000 km away). Because of this many solve the problems which arise themselves (Fig. 1). One even ignored the damage to the artificial foot and kept on walking until the whole foot was gone, together with the screw, and the prosthesis was about 5 inches shorter than it should be. We also found that many poor amputees in villages still use the home-made pylon (Fig. 2), which of course does not fit the stump properly.

Fig. 2. Home-made bamboo prosthesis.

To accommodate these facts, we developed a very simple, cheap, and almost maintenance free below-knee prosthesis. This prosthesis evolved from the idea that patients with forefoot amputation can walk quite well, even if the gait is not normal, and the foot of this simple prosthesis imitates their stumps (Fig. 3).

This simplified prosthesis is different from the ancient peg leg in three ways.

1. The weight-bearing area at the end is greater, giving more stability during standing. It also has slight rocker action which makes walking more easy.

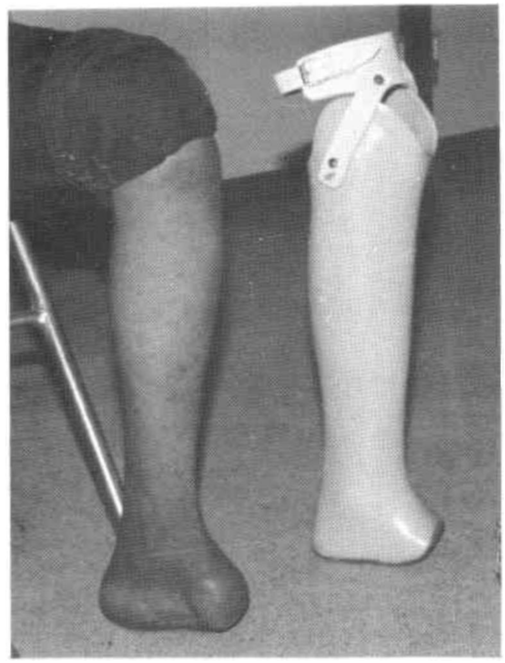

Fig. 3. Simple, cheap and almost maintenance-free below-knee prosthesis. The foot of the prosthesis is modelled on the shape of a forefoot amputation stump (see text).

2. Fabrication of the socket is the same as in standard PTB only without Pe-lite or other liner so that there is no need of replacement. It will fit the stump properly and comfortably.

3. All of these simple prostheses are made using a Staros/Gardner coupling during the dynamic alignment phase to ensure that every one has a good alignment.

Locally manufactured SACH feet

Other than the imported SACH feet from Germany, U.S.A. and Japan, the workshop at Siriraj also manufactures some local feet such as:

1. Wooden SACH foot (Fig. 4, top). This is the oldest local construction, made about 20 years ago, the weak point of this foot is damage to the toe break.

2. SACH foot with wooden keel, sponge rubber heel and toe. The sole is reinforced with old automobile tyre (Fig. 4, centre).

3. Rubber SACH foot with toes (Fig. 4, bottom), so that the amputee can walk bare-foot or with a canvas shoe. The main disadvantage is weight.

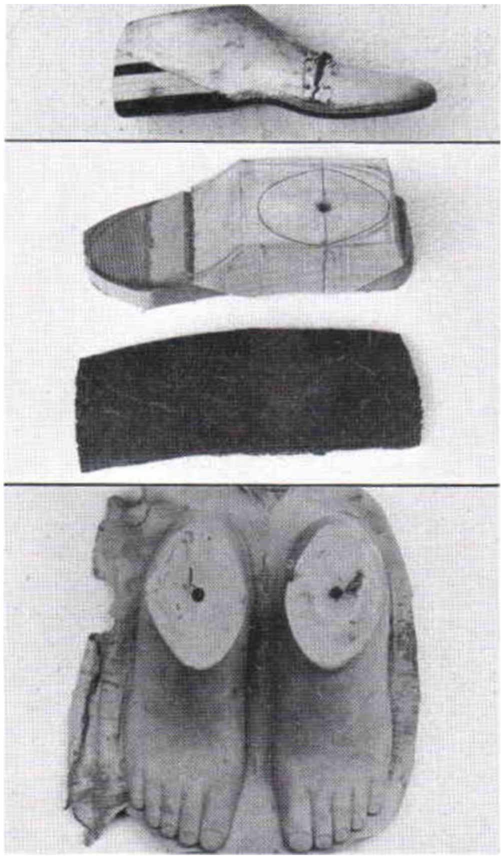

Fig. 4. Top, locally made wooden SACH foot. Centre, SACH foot with wooden keel, sponge rubber heel and toe and old tyre sole. Bottom, rubber SACH foot with toes.

4. The most simple foot without forefoot. This has the lowest cost and is maintenance free, being good for walking bare-foot on any surface (Fig. 5), or for walking in the water.

Conclusion

The standard SACH foot is not suitable for every amputee in the developing countries. Some villagers may need a very simple, cheap and almost maintenance free prosthesis, suitable for walking on any terrain, and the one we present may suit them.

Fig. 5. The simplified prosthesis can be used on any terrain.

After more than 15 years of follow up, we are very satisfied with this simple limb, and still make it for anyone who needs it. Many veterans who live in the country and work in the fields, will get one as their second prosthesis for walking in the fields, and for during the high tide season when many surfaces are covered with water. It is much more economic for the Veteran's Organization which has to pay for the appliances.

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Technical note

Evaluating the Contourhook—help or hindrance?

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Abstract

A new Contourhook terminal device was introduced to the Central Development Unit (CDU) in Australia through the therapist attending the exhibit at the ISPO World Congress, London, September, 1983. Ten upper limb amputees, who were experienced prosthetic users were selected for the evaluation. The patients were asked to attend the CDU to perform selected activities; 7 activities were designed to simulate hand prehension and 17 were bimanual activities of daily living. The activities were performed using the conventional split hook terminal device. The same activities were repeated using the Contourhook terminal device. Performances and patients' comments were recorded. In general the Contourhook was found to compare unfavourably with conventional terminal devices, aspects of the brochure were misleading and all patients preferred their previously worn terminal device.

Introduction

From time to time in the three decades following the 1950's, a frequent query at prosthetic meetings or in patient discussions has been "have there been any changes in design or improvements to the split hook terminal device for an upper limb prosthesis?" The new Contourhook provided one answer.

It was therefore anticipated that the CDU would receive enquiries about the Contourhook from persons in Australia with upper limb prostheses and from professionals working in the field. Accordingly, a chart was designed to make a comparative overall evaluation of the Contourhook with a conventional Hosmer split hook terminal device (Table 1).

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Ten subjects were selected who were experienced prosthetic users for the comparative evaluation. Six subjects were below-elbow (B-E) amputees, of these one had a traumatic amputation and five had a congenital limb deficiency. Four subjects had 'traumatic amputations above the elbow. All were unilateral and with the exception of two girls aged 13 and 16 respectively, all were active adults (Tables 2 and 3). A letter was sent to the subjects inviting them to attend and asking for their assistance in assessing a new terminal device. To avoid prejudice prior to attendance, neither a brochure nor a description of the Contourhook was supplied.

Table 2. Subject occupation

Occupation	Prosthesis
Bank clerk	B-E
Business executive	A-E
Business executive	B-E
Gardener	A-E
Lawyer	B-E
Office clerk (2)	A-E (2)
Storeman	B-E
School student (2)	B-E (2)

Table 3. Age and sex

Age		Sex M	F
–15 years	—		
15–20	2		2
20–30	3	2	1
30–40	4	4	
40–50	—		
50–60	1	1	
over 60	—		
Total	10	7	3

All 10 subjects wore a prosthesis for all their waking hours. Of the six with a B-E prosthesis, three wore Model 5x canted terminal device (t.d.) and a young woman and the three teenagers wore an 8x t.d. Of the four above-

Table 1. Comparison of split hook and Contourhook.

Key to performance:— 3. Activity accomplished without difficulty.
2. Performance adequate.
1. Activity possible but very slow or difficult.
0. Activity impossible.
X. Not tested.

Name of Patient________________ No. of bands_______ conventional t. d.
_ Contourhook.

SIMULATING HAND PREHENSION	t.d.'s conventional	Contourhook
1. Chuck grip—remove cap from tube.		
2. Plier grip—pick up 2" block.		
3. Pincer—pick up pin.		
Pincer—pick up 12 jellybeans (time taken)		
4. Clip—pick up envelope.		
5. Hook—carry bucket.		
6. Spherical—pick up tennis ball.		
7. Grasp—hold trolley.		
BI-MANUAL ACTIVITIES		
1. Strike match.		
2. Cut along line with scissors, t.d. holds paper.		
3. Eat with knife and fork, knife in t.d.		
4. Hold telephone while taking notes.		
5. Pick up large heavy box.		
6. Hold glass to drink.		
7. Hold glass under tap, turn tap to fill.		
8. Hold paper while writing.		
9. Peel orange.		
10. Sweep with broom.		
11. Thread needle.		
12. Draw line using ruler.		
13. Use nail file.		
14. Manage money from wallet.		
15. Remove lid from screw top jar.		
16. Sharpen pencil.		
17. Pick up coin.		

ASSESS—
1. Sitting with both correct table height ratio to chair while performing activities.
2. Standing — to perform activities.
3. Previous use of conventional t.d.:—

i) Number of working hours conventional t.d. is worn ....

ii) Number of working hours conventional t.d. is not worn ....

iii) Activities for which t. d. is necessary or commonly used ....

iv) Activities with which there is some difficulty with conventional t.d. ....

v) Current employment ....

vi) Current recreation/sport/hobbies regularly undertaken ....

Patient's comments on the two t.d.'s:—

Therapists' comments on patient's performance:—

Control system efficiency — conventional______ x100=______

$\frac{f.,.d}{f.c.}$ x100 — Contourhook______ x 100=______

elbow (A-E) amputees, three wore Model 555 and one wore Model 7 "heavy duty t.d. for his employment and a 5x at meal times. For the comparative evaluation the latter subject wore the heavy duty t.d. Tests on 'heavy' outdoor work for which he uses the heavy duty hook were not tried with the Contourhook.

Prior to assessment the Contourhook was fitted to the "training arm" prosthesis and worn by the therapist. It was noted that although the brochure states " . . . Contourhook is totally compatible with existing prosthetic arms. No changes or adaptions are necessary" it was found that it is not interchangeable unless approximately 55mm length of extra cable is fitted to the conventional split hook t.d. The subjects found they could not open the Contourhook to its maximum as they were limited by the cable housing and liner. The cable, housing and liner for the conventinal t.d. was not interchangeable with the Contourhook. Similarly, for a given amount of energy expended, the Contourhook required one less rubber band to give similar ease of operation to that of the split hook but efficiency was reduced (Fig. 1, top).

Maximum voluntary opening of the Contourhook is not possible due to its line of pull impinging on the cable flow at the wrist unit. In comparing the maximum opening of the t.d.'s, the attachment point on the lever arm or 'thumb' of the 5x split hook t.d., into which the ball terminal fits, is displaced 5cm (2"), giving a maximum opening of the terminal device of 9.5cm (3 3/4").

The Contourhook lever arm can be passively displaced 9cm *(3 1/2)* giving a maximum t.d. opening of 12cm (4 3/4"). However, maximum opening is impeded as the moving 'finger' approaches the wrist unit (Fig. 1, centre). The maximum practical opening of the Contourhook was 9.5cm, the same as for the 5x t.d. however the lever arm was displaced 7.5cm, hence greater exertion for the extra 2.5cm over that of the 5x t.d. The greater the distance between the two distal 'fingers' of the Contourhook, the wider the space between the two counter levers proximal to the axis. This leaves a vulnerable point for pinching objects or a person's finger (Fig. 1, bottom).

The subjects were originally advised that they would only need to attend the CDU for one half hour for the assessment. The subjects were busy,

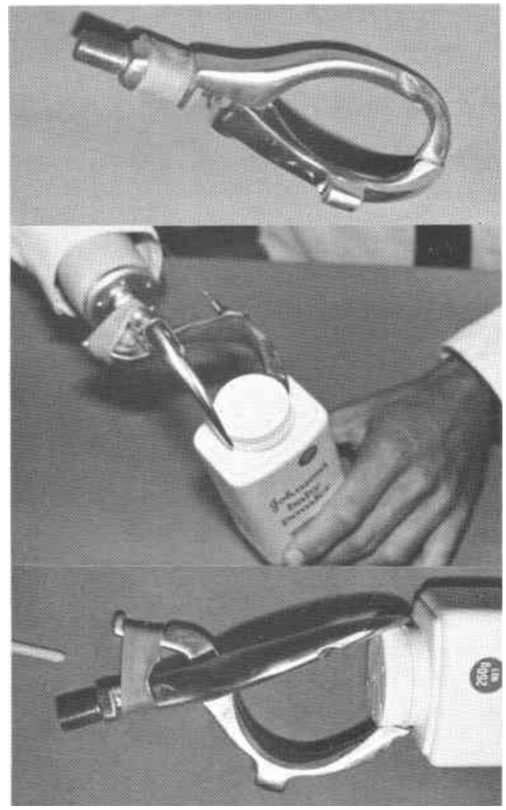

Fig. 1. Top, the Contourhook, left side (see text). Centre, maximum opening impeded by rubber bands on counter levers. Bottom, vulnerable area between counter levers (see text).

employed persons with the exception of the two teenagers who attended school. It was considered important that the time spent away from work/school for attendance and travel time should be kept to a minimum. However, attendance time approximated 1 1/2 hours. Additional time being given to the adaption of cable length and determining the number of rubber bands required for effective use of the Contourhook to its maximum, which was limited by the cable housing and liner. The cable housing and liner for the conventional t.d. was not interchangeable with the Contourhook. The subjects' performance was recorded on videotape — this added to the attendance time.

Discussion

The subjects in the trial stated that they would not choose a Contourhook in preference to a conventional split hook t.d. with the exception of one subject with an above-elbow prosthesis who mostly wears a heavy duty t.d. He considered that the Contourhook performed equally well to the heavy duty t.d. in the limited range of activities tested and, not surprisingly, preferred the appearance of the Contourhook to the heavy duty t.d.

Of the remaining A-E patients, one found the Contourhook required less pre-positioning, one found it required more pre-positioning and the other considered it would only have limited use for him in his place of work (as a business executive).

The three females with a B-E prosthesis wore a Model 8x t.d. and by comparison found the Contourhook large and heavy and did not like the appearance.

The three males with a B-E prosthesis found it less efficient than the conventional t.d. One found it no use for tying shoe laces or for dressing, one found it not sufficiently robust for his various activities in the house or garden and the third found it dangerous where the levers opened at the proximal end.

Additional comments on the Contourhook included:—

Advantages: when holding paper in the t.d. while cutting with scissors, the Contourhook 'tip' permits paper to slide through as scissors progress through the paper.

Disadvantages: after pre-positioning the Contourhook it is not possible to push it into the wrist unit with the other hand; the quality of the material in the Contourhook, together with the design do not stand up to the tasks required for gardening and other household duties; and it will not hold a knife for cutting food in the Western European style of eating.

Summary

The Contourhook was found to compare unfavourably with the conventional split hook terminal device; aspects of the brochure were misleading and all subjects preferred their previously worn terminal device for function, with the exception of the A-E subject who wore a heavy duty hook. Major criticisms were: it was not interchangeable with a conventional terminal device; an extra cable length was required; many objects were more difficult either to pick up or to grasp in the Contourhook t.d.; it was unsatisfactory for eating in the two handed Western European style, i.e. holding knife in prosthesis.

It was considered that with some modification to the Contourhook, e.g. if it were more robust and had a better grip for some objects and a larger gripping surface, it would be acceptable to those patients who did not require constant optimal functional use from the t.d. Similarly, for patients who have not previously been fitted with a split hook t.d., e.g. 5x, and are therefore not accustomed to its appearance, the Contourhook, largely because it does not have the connotations of 'Captain Hook', may well be preferred.

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Prosthetics and Orthotics International, 1986, 10, 103-104

Technical note

Coupled bicycles for disabled and able-bodied to ride together

L. C. NAVA

Abstract

The present note describes a very simple and economic, yet highly successful, concept which makes use of two standard bicycles and should prove useful in developing countries.

Introduction

As rightly stated by Schwandt et al (1984) "individuals with lower limb disability who endeavour to live healthy and meaningful lives may benefit greatly in their physical, psychological and social wellbeing from participation in active recreation with family and friends".

Schwandt and coworkers have developed two very useful mechanical systems to serve that goal:

a single rider arm - powered bicycle, the ***Handbike;***

a tandem consisting of merging the ***Handbike*** in the front with a standard bicycle in the back.

It is important to point out that a manufacturer has recently begun initial production of the ***Handbike*** and several versions are now available.

A very simple solution has been devised at the Institute of Applied Mechanics. This consists of coupling two standard bicycles — the machine ridden by the patient is fitted with a fixed pinion. The solution is economic and efficient from the point of view of disabled people living in developing countries where more specialized equipment is generally not available. Frequently, only crutches, canes and simple orthotic devices are fabricated. Foreign appliances tend to be extremely expensive. Furthermore the concept discussed in this note can be easily implemented by the family and/or friends of the disabled.

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Results

The experiences of the author with disabled children using the system have been highly successful.

The disabled child shown in Figure 1 riding with his elder brother suffers from a severe case of cerebral palsy (spastic quadriplegia).

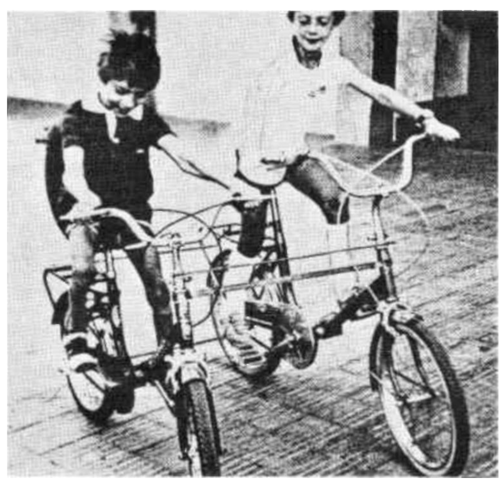

Fig. 1. Disabled 9 year-old boy riding the IMA coupled-bike system.

His overall improvement has been considerable and after a period of three months using the coupled-bike system (shown diagramatically in Fig. 2) he is able to single - ride a standard bicycle with two additional small wheels attached to the rear wheel axis.

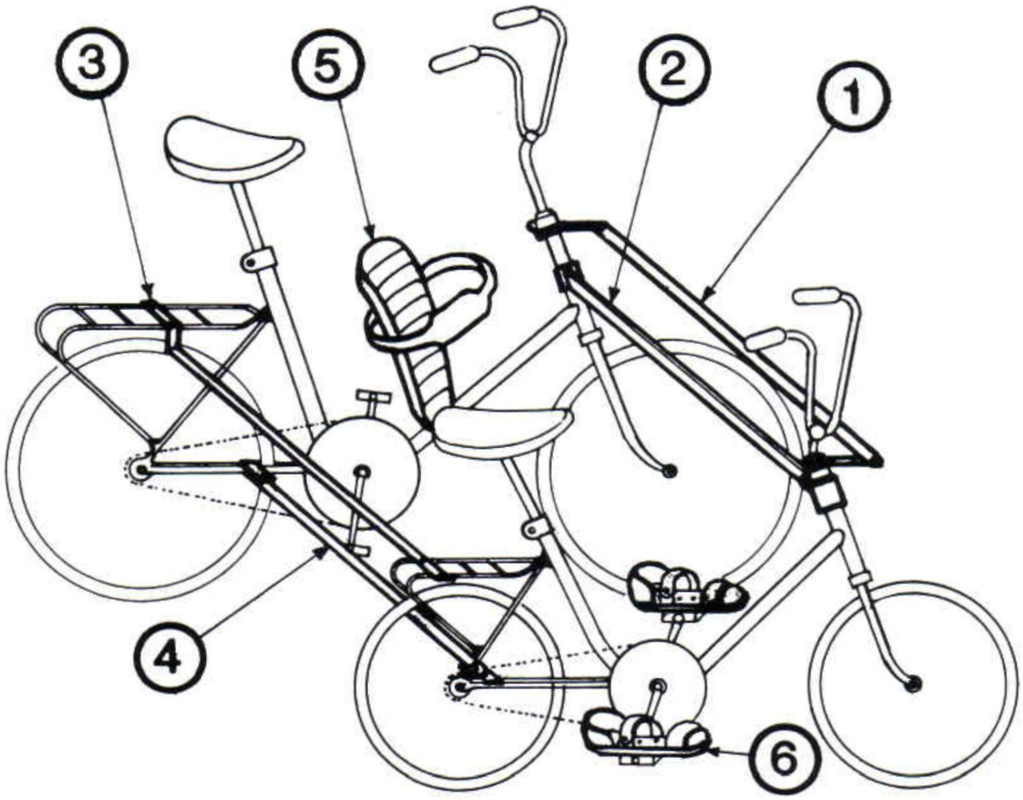

Fig. 2. Basic elements for coupling two standard bicycles: 1 and 2, front upper and lower transverse bars. 3 and 4, back upper and lower transverse bars. 5, special seat. 6, foot harness.

Acknowledgements

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The author expresses his deep gratitude to Mr. Edgardo Tabochini who suggested the possibility of developing the system described in this paper.

The author is indebted to P. A. A. Laura, Ph.D., Director of the Institute of Applied Mechanics for his valuable criticism and generous cooperation in the development of his works.

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Prosthetics and Orthotics International, 1986, 10, 105–108

Calendar of events

National Centre for Training and Education in Prosthetics and Orthotics
Short-Term Courses and Seminars 1986/1987

Courses for Physicians, Surgeons and Therapists

NC503 Introductory Biomechanics; 20th–22nd October, 1986.
NC504 Lower Limb Orthotics; 3rd–7th November, 1986.
NC508 Orthopaedic Footwear; 10th–11th November, 1986.
NC505 Lower Limb Prosthetics; 19th–23rd January, 1987.
NC502 Upper Limb Prosthetics and Orthotics; 26th–30th January, 1987.
NC510 Wheelchairs; 9th–10th March, 1987.
NC511 Clinical Gait Analysis; 23rd–25th March, 1987.
NC506 Fracture Bracing; 30th March–3rd April, 1987.
NC501 Functional Electrical Stimulation; 6th–9th April, 1987.

Courses for Prosthetists

NC212 Hip Disarticulation Prosthetics; 22nd September–3rd October, 1986.
NC211 PTB Prosthetics; 17th–28th November, 1986.
NC205 Above-Knee Prosthetics; 16th–27th February, 1987.
NC214 Flexible Above-Knee Sockets; 16th–18th March, 1987.

Courses for Orthotists

NC215 Knee-Ankle-Foot and Knee Orthotics; 8th–12th December, 1986.
NC216 Contemporary Orthotic Management of the Spine; 2nd–6th February, 1987.
NC217 Ankle-Foot-Orthoses for the Management of the Cerebral Palsy Child; 2nd–5th March, 1987.

Courses for Prosthetics Technicians

NC605 Contemporary Prosthetic Construction Techniques; 9th–13th February, 1987.

Seminar

NC716 Mobility Aids (In conjunction with SCD) Date to be announced.

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

Northwestern University Medical School
Short Term Courses

Courses for Physicians and Surgeons

603B Lower and Upper Limb Prosthetics; 3–7 November, 1986.
703A Spinal, Lower and Upper Limb Orthotics; 17–21 November, 1986.
603C Lower and Upper Limb Prosthetics; 1–5 December, 1986.
603D Lower and Upper Limb Prosthetics; 16–20 March, 1987.
603E Lower and Upper Limb Prosthetics; 20–24 April, 1987.
703B Spinal, Lower and Upper Limb Orthotics; 27 April–1 May, 1987.
603F Lower and Upper Limb Prosthetics; 11–15 May, 1987.

Courses for Therapists

602B Lower and Upper Limb Prosthetics, 3–7 November, 1986.
702A Spinal, Lower and Upper Limb Orthotics; 17–21 November, 1986.
622A Lower Limb Prosthetics; 16–20 February, 1987.
702B Spinal, Lower and Upper Limb Orthotics; 27 April–1 May, 1987.
622B Lower Limb Prosthetics; 18–22 May, 1987

Courses for Rehabilitation Personnel

640 Orientation to Prosthetics for Rehabilitation Personnel; 23–24 March, 1987.

Courses for Pedorthists and Orthotists

801 Pedorthic Management of the Foot; 8–12 June, 1987.

Requests for further information should be addressed to Charles M. Fryer, Director, Prosthetic-Orthotic Center, 345 East Superior Street, Room 1723, Chicago, Illinois 60611, USA.

29 September–2 October, 1986
Pediatric Orthopaedic Update, Palm Beach, FL.
Information: AAOS, 444N Michigan Avenue, Chicago, IL 60611.

7–10 October, 1986
IX Congress of the Yugoslav Orthopaedic and Traumatologic Association, Novi Sad, Yugoslavia.
Information: JOUT'86, c/o Drustvo lekara Vojvodini, Vose Stajica, a 21000 Novi Sad, Yugoslavia.

9–11 October, 1986
91st Congress of the German Society for Physical Medicine and Rehabilitation, Muenster, Germany.
Information: President, Prof. Dr. Reinhard Fricke, Dept. of Rheumatology, St. Josef's Hospital, 4415 Sendenhorst, Germany.

13–17 October, 1986
"Amputee Rehabilitation" for therapists, ALAC, Manchester, England.
Information: Mrs. Hindley, Rehabilitation Unit, Withington Hospital, Manchester M20 8LB, England.

16–18 October, 1986
Clinical Biomechanics for Chiropodists, London, England.
Information: Mr. Clive Chapman, MChS, District Chiropodist, Tottenham Town Hall, 359 High Road, Tottenham, London N15 4RY, England.

19–24 October, 1986
American Academy of Physical Medicine and Rehabilitation and the American Congress of Rehabilitation Medicine Annual Meeting, Baltimore, USA.
Information: Randall Braddom, Holmes Hospital, Eden and Bethseda Aves., Cincinnati, Ohio 45219, USA.

24–25 October, 1986
American Academy of Orthotists and Prosthetists Continuing Education Conference 5–86, "Lower Limb Prosthetics", Kansas City, Missouri.
Information: American Academy of Orthotists and Prosthetists; 717 Pendleton St., Alexandria, VA 22314.

24–25 October, 1986
American Academy of Orthotists and Prosthetists Continuing Education Conference 5–86, "Spina Bifida", Cincinnati, Ohio.
Information: American Academy of Orthotists and Prosthetists, 717 Pendleton St., Alexandria, VA 22314.

27–31 October, 1986
Course on Advanced Prosthetic Techniques, Los Angeles, California.
Information: UCLA Prosthetics Education Program. Room 22–46 Rehabilitation Center, 1000 Veteran Av., Los Angeles, California 90024, USA.

1–6 November, 1986
American Academy of Pediatrics Annual Meeting, Washington, DC.
Information: AAP, PO Box 927 EIK Grove Village, IL 60007.

4–9 November, 1986
American Academy of Orthotists and Prosthetists Annual National Assembly, Orlando, Florida.
Information: American Academy of Orthotists and Prosthetists, 717 Pendleton St., Alexandria, VA 22314.

24–27 November, 1986
European Congress on "Adapted Physical Activity for Disabled Persons — From Theory to Practice", Brussels, Belgium.
Information: Mrs. M. Plasch, Congress European en APA, Avenue Paul Heger 28, B–1050 Brussels, Belgium.

1987
16–18 January, 1987
Rehabilitation symposium on locomotor systems, Singapore.
Information: Dr. Lee Eng Hin, Chairman, Rehabilitation Symposium 1987, c/o Department of Orthopaedic Surgery, National University Hospital, Lower Kent Ridge Road, Singapore 0511.

22–27 January, 1987
American Academy of Orthopaedic Surgeons Annual Meeting, San Francisco, California.
Information: AAOS, 444 N. Michigan Av., Chicago, IL 60611.

15–22 February, 1987
American Academy of Orthotists and Prosthetists Annual Meeting and Scientific Symposium, Tampa, Florida.
Information: American Academy of Orthotists and Prosthetists, 717 Pendleton St., Alexandria, VA 22314.

2–6 March, 1987
International Symposium on Sexuality and Disability, Eilat, Israel.
Information: Israel Rehabilitation Society, 18 David Elazar St., Hakirya, Tel Aviv, 61909 Israel.

3–8 May, 1987
American Orthopaedic Association Annual Meeting, Washington, DC.
Information: AOA, 444 N. Michigan Av., Chicago, IL 60611.

17–20 May, 1987
Pediatric Orthopaedic Society, Toronto, Canada.
Information: POS, PO Box 11083, Richmond, VA 23230.

18–20 May, 1987
"Toward 2000" The World Confederation for Physical Therapy — 10th International Congress, Sydney, Australia.
Information: Frank Allandar APTA, 1111 N Fairfax St., Alexandria, VA 22314.

5–10 July, 1987
International Conference on Disability Education, Jerusalem, Israel.
Information: Israel Rehabilitation Society, 18 David Elazar St., Tel Aviv 61901, Israel.

12–16 July, 1987
International Conference of Rehabilitation Journalists, Jerusalem, Israel.
Information: Israel Rehabilitation Society, 18 David Elazar St., Tel Aviv 61901, Israel.

September, 1987
17th Congress of the International Society of Orthopaedic Surgery and Traumatology, Munich, Germany.
Information: Dr. R. de Marneffe, Rue Washington 40, B–1050 Brussels, Belgium.

6–10 September, 1987
International Seminar on Prosthetics and Orthotics, Herzliya, Israel.
Information: Secretariat ISPO 1987, PO Box 50006, Tel Aviv, Israel.

21–27 September, 1987
American Academy of Orthotists and Prosthetists Annual National Assembly, San Francisco, California.
Information: American Academy of Orthotists and Prosthetists, 717 Pendleton St., Alexandria, VA22314.

3–8 October, 1987
Western Orthopaedic Association, Colorado Springs, CO.
Information: 2975 Treat Blva,-E5, Concord 94518.

1988
5–9 September, 1988
16th World Congress of Rehabilitation International, Tokyo, Japan.
Information: Secretary General, 16th World Congress of Rehabilitation International Japanese Society for Rehabilitation of the Disabled, 3–13–15, Hiyashi, Ikebukuro, Toshima-ku, Tokyo 170, Japan.

25–30 October, 1988
American Academy of Orthotists and Prosthetists Annual National Assembly, Washington, DC.
Information: American Academy of Orthotists and Prosthetists, 717 Pendleton St., Alexandria, VA 22314.

Prosthetics and Orthotics International, 1986, 10, 109–110

Book Reviews

Understanding and using your Myoelectric Prosthesis
Series Editor A. S. Muzumdar
Bioengineering Institute
University of New Brunswick.

This is the second publication in the series of monographs on Myoelectric Prostheses produced by the Bioengineering Institute. It is aimed, as the title suggests, at the user, but the four authors R. N. Scott, R. R. Caldwell, E. R. Sanderson and Z. Wedderburn have packed it with sufficient information to be of interest also to health care professionals.

The book, which is only fifteen pages long describes the myoelectric prosthesis and how it works, the way the fitting and fabrication is performed and the training and care required for successful use of the final prosthesis. It also describes the prosthetic team as it should, because the authors comprise an Engineer, a Manager of a Research Centre, an Occupational Therapist and a Prosthetist. They are to be congratulated on producing an account which is easily understood by the user without "talking down" to him. I have nothing but praise for this little book.

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

Physiotherapy for Amputees, The Roehampton Approach
Barbara Engstrom and Catherine Van de Ven
Published by Churchill Livingstone
289pp, £14.95

The book opens with a brief historical section followed by details of the present day amputee population and an introduction to the Roehampton service.

The pre-operative assessment, care and treatment chapter deals with causes of amputation and relevant investigations. There is little mention of the importance of preserving the knee joint or of the influence of good surgical techniques on the future rehabilitation prospects of the amputee.

In the early post-operative phase stump bandaging is not favoured by the authors, however most other methods discussed for controlling stump oedema are ineffective. Aspects of general care, transfers and bed exercises are covered with some good exercises for stump strengthening. The use of the Pneumatic Post-Amputation Mobility Aid is fully covered. It is disappointing that the Femurett, Tulip aid and "walking plasters" are only briefly mentioned as, properly used, they are valuable in early mobilization.

The chapter on referral to a Limb Fitting Centre assumes that the amputee attends as an out-patient. Guidelines are given for the assessment of an amputee's potential as a limb wearer and the likely functional outcome. Alternate forms of mobility are discussed, some of which are primitive. The sections on gait borrow heavily from the manuals of Strathclyde University, Glasgow, New York University and North Western University, Chicago.

Each level of amputation has a separate chapter, from hemi-pelvectomy and hip disarticulation to Syme's and partial-foot. Temporary prostheses are advocated for almost all levels as a first limb. Topics covered for each level are temporary prosthesis components, checking the prosthesis, functional re-education (donning etc.) and gait re-education. These are repeated with reference to the definitive prosthesis. All above-knee and through-knee temporary prostheses described are fitted with a knee- lock regardless of the amputees' age or ability.

Greater coverage is given to "conventional prostheses" than to modular systems and modern materials.

The problems of the bilateral amputee are considered separately, as are other complicating conditions such as stroke, arthrodesed joints or burns. A good chapter on the management of upper limb amputees is contributed by Alicia Mendez. The chapter "General Advice to the Amputee" is full of sound commonsense regarding care of the remaining limb, stump, stump socks and prosthesis.

The Appendix lists sources of further information, addresses, a glossary of terms and bibliography.

This book will be extremely valuable for the physiotherapist treating amputees within the current service in England and Wales but the Roehampton approach should not be regarded as providing the only or the optimum level of care and prosthetic provision which is available in the United Kingdom or abroad.

J. Cree,
E. Ramsay,
Dundee Limb Fitting Centre,
133 Queen Street,
Broughty Ferry,
DUNDEE

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Beijing Prosthetic Research Institute,
No. 147, Beiheyan Street,
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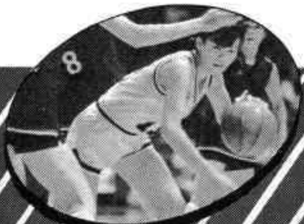

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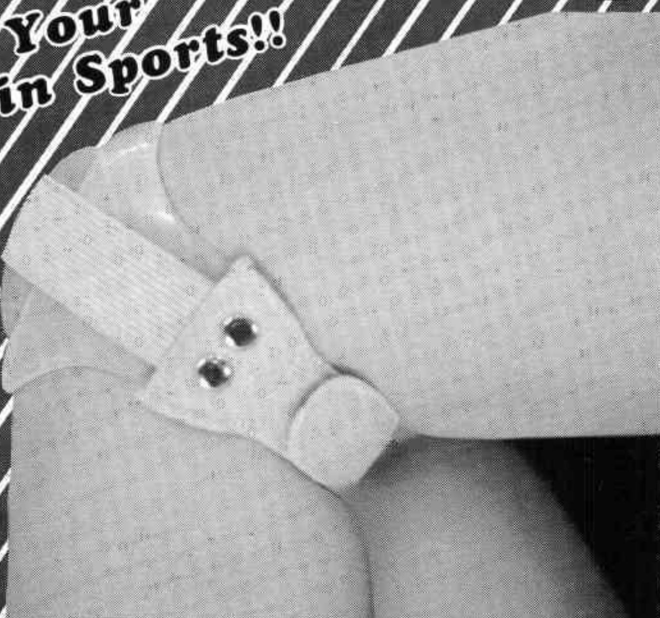

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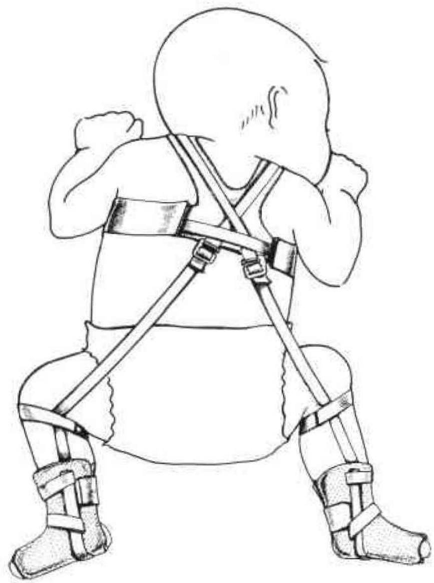

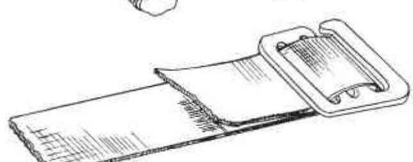

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- Reprints of Dr. Hirsh's paper available.

Information for Contributors

Contributions should be sent to Prosthetics and Orthotics International, National Centre for Training and Education in Prosthetics and Orthotics, University of Strathclyde, Curran Building, 131 St. James' Road, Glasgow G4 0LS, Scotland. In the meantime considerable difficulty and delay is entailed in processing contributions in languages other than English. Authors are asked to provide three copies of text, tables and figures. Papers are accepted on the understanding that they may be subject to editorial revision and that no substantial part has been, or will be published elsewhere. Subsequent permission to reproduce articles must be obtained from the publishers. Manuscripts should be typewritten in double line spacing on one side of paper only with margins of 25 mm. **Papers must commence with an abstract not exceeding 250 words.** On a separate sheet must be:

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All illustrative material should be lightly marked on the back in pencil with the figure number in Arabic numerals, title of paper, authors' names and a clear indication of the top of the figure. The approximate location in the text should be marked. Figure captions should be typed on a separate sheet. Tables should be used only when necessary to clarify important points. Each table should be typed on a separate sheet and numbered consecutively in Arabic numerals.

References

References in the text should follow the author/date system, for example Peizer (1971). If there are more than two authors *et al.* should be used as in Solomonidis *et al* (1974). References cited in the text should be listed on a separate sheet alphabetically by first author. All authors should be listed and journal titles given in full.

Reference to an article in a journal

Should include Author(s); Year of publication; Article title; Journal title; Volume number; First and last page numbers.

Newcombe, J. F., Marcuson, R. W. (1972). Through-knee amputation. British Journal of Surgery, 59, 260–266.

Reference to a contribution in a book

Should include Author(s) of contribution; Year of publication; Title of contribution (followed by 'In:'); Author(s), Editor(s) of book; Book title; Edition; Place of publication; Publisher; Volume number; First and last page numbers.

Cruickshank, C. N. D. (1976). The microanatomy of the epidermis in relation to trauma. In: Kenedi, R. M. and Cowden, J. M. (eds). Bedsore biomechanics, London, Macmillan Press Ltd, p. 39–46.

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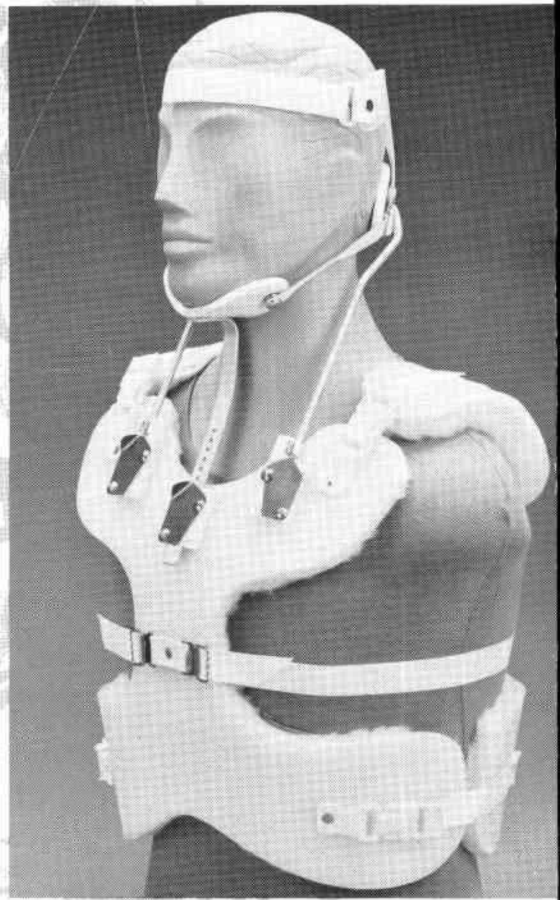

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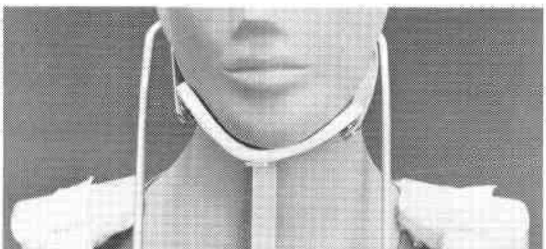

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