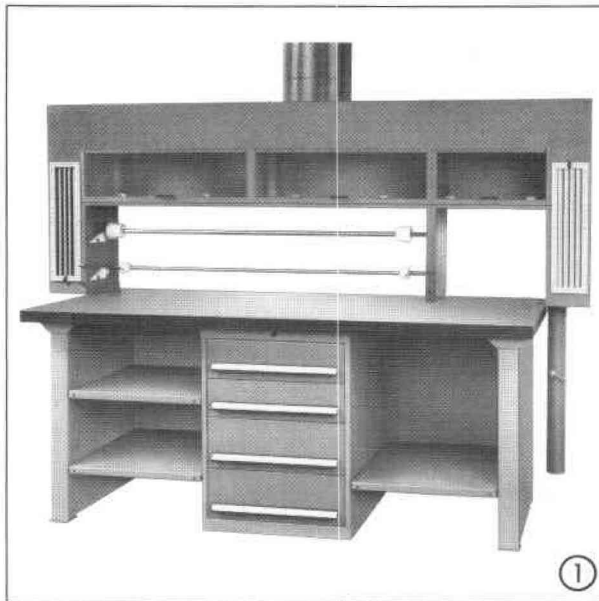




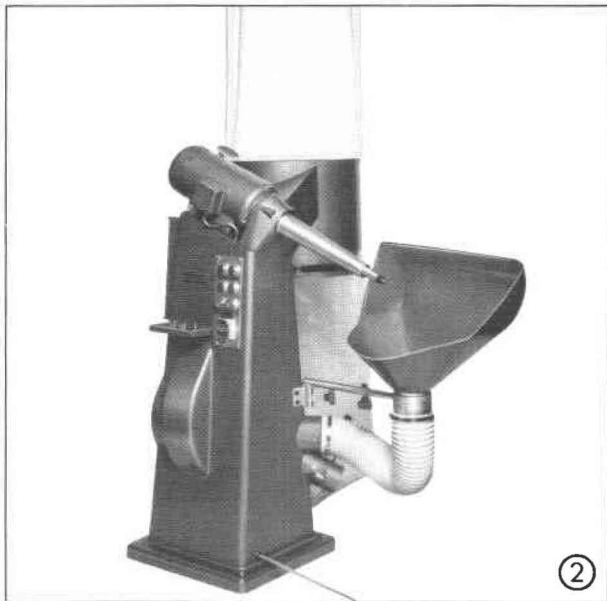
**The Journal of the International Society  
for Prosthetics and Orthotics**

# **Prosthetics and Orthotics International**

**April 1987, Vol. 11, No. 1**



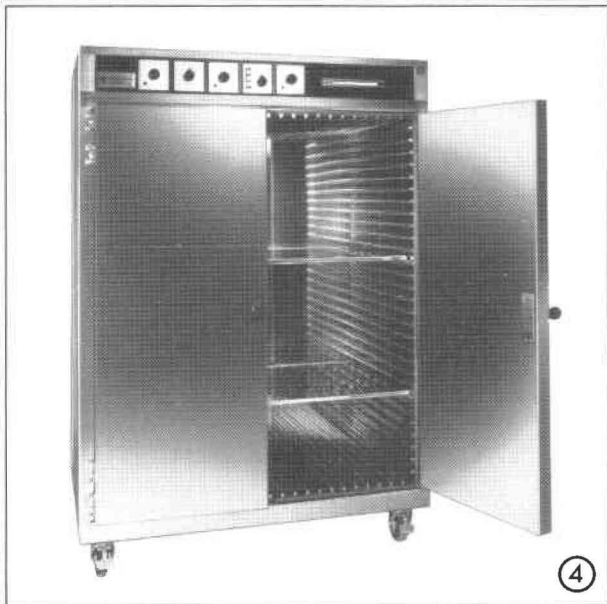
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# Prosthetics and Orthotics International

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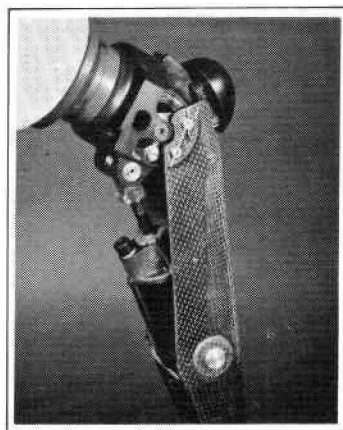
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# The Journal of the International Society for Prosthetics and Orthotics

April 1987, Vol 11, No. 1

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# ISPO

## *Elected Members of Executive Board:*

J. Hughes (President)	UK
W. H. Eisma (President Elect)	Netherlands
S. Heim (Vice President)	FRG
S. Sawamura (Vice President)	Japan
V. Angliss	Australia
R. Baumgartner	FRG
A. Jernberger	Sweden
M. Stills	USA
E. Lyquist (Past President)	Denmark
G. Murdoch (Past President)	UK
J. Steen Jensen (Hon. Treasurer)	Denmark
N. A. Jacobs (Hon. Secretary)	UK

## *Standing Committee Chairmen and Task Officers*

J. Kjøbye (Finance)	Denmark
E. Lyquist (Protocol)	Denmark
W. Eisma (Congress, Publications and Membership)	Netherlands
G. Murdoch (Education)	UK
H. C. Thyregod (Professional Register)	Denmark
B. Klasson (Socket Design)	Sweden
E. Marquardt (Limb Deficient Child)	FRG

## *Consultants to Executive Board*

H. C. Chadderton (Consumer)	Canada
J. Van Rollegem (INTERBOR)	Belgium
J. N. Wilson (WOC)	UK

## *International Consultants to Executive Board*

P. Kapuma	Africa
Wu Zongzhe	China
G. Bousquet	France
M. K. Goel	India
H. Schmidl	Italy
Yongpal Ahn	Korea
E. K. Jensen	South America
T. Keokarn	South East Asia
R. Lehneis	USA
N. Kondrashin	USSR

## *Chairmen of National Member Societies*

Australia	W. Doig
Belgium	M. Stehman
Canada	G. Martel
China	Tang Yi-Zhi
Denmark	H. C. Thyregod
FRG	G. Neff
Hong Kong	K. Y. Lee
Israel	T. Steinbach
Japan	K. Tsuchiya
Netherlands	P. Prakke
Norway	G. Veres
Sweden	A. Jernberger
Switzerland	J. Vaucher
UK	D. Condie
USA	F. Golbranson

## *Past Presidents*

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

## *Secretary*

Aase Larsson	Denmark
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## **Editorial**

This issue of the Journal displays the financial statement for the year 1986.

Due to alterations in Danish law and regulations, the Society has changed to the State Authorized Public Accountants, Schøbel & Marholt, who are internationally represented by Touche Ross International. Our new accountants also act as investment advisors with respect to Danish tax legislation and with the purpose of increasing the yield on our long-term investment programme.

The accounts show that securities have increased by 1,463,165 DKK since the fiscal year, 1985. This is mainly generated by reinvestment of interest and the year's surplus, which includes the profit from the V World Congress. About two thirds of the securities consist of government bonds, which provide a yearly interest of 10–12% of the face value and are freely negotiable without taxable yield. The market value is influenced by the Danish interest rate. The remainder of our securities are placed in investment trust units the profit on which is not taxable after three years retention. Consequently none of the investments should be taxable and they will securely cover the liabilities and the contingency fund of 1,500,000 DKK.

The present financial statement is prepared in accordance with the Danish Articles of Associations. The accrual concept of accounting has been introduced from January 1, 1986 replacing the previous cash accounting. This provides a more accurate picture of the financial state of the Society, but makes direct comparison with previously published accounts difficult, as is explained in note 9 to the Accounts.

The Journal, Prosthetics and Orthotics International is identified under a separate account. The deficit of 12,075 DKK is rather close to the profit of 6,561 DKK for 1985, which appears after adjustment for prepaid advertising and subscriptions. The Journal is thus being produced at virtually no cost to the Society.

The total surplus of the Society has increased over the years from 421,219 DKK in 1983, 629,724 DKK in 1984 and 489,306 DKK in 1985 to 1,050,754 DKK in 1986. The major contributions to the latter increase has been from the income on investments and the profit obtained from the world congress, which in 1986 was 325,751 DKK.

The Society is very grateful for the contributions totalling 134,424 DKK provided by the Society and Home for the Disabled and the War Amputations of Canada. These bodies have indicated their continuing support.

In spite of unchanged individual fees since 1984, our income on membership is constantly increasing as the Society grows. This contributes sufficiently to run the daily administration of ISPO and will once more be held at 400 DKK for 1987 and 1988. The costs of our office in Copenhagen amount to 429,265 DKK, including the cost of our one salaried staff member, Aase Larsson. The costs are only kept down by her enthusiastic spirit and the free office facilities provided by the Society and Home for the Disabled.

The meeting and travelling expenses for the Executive Board have been kept down to the 1984 level, including our participation in meetings of the International Standard Organizations, of Rehabilitation International and of task officer visits.

The economy of the Society is sound. We have created the basis for increased future activity, which the Executive Board is already generating.

Finally we express our gratitude to sponsors for their support and members for their activity. These contribute to the future successful development of our Society.

J. Steen Jensen  
*Honorary Treasurer*

## I.S.P.O. Statement of Accounts, 1986

### Auditors' Report

We have audited the financial statements for the year ended December 31, 1986.

The audit has been performed in accordance with approved auditing standards and has included such procedures as we considered necessary. We have satisfied ourselves that the assets shown in the financial statements exist, have been fairly valued and are beneficially owned by the company and that all known material liabilities on the balance sheet date have been included.

The financial statements have been prepared in accordance with statutory requirements and the articles of association and generally accepted accounting principles. In our opinion the financial statements give a true and fair view of the state of the company's affairs on December 31, 1986 and of the profit for the period then ended.

Copenhagen, February 19, 1987  
Schøbel & Marholt  
Søren Wonsild Glud  
State Authorized Public Accountant

### Accounting Policies

The accrual concept of accounting has been used from January 1, 1986. In prior periods cash accounting concept has been used. The effect on the result for the year is explained in note 9.

Securities: Bonds and shares have been valued at the lower cost on market.

## Income Statement for the Year 1986

### SUMMARY

Society membership and administration (note 1)	130.873
Sponsorship (note 2)	134.424
Conferences, courses etc. (note 3)	254.893
Prosthetics and Orthotics International (note 4)	(12.075)
Publications (note 5)	3.206
Investment income (note 6)	539.433
	<hr/>
	DKK 1.050.754
	<hr/>

## Balance sheet as of December 31, 1986

### ASSETS

Cash	DKK 148.742
	<hr/>
<b>Accounts due</b>	
Advertising due	13.510
Dividend tax due	779
Accrued interest	157.733
Advance funding of World Congress 1980	119.690
	<hr/>
	DKK 291.712
	<hr/>
<b>Securities (at cost) (note 7)</b>	3.317.768
	<hr/>
<b>Total Assets</b>	DKK 3.758.222
	<hr/>

### LIABILITIES AND CAPITAL

<b>Liabilities</b>	
Provision	DKK 119.690
	<hr/>



<b>Capital</b>	
Capital January 1, 1986	2.495.595
Provision for Advance Funding of World Congress 1980	(119.690)
	2.375.905
Result for the year	1.050.754
Capital December 31, 1986	DKK 3.426.659
<b>Short-term liabilities</b>	
Accrued expenses	59.469
Prepaid advertising income	72.408
Prepaid subscription income	79.996
	DKK 3.758.222
Contingent liabilities (note 8)	

## Notes to the Financial Statements

### 1. SOCIETY MEMBERSHIP AND ADMINISTRATION

#### Income

Membership — fees	714.218
Transfer from Knud Jansen's foundation	2.105
	DKK 716.323

#### Expenditure

Executive Board:	
Travel and hotel	(110.609)
Meeting expenses	(40.409)
Meeting in other organizations	(5.167)
Travelling expenses, Honorary Secretary and Treasurer	(25.256)
Staff salaries	(219.174)
Membership, Rehabilitation International	(6.188)
Data service	(40.111)
Stationery printing	(65.900)
Office supplies	(4.154)
Accountant	(35.008)
Telephone	(5.789)
Postage	(22.465)
Maintenance	(1.845)
Sundries	(3.375)
	(585.450)
	DKK 130.873

### 2. SPONSORSHIP

Contribution from the War Amputation of Canada	59.424
Contribution from SAHVA	75.000
	DKK 134.424

### 3. CONFERENCES, COURSES etc.

World congress 1986	325.751
Dundee course publication	(63.167)
Toronto Education Symposium	(1.829)
Pakistan	(7.499)
Education Workshop Questionnaire	(2.021)
	DKK 254.893

**4. PROSTHETICS AND ORTHOTICS INTERNATIONAL****Income**

Advertising	136.018
Subscriptions	73.500
	<u>DKK 209.518</u>

**Expenditure**

Printing	(190.304)
Mailing inclusive of labels	(14.130)
Production editor	(15.109)
Committee meeting, Publication	(2.050)
	<u>DKK (221.593)</u>
	<u>DKK (12.075)</u>

**5. PUBLICATIONS**

Book sale	3.206
	<u>DKK 3.206</u>

**6. INVESTMENT INCOME****Bonds**

Maturity yield	82.024
Interest	434.000
	<u>DKK 516.024</u>

**Shares**

Dividend	DKK 1.095
----------	-----------

**Bank account**

Interest income	24.655
Interest expense	(990)
	<u>DKK 23.665</u>

**Expenditure**

Safekeeping fee	(1.351)
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Result	<u>DKK 539.433</u>
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**7. SECURITIES**

<b>Bonds</b>	Rate 31/12-86	Face value	Market value	Original cost
12% Dansk Statslån S.2001	101,25	632.000	639.900	575.292
10% Dansk Statslån S.2004	91,50	400.000	366.000	367.551
10% Dansk Statslån 1979/89	99,00	260.000	257.000	239.559
10% Dansk Statslån ST.L. 1994	94,00	600.000	564.000	606.909
10% Dansk Statslån S.1988	99,75	269.000	268.328	250.842
10% Østifternes Krf. 18. serie 2003	91,00	100	91	71
		<u>DKK 2.161.100</u>	<u>2.095.719</u>	<u>2.040.224</u>

**Investment trust  
units**

	Rate 31/12-86	Face value	Market value	Original cost
Sparinvest, D	226,00	90.000	203.400	224.751
Privatinvest 2	611,25	38.000	232.275	227.371
Privatinvest 5	99,50	450.000	447.750	453.359
Investor-Maximum	100,00	343.000	343.000	349.885
		<u>DKK 921.000</u>	<u>1.226.425</u>	<u>1.255.366</u>

<b>Shares</b>				
Københavns Handelsbank	260,00	8.000	20.800	22.178
		<u>8.000</u>	<u>20.800</u>	<u>22.178</u>
		DKK		
		<u>8.000</u>	<u>20.800</u>	<u>22.178</u>
Total result	DKK 3.090.100		3.342.944	3.317.768
			<u>3.342.944</u>	<u>3.317.768</u>

**8. CONTINGENT LIABILITY**

The association is involved in a court trial in connection with the World Congress 1980. The association might be liable to additional cost in this connection. The outcome is at present uncertain.

**9. CHANGE IN ACCOUNTING POLICY**

Effect from changing accounting policy from cash accounting concept to accrual accounting concept.

Interest income earned up to December 31, 1985, but received in 1986		215.870
Advertising income earned up to December 31, 1985, but received in 1986		27.665
Advertising income relating to 1986, but prepaid as of December 31, 1985		(11.124)
1986 subscriptions received in 1985		(60.480)
Net effect	DKK	<u>171.931</u>

## INTERNATIONAL SOCIETY FOR PROSTHETICS AND ORTHOTICS

### FEE REDUCTION FOR DEVELOPING COUNTRIES

The Executive Board has agreed that individuals from Developing Countries who wish to join the Society can do so at a reduced annual membership fee of DKK150 (that is one hundred and fifty Danish Crowns). This reduced fee also applies to existing members. Those individuals who wish to take advantage of this reduced fee should apply in writing to:

The Secretariat,  
ISPO,  
Borgervaenget 5,  
2100 Copenhagen Ø,  
DENMARK.

## **Executive Board Meeting**

**17th and 18th January, 1987**

The following paragraphs summarize the major discussions and conclusions of the last Executive Board Meeting held in Copenhagen. They are based on the draft minutes of that meeting which have not yet been approved by the Executive Board.

### **International Committee Meeting**

The Executive Board discussed a number of matters which had been raised at the International Committee Meeting which was held at the time of the Copenhagen Congress:

- a) it was agreed that the Executive Board should pursue the possibility of holding an interim meeting of representatives of the International Committee between Congresses subject to finances being available.
- b) in response to a suggestion from the International Committee, Melvin Stills was working on the production of a Tape Slide Set which would describe the workings and interests of the Society. When this work had been completed copies of the set would be made available in order to help promote the Society.
- c) the Executive Board discussed the International Committee's proposal that some form of ISPO certificate of attendance should be produced for locally organized courses and meetings. The Protocol Committee were asked to examine this matter and report to the next Executive Board meeting.
- d) the Executive Board discussed the suggestion that the Society should improve its Information Service. No conclusion was reached, however the President and Honorary Secretary would make proposals on this matter to the next Executive Board meeting.
- e) at the request of the International Committee, George Murdoch had prepared a draft proposal regarding the protocol for inspection of prosthetic and orthotic education centres. The Executive Board made further suggestions with regard to this protocol and an amended form of protocol would be presented to the next Executive Board meeting.

### **Committee, Task Officer and Consultant Appointments**

The Executive Board discussed Committee, Task Officer and Consultant appointments. A complete list of these appointments can be seen on page iv of this issue of the Journal.

### **Task Officer Reports**

The Honorary Treasurer reported that there would be a surplus available to the Society from the year 1986. The official accounts for the year are printed elsewhere in this issue of the Journal. A revised budget for 1987 and a draft budget for 1988 was presented to the Executive Board. It was agreed that the membership fee for 1988 should remain at 400 DKK.

The Chairman of the Protocol Committee indicated that they had discussed the protocol for the adjudication and award of the Blatchford Prize and this would be put to the next Board meeting. The President reported that the Forchheimer family wished to offer a Prize, to be awarded every three years, in memory of Alfred Forchheimer. It was intended that the prize be awarded through the Society for outstanding work in clinical assessment, evaluation or measurement. More information regarding these prizes will be intimated to the membership in due course.

The Executive Board discussed a proposal to hold a Workshop on the Upgrading of Short Course Trained Technicians and agreed that this workshop should be held in the University of Strathclyde from the 19th-25th July 1987.

The Board agreed that Ron Donovan should be appointed as Co-editor (Production) of 'Prosthetics and Orthotics International'. It was decided that the Journal be airmailed to all members and subscribers outside Europe. The Board agreed that the Society should pursue the establishment of an International Newsletter. At present it should be an integral part of the Journal and if successful, might eventually become independent. It was agreed that David Condie and Joan Edelstein be invited to edit the International Newsletter. The Publications Committee had examined the possibility of publishing a separate volume of selected articles from the Journal, but recommended that this should not be pursued at present.

The manual on 'The Planning and Installation of Orthopaedic Workshops in Developing Countries' has now been published and copies are available at a cost of \$10 (US) for non-members and \$5 (US) for members.

The Executive Board discussed a proposal from A. Bennet Wilson Jr. and Melvin Stills with regard to the possibility of holding an ISPO Workshop on 'Above-knee Fitting and Alignment Techniques'. The Board agreed that there was an urgent need to study the various techniques of above-knee fitting and that, if possible, a workshop should be arranged as soon as possible. A steering committee, comprising of A. Bennet Wilson Jr., Melvin Stills, Al Muilenburg and George Murdoch was appointed to discuss detailed arrangements. It was agreed that the final decision to go ahead with the workshop should be made by the President in consultation with the Honorary Treasurer and the Honorary Secretary after submission of a detailed proposal from the Steering Committee.

### **International Organizations**

The President, President Elect and Honorary Secretary attended the last meeting of the INTERBOR Board of Directors in November 1986. The Society is collaborating with INTERBOR with regard to their Congress in Barcelona in June 1987, and the President Elect has been appointed to its Scientific Committee. INTERBOR is interested in establishing standards of education in Europe and it was agreed that there should be a more formal meeting between representatives of ISPO and INTERBOR regarding this subject which should take place at the time of the Barcelona Congress.

The President reported on a warm and friendly meeting with officers of the International Committee of the Red Cross (ICRC) in November 1986. The meeting was attended by the President, President Elect and Honorary Secretary on behalf of the Society. The Executive Board approved of these initial contacts and recommended that the Society should continue to develop its collaboration with ICRC.

The President reported that whilst in Geneva visiting ICRC the group had taken the opportunity to meet with the World Health Organization (WHO). The meeting had established initial contacts with WHO and means of further collaboration were being explored.

The Honorary Secretary reported on a recent meeting with the Secretary General of Rehabilitation International (RI) which explored ways in which closer collaboration could be achieved between the two organizations. The Board agreed that the Society should seek an RI/ICTA representative to the Executive Board. The Board further agreed that Willem Eisma should co-ordinate the sectoral meeting on 'Changes in Prosthetics and Orthotics with regard to new Technology' that ISPO would be presenting at the RI Congress in Japan in 1988. The President and Honorary Secretary had attended the RI Assembly meeting held in October 1986 in London on behalf of the Society.

Margaret Ellis had attended the International Commission on Technical Aids (ICTA) meeting in Newcastle in October 1986 on behalf of the Society during which a number of matters were raised which were of interest to the Society:

- a) the new Wheelchair Manual has been compiled and is now available from ICTA/INFORM.
- b) a Seminar on the Provision of Technical Aids for Third World Countries was held in Bombay in September 1986.
- c) the European Economic Community Group of ICTA are involved in helping develop Handinet, a computerized system of information related to technical aids.

The Executive Board agreed that Margaret Ellis, Bo Klasson and George Murdoch continue to be representatives of ISPO to ICTA.

The Honorary Secretary reported on a recent meeting with World Rehabilitation Fund (WRF). During the meeting, it emerged that WRF would be interested in co-operating with the Society in the Workshop on the Upgrading of Short Course Trained Technicians by sending representatives to the meeting.

Proposals from the International Labour Office (ILO) to hold a Pan African Workshop for Experts and Policy Makers in Prosthetics and Technical Aids had been taken over by a newly established organization known as the African Rehabilitation Institute (ARI) which is based in Zimbabwe. ARI is funded by the African community and is actively pursuing arrangements to hold this workshop in the near future. The Society would keep in contact with ARI and offer to collaborate in the organization of the workshop.

The Executive Board reviewed its representation to the United Nations (UN). It was agreed that Jean Vaucher and Sepp Heim should be the Society's representatives in Geneva and Vienna and that Melvin Stills and Richard H. Lehneis should be its representatives in New York.

The Society continues to have contact with other organizations such as World Orthopaedic Concern (WOC), Internationaler Verband der Orthopadie-Schuhtechniker (IVO) and SICOT.

### World Congress

The President reported on the Bologna Congress. There have been no developments with the court case and no new date for a further hearing had been set.

The Secretary General of the Copenhagen Congress reported that the final accounting was almost complete and would be presented to the next Board Meeting. There had been over 600 active participants and the Exhibition had been successful and made a substantial surplus. The President thanked the Secretary General and his colleagues for a very satisfactory outcome.

Seishi Sawamura outlined the draft scientific programme for the Japanese Congress in 1989. This programme had been discussed by the International Congress Committee prior to the Executive Board meeting and a number of suggestions had been made. He also indicated that he had been in contact with the National Member Societies for their comments. One major suggestion is that the Instructional Courses should not take place in the morning, but the late afternoon and the Japanese programme committee had been asked to look into the possibility of implementing this suggestion. It was agreed that the registration fee for INTERBOR members should be the same as that available to ISPO members.

No invitations had been received as yet to host the 1992 Congress. The Honorary Secretary was asked to remind National Member Societies that the final date for submission of official invitations is the end of March 1987 and should be made according to the guidelines outlined in the Society's booklet, "Information and Guidelines for National Secretaries and other Officers of National Member Societies".

### Future Activities

- a) Arrangements for the Symposium on Traumatic Amputation to be held in Herzliya, Israel on September 6-10 1987 were well underway. It was agreed that there should be a special meeting of the Executive Board members participating in the Symposium.
- b) Willem Eisma reported that the arrangements for the meeting in Netherlands, 28th-30th October 1987 were progressing well and the organization had reached an advanced stage.
- c) The Symposium on the Limb Deficient Child will be held in Heidelberg, FRG on August 28th-September 1st 1988.
- d) The possibility of the Society collaborating in a conference in the USSR in 1988 is being investigated.
- e) The Swedish National Member Society is discussing the possibility of holding a meeting on the Deformed Foot, but not until 1990.

### Developing Countries

The Executive Board discussed the level of membership fee for developing countries. It was agreed that a special rate should be instituted, namely 150 DKK. The Honorary Secretary and Honorary Treasurer would administer this scheme.

George Murdoch reported on a visit to Pakistan at the invitation of the Pakistani Orthopaedic Association.

The Honorary Secretary informed the Board that he had been in correspondence with the National Training Centre for Orthopaedic Technologists in Jordan with regard to an inspection visit, arrangements had yet to be finalized.

Sepp Heim reported that plans for a West African Survey of former students had not yet been finalized. As soon as information was available he would forward this to the Honorary Secretary.

M. K. Goel presented a video to the Executive Board which illustrated the scale of the disabled problem in India. This was a very informative presentation.

The Executive Board agreed that Sepp Heim should prepare an overview of activities in Prosthetics and Orthotics in the Developing World.

### Fellowship

Bernard Schievink (FRG) has been elected as a fellow of the Society.

Norman A. Jacobs  
Honorary Secretary

## **Obituary – Fred Forchheimer**

Fred Forchheimer, Stockholm, passed away on the 17th of November 1986 at the age of 68. He is survived by his wife Sylvia, physician and PhD, his son Robert, acting professor at Linköping University with wife Irene M.Sc. Linköping and his daughter Claire M.A. Stockholm.

Fred Forchheimer was an unusually productive scientist, philosopher and friend. He came to Gothenburg, Sweden in the 40's having experienced severe difficulties and the loss of his family in World War II. In Gothenburg he attained an Engineering degree and his creativity immediately started to produce results. His work regarding the development of rust protective systems, light consistent ink for ball-point pens, emulgation techniques, techniques for photography and enlargements as well as tixotropic solvents are examples of early achievements which have reached industrial application. In the early 60's after having moved to Stockholm he started academic studies in measurement techniques and focused his interest towards medical applications. In a joint effort at The Wallenburg Laboratory, his expertise in the fields of mechanical and electronic engineering as well as his knowledge in the patent field were of great importance for the project "Isoelectric Focusing", an electrophoresis technique that has given rise to a methodology and products which are used all over the world today. Towards the end of the 60's he started, in his spare time, a collaboration with the Department of Tumour Biology at the Karolinska Institute. He created many technical solutions with regard to the construction of an experimental radiation system in which oxygen concentration could be measured with an hitherto unachieved accuracy. His system is still being used and has contributed to discoveries and characterizations of several oxygen related radiation-biological effects. In the early 70's he participated in a research project with Professor Britton Chance, Philadelphia to set up a measurement programme for the biological measurement of oxygen concentration using yeast hemoglobin. The time consuming measurements were made during the night to avoid disturbing his regular daily work. Many technical problems had to be solved and he also significantly improved Professor Chance's "Time Sharing Dual Wavelength Spectro-photometer". His most recent activity was a project related to morphometrical problems, where he worked towards a computerized solution. In spite of his engineering background he decided to present a PhD thesis in medicine. At the age of 61 he went back to school and graduated in medicine in 1980. Soon after he registered as a post graduate student with the Department of Tumour Biology of the Karolinska Institute.

In his "daytime" professional career he was responsible for measurements related to temperature and heat transfer until in the mid 70's he moved to the Prosthetics Research Laboratory of the Karolinska Hospital. This included collaboration with the Department of Orthopaedic Surgery at the same hospital. (In 1980 the management of the laboratory was transferred to the Een-Holmgren Ort. AB.) This was a very important move for prosthetics and orthotics as well as for himself. For the first time he could fully combine his deep knowledge in engineering, medicine, natural sciences and psychology. His first task was to organize and conduct the evaluation of upper extremity prostheses. He caused some turbulence by his strong statement that an evaluation can only be made if the questions "value for whom" and "in which situation" are carefully considered. At this time a lot of prosthetics and orthotics developments were more related to engineering ambitions than to the patient's need. He also helped us to understand that the evaluation itself could influence the acceptance of the aid to be evaluated. Although he worked with very advanced systems, he always looked for simplicity. He loved the following aphorism coined within his team: "The most advanced application of technology is not necessarily the same as the application of the most advanced technology".

He was involved in or responsible for several projects, including gait analysis, ergonomic measurements, mechanical component testing etc. Very often he made his test-rigs himself. Whatever project or activity he was involved in, he always took the time to look into the philosophical and ethical aspects of it. If it did not meet his requirements he preferred not to participate.

He also served as a teacher, covering subjects like mathematics, physics, biology, biomechanics, computer science, psychology and philosophy.

After retiring he increased his activity level, serving also as a patent consultant—he held several patents himself.

He was one of the early Swedish ISPO members serving as auditor for ISPO Sweden until his passing. One of the most important contributions to the Society was, however, his participation in the organizing of the 1976 workshop on "The Deformed Foot and Orthopaedic Footwear". The book was printed in the English and German languages which was possible only thanks to Fred's participation in the editorial group. He was also an invited member of "Professors World Peace Academy" (PWPA).

But first of all he was a friend and a true altruist. His own career was not important. He would rather spend work on assisting friends in their research than on finishing his own PhD thesis. It was so obvious that his main sources of energy were friendship and givingness.

His love for life and peace was emotionally as well as scientifically based. He used to say: "How can we allow ourselves to take lives when we can't even make a substitute for one of the most important conditions for life — the cell membrane".

And indeed, he did carry insects out of the room instead of killing them!

Bo Klasson.

## The effect of adjuvant oxygen therapy on transcutaneous $pO_2$ and healing in the below-knee amputee

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### Abstract

The effects on tissue oxygenation of post-operative adjuvant oxygen have been studied in a group of 20 patients undergoing below-knee (BK) amputation for vascular disease. Ten patients received no therapy, the remainder receiving 28% oxygen for 48 hours following surgery. The results showed that the transcutaneous  $pO_2$  in the amputation flaps fell significantly by some 20 mmHg ( $p < 0.01$ ) following surgery and that this fall was prevented by the use of adjuvant oxygen. The fall was not observed in the non-amputated limbs.  $TcpO_2$  took almost two weeks to reach its pre-operative levels in the amputated limbs.

The effect on stump healing of adjuvant oxygen therapy was investigated in a randomized controlled trial in a series of 39 patients undergoing BK amputation. There were 22 patients in the control (untreated) group and 17 in the treated group (adjuvant oxygen for 48 hours). In the treated group 14 patients healed primarily and three amputations failed. In the untreated group 14 limbs healed primarily, one secondarily and there were 7 failures. The pre-operative transcutaneous values in the stumps which failed ( $26 \text{ mmHg} \pm 14$ ) was significantly lower ( $p < 0.005$ ) than in those which healed ( $40 \text{ mmHg} \pm 9$ ). The mean pre-operative  $TcpO_2$  in the patients in whom healing occurred in the treated group ( $35 \text{ mmHg} \pm 10$ ) was significantly lower ( $p < 0.001$ ) than the mean pressure observed in the untreated group ( $44 \text{ mmHg} \pm 9$ ).

### Introduction

Despite the many advances which have been made in the early diagnosis of arterial disease

and in vascular reconstructive procedures, amputation of the limb remains the final outcome for many patients. As the anticipated life span of these amputees is relatively short (Finch et al, 1980), rapid and effective rehabilitation is essential. It is now widely agreed that a below-knee (BK) amputation gives the vascular amputee the best chance of independent mobility on a prosthesis (Jamieson and Hill, 1976). However, a failure rate of 15-20% leads some surgeons to opt for the more likely healing of an above-knee (AK) amputation in patients with ischaemia despite the higher mortality and less satisfactory rehabilitation (Finch et al, 1980; Jamieson and Hill, 1976). The latest available figures for England and Wales show an overall ratio of 55% above to 45% below-knee amputation if other levels are excluded (McColl, 1986) and although these figures show a trend towards more BK amputations there is still some way to go to achieve the much higher BK rates reported by some centres (Lim et al, 1967; Ham et al, 1987).

In recent years there have been many reports of methods designed to help the surgeon pre-operatively to predict the likely healing of amputation stumps. Doppler ultrasonic assessment of segmental pressure (Pollock and Ernst, 1980; Lepentalo et al, 1982; Cederberg et al, 1983), thermography (Spence et al, 1981), measurement of skin blood flow (Moore et al, 1981) and pressure (Holstein et al, 1979; Spence and Walker, 1984) have all been found to be of some value. More recently, with the advent of the skin oxygen electrode, transcutaneous  $pO_2$  ( $TcpO_2$ ) has been suggested as a more reliable indicator of the potential for healing (Franzeck et al, 1982; Burgess et al, 1982; Mustapha et al, 1983; Ratcliff et al, 1984; Katsamouris et al, 1984; Harward et al, 1985; McCollum et al, 1986).

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In fields unrelated to vascular amputation, a number of animal and human studies have shown that increasing inspired oxygen concentration results in increased available tissue oxygen and that this may be of benefit in reducing wound infection and improving tissue healing (Hunt and Pai, 1972; Knighton et al, 1984; Chang et al, 1983). Mustapha and colleagues have reported that increasing inspired oxygen concentration results in an increase in below-knee  $TcpO_2$  in patients with ischaemic limbs (Mustapha et al, 1984), though they have not reported on its effect on healing.

This present study was designed firstly to investigate the effects of amputation surgery on stump  $TcpO_2$  and to test the hypothesis that increasing inspired oxygen concentration could beneficially increase stump transcutaneous oxygen levels and secondly, to assess prospectively the value of post-operative adjuvant oxygen therapy in relation to stump survival.

#### **Patients and methods**

The study was in two parts. The first, involving 20 patients undergoing BK amputation, was aimed at gaining an understanding of the effects of adjuvant oxygen and amputation surgery on the transcutaneous oxygen levels in below-knee stumps. The second, involving 39 patients undergoing BK amputation, was aimed at evaluating the effects on healing of post-operative adjuvant oxygen therapy. All patients admitted consecutively to the vascular unit of Dulwich Hospital and requiring major amputation for ischaemia were considered for entry. The only criteria for exclusion were visible ischaemic demarcation above a suitable level for below-knee amputation or severe disease of the ipsilateral knee joint precluding satisfactory prosthetic fitting. All remaining patients were entered sequentially into the study. These patients underwent skew-flap myoplastic below-knee amputation after identical pre-operative ward preparation and antibiotic prophylaxis using the regime and operative techniques described by Robinson et al (1982).

#### *Skin oxygen study*

The first 20 patients entering the study were allocated using a restricted randomization into either treated or untreated groups. The

operations were performed alternately by one of two surgeons only (CB or KL). The treated group ( $n=10$ ) received 28% adjuvant oxygen by Ventimask (Vickers Medical) for 48 hours post-operatively at a rate of 4 litres per minute. The untreated group ( $n=10$ ) received nothing. Only light gauze dressings were used and conventional stump bandaging or plaster were not used.

Transcutaneous  $pO_2$  ( $TcpO_2$ ) measurements were made independently (RH) and the results not examined until the end of the study. A Roche cutaneous  $pO_2$  monitor (Kontron Medical) containing two 632 modules, enabling simultaneous recording at two sites, was used throughout. Electrode positions were at a central site 5cm below the clavicle and at anterior and posterior sites 10cm below the knee at the centre of the amputation flaps on the stump and 5cm medial to the tibial shaft and at the same level on the contralateral limb. The measurements were made in each case on the day prior to operation and at 1, 2, 7 and 14 days post-operatively. The measurement on the second post-operative day was made at least two hours after stopping oxygen therapy.

All readings were made with the patient semi-supine having been resting in bed for at least 20 minutes. Sensor temperature was  $44^\circ C$  and the calibration of the modules and derivation of  $TcpO_2$  was described by Ratliff et al (1984). All patients had regular physiotherapy, early ambulation using the P.P.A.M.-Aid (Vessa Ltd.) and were measured for their artificial limb in the early post-operative period on the ward by a team from the Department of Health and Social Security (DHSS) limb fitting centre at Roehampton.

#### *Healing study*

In this study 39 patients selected as above for BK amputation were entered consecutively into a randomized controlled trial of the effects on healing of post-operative adjuvant oxygen therapy. Using this randomization 17 patients fell in the treated group and 22 in the untreated group. Patient treatment was as for the previous study, the treated group receiving the adjuvant oxygen and the untreated group no additional therapy. Healing was independently assessed as 'primary', 'secondary' when partial or complete breakdown of the stump occurred with subsequent satisfactory healing, or 'failed' when

a proximal reamputation was necessary to achieve healing. Patients were followed up for at least one year following amputation. The composition of the two groups is shown in Table 1.

### Results

The results from the study of transcutaneous oxygen have been assessed using the Student-t test and those for the healing study using the Chi<sup>2</sup> test with Yates' correction.

There was no morbidity associated with the use of adjuvant oxygen and the patients and ward staff were able to manage the Ventimasks without problems.

The heated TcpO<sub>2</sub> electrode usually produced a spot of erythema, but no significant skin damage.

Table 1. Composition of groups

	Treated Group	Untreated Group
Men (mean age)	11 (71)	13 (65)
Women (mean age)	6 (72)	9 (68)
Insulin dependent diabetic	4	6
Previous vascular surgery	7	7
Paravertebral block	6	7
Previous amputation (contralateral)	2	5
Mean pre-op TcpO <sub>2</sub>	33 (±10)	39 (±14)

### Skin oxygen

The results of the transcutaneous oxygen study are illustrated in Figure 1. The top figure shows the TcpO<sub>2</sub> levels for the treated group and the bottom one the untreated group. The hatched bar indicates the duration of therapy. Each point indicates the mean value of each set of ten readings, and the vertical bars indicate one SD. For clarity, levels for the posterior flap have not been shown. They followed the anterior flap figures, usually at a slightly higher level.

In the treated group there was significant ( $p < 0.01$ ) fall in TcpO<sub>2</sub> of the anterior flap at day 2, following cessation of adjuvant O<sub>2</sub> compared with pre-operatively (Fig. 1, top). This fall occurred immediately in the untreated group (Fig. 1, bottom) and a significant ( $p < 0.01$ ) difference existed between anterior flap TcpO<sub>2</sub> at day 1 between the groups. The oxygen levels in both untreated amputated limbs returned to their pre-operative levels by day 14.

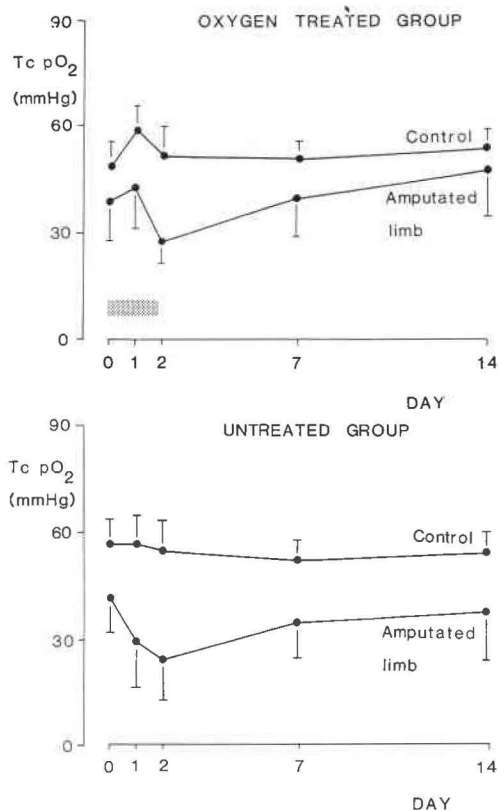


Fig. 1. Top, mean TcpO<sub>2</sub> levels for the oxygen treated group in patients whose stumps healed (n=9). The hatched bar indicates the duration of therapy. Bottom, mean TcpO<sub>2</sub> levels for the untreated group in patients whose stumps healed (n=7). Vertical bars show one standard deviation in both illustrations.

### Stump healing

The results of the study into stump healing are indicated in Table 2. In the treated group (n=17) one of the patients who failed appeared to be healing secondarily after a small area of flap necrosis developed. However, considerable deterioration in the stump at two months post operation necessitated conversion to the above-knee level. Two deaths occurred in this group, one of which occurred three days after amputation and the other seven months post amputation of myocardial infarction.

In the untreated group (n=22) one patient had a partial stump breakdown which

Table 2. Effects of treatment on healing

	1 <sup>st</sup> Heal	2 <sup>nd</sup> Heal	Failed	Early Death	Late Death
Treated	14	0	2	1	1
Untreated	14	1	4	5	1

subsequently healed and four required proximal reamputation, two at one week, one at two weeks and one at four weeks. Five of the six deaths in the group occurred within a month of surgery. The late death occurred at eight months due to myocardial infarction. Although the mortality in the untreated group was higher than in the treated group, the difference was not significant.

Although overall healing rates appeared better in the treated (oxygen) group (Table 2), the numbers are too small to achieve statistical significance. However, when the pre-operative  $TcpO_2$  levels are examined, the results are more revealing. If the two groups are taken as a whole, regardless of post-operative therapy, the mean pre-operative value of  $TcpO_2$  in the successful cases ( $40 \text{ mmHg} \pm 11$ ) was significantly higher ( $p < 0.005$ ) than that observed in the failure cases ( $26 \text{ mmHg} \pm 14$ ). Similarly, in both the treated and untreated groups, the  $TcpO_2$  values in the failure cases were significantly ( $p < 0.005$ ) lower than the mean values for the successful cases. That is to say low tissue oxygen is more likely to lead to failure.

Furthermore, the pre-operative  $TcpO_2$  levels of the successful cases in the treated group ( $35 \text{ mmHg} \pm 10$ ) was significantly lower ( $p < 0.001$ ) than the corresponding value in the untreated group ( $44 \text{ mmHg} \pm 9$ ). Also, the mean value of  $TcpO_2$  in the untreated failures ( $27 \text{ mmHg} \pm 3$ ) did not differ significantly from the mean value in the treated patients who healed ( $35 \text{ mmHg} \pm 10$ ). In other words, adjuvant oxygen increased the likelihood of healing in patients with a low pre-operative transcutaneous oxygen. There was no significant difference between the pre-operative  $TcpO_2$  levels in the treated or untreated groups taken as a whole, nor was the  $TcpO_2$  value in the treated (failure) group ( $23 \text{ mmHg} \pm 3$ ) significantly lower than the corresponding value in the untreated group ( $27 \text{ mmHg} \pm 17$ ).

In Table 3 are shown the distribution of successful and unsuccessful amputations as a function of three bands of pre-operative  $TcpO_2$ . This table shows the pattern of the effect of adjuvant oxygen. However the numbers in each group are insufficient to achieve statistical significance.

All of the surviving patients in this study have been discharged mobile with a prosthesis with the exception of six patients who were

Table 3. Distribution of  $TcpO_2$  levels

$TcpO_2$ (mmHg)	Failure		Success	
	Untreated	Treated	Untreated	Treated
0-19	3	0	0	1
20-39	2	3	5	9
40-	2	0	10	4

discharged fully rehabilitated in wheelchairs, four in the untreated group and two in the treated group. The mean time from operation to discharge was 43.5 days with a range of 16-132 days. There was no significant difference in length of hospital stay between the groups, the mean for the treated group being 46 days and the untreated group 42 days.

### Discussion

The effects of tissue oxygen on wound healing have been appreciated for many years. For example, it is known that in mountain dwelling peoples wounds heal better in the valleys than in the rarefied mountain air and a similar effect has been observed in divers when wounds healed more quickly during prolonged spells under water (Hunt and Pai, 1972).

It is possible to measure oxygen tensions directly in wounds and the work of Hunt and colleagues using experimental wounds in animals has shown that oxygen supply is usually below the optimum for collagen synthesis and that some of the processes of wound repair benefited from increased inspired oxygen tension (Hunt and Pai, 1972). Kirk and Irvin (1977), however, were unable to demonstrate any benefit of oxygen therapy in experimental skin wounds or colonic anastomoses in rats, and concluded that further studies would be necessary to determine benefit.

More recently Chang and his colleagues (1983) have reported a study in patients in whom tissue oxygen was measured using an implanted silastic catheter. They showed tissue hypoxia to be common and most severe in the immediate post-operative period. They also showed that increasing inspired oxygen resulted in an increase in tissue oxygen levels. Additionally, Knighton et al (1984) have reported that increased inspired oxygen levels significantly inhibit experimentally induced infections in animals.

In the vascular amputee the precarious and variable blood supply to the ischaemic limb complicates the study of wound oxygenation and healing. Strictly  $TcpO_2$  values do not

measure skin oxygen, which varies from the  $\text{PaO}_2$  of capillary blood to zero at the epidermis. With the probe used here at  $44^\circ\text{C}$ , the values of  $\text{TcpO}_2$  can reasonably be taken to reflect capillary oxygen levels. The results of the first study have highlighted the profound fall in  $\text{TcpO}_2$  which occurs in the amputated limb following surgery. The results also show how this fall can be prevented by the use of adjuvant oxygen therapy. The exact mechanism behind this fall in  $\text{TcpO}_2$  is not well understood and needs further investigation. Another study currently being conducted within the authors' department (Fairs et al, 1986) has shown that skin blood flow in an amputation stump, measured with a laser Doppler flowmeter, rises immediately following surgery, thereafter falling to a stable baseline as healing progresses. It is attractive to argue from this evidence that such a simple treatment as adjuvant oxygen would be an aid to healing in such patients (Mustapha et al, 1983) since it would potentiate an already elevated skin perfusion. However, no rationale has been established for an optimum treatment regime. The choice of 48 hours therapy was based on convenience rather than on any scientific basis, but nevertheless, it appears from these present studies that adjuvant oxygen therapy does affect the operative outcome.

Although significant increases in healing rates with adjuvant therapy have not been demonstrated, the authors have been encouraged by the significantly lower levels of pre-operative  $\text{TcpO}_2$  at which healing can be achieved with the help of adjuvant oxygen. Furthermore, it seems likely that with larger numbers the authors would also be able to demonstrate that the  $\text{TcpO}_2$  in the oxygen-treated failures was significantly lower than in the untreated failures. This must await further studies. It might be argued that "force healing" by the use of adjuvant oxygen merely delays the breakdown of wounds for a month or so. However the long term follow-up has shown no evidence of this. The fall observed in  $\text{TcpO}_2$  after stopping oxygen might suggest a rational basis for continuing therapy for longer than 48 hours, although difficulties will inevitably occur in maintaining continuous therapy as patients become more mobile.

It might reasonably have been expected that if oxygen therapy improved healing the time to

discharge in the treated group would be less than that in the untreated group. That it was not is however more a reflection of the other factors which determine discharge times (such as the delay between measuring and fitting the prosthesis, the completion of home modifications etc). In any event the discharge times achieved during this study were less than the average of 51 days which is typical for the District (Ham et al, 1987). It is anticipated that with more extensive use of oxygen therapy and with a resident prosthetist significantly shorter rehabilitation times might be achieved.

Many reports have appeared on the use of the  $\text{TcpO}_2$  monitor (Ratcliff et al, 1984; Mustapha et al, 1983; Dowd et al, 1983; Spence and Walker, 1984; Dowd, 1986). The principle of the technique has been described elsewhere (Simpson and Bryan, 1982) and, although debate continues as to the exact physiological significance and accuracy of  $\text{TcpO}_2$  measurement in ischaemic limbs (Spence and Walker, 1984), most authors agree that it is of value as an indicator of skin oxygenation. In the authors' series no additional useful information was obtained by measurement at both anterior and posterior sites. A central measurement is probably useful to exclude significant central hypoxia and the results agree with the findings of Mustapha and his colleagues (1983) that no additional information can be gained by examining the chest to below knee ratio.

Most of the published reports on the prognostic value of pre-operative  $\text{TcpO}_2$  monitoring have included patients with amputations at different levels and more importantly performed by many different surgeons using a variety of methods. This makes the results difficult to interpret. The present trial, although of small numbers, was carefully designed to try to keep the treatment of each patient as identical as possible. The authors were satisfied to achieve an overall healing rate of 83% for all the below-knee amputations. This is as good as published series where much more rigorous criteria for exclusion were used. The authors now believe that there can be little expectation of healing of below-knee amputations below a  $\text{TcpO}_2$  level of 20 mmHg at the anterior 10cm below knee level. Other authors (Harward et al, 1985) have suggested levels as low as 10 mmHg to indicate potential success. Others specify 30 mmHg or higher (Ito

et al, 1984). These differences appear difficult to reconcile. However, they may be more a reflection of the performance of the instrumentation used than of the tissue oxygen levels (Spence et al, 1985), and each centre must in the end adopt the level which it finds appropriate for its own patients and instrumentation.

It is wrong to assume that a single pre-operative level of  $TcpO_2$  will predict success in every case and that adequate tissue oxygenation is the only requirement for a successful amputation. Some would argue that a better identification of potential success or failure can be achieved by measurements following some circulatory provocation such as exercise or oxygen inhalation (Harward et al, 1985; McCollum et al, 1986). This has not yet been the authors' experience. There is no doubt that success in amputation surgery and rehabilitation depends primarily on the interest shown in the individual patient, the use of careful operative technique and enthusiastic post-operative care (Malone et al, 1981). However, the authors believe that this study, where the above criteria have been closely followed, has shown that pre-operative  $TcpO_2$  at an anterior below-knee site is a useful prognostic indicator.

A strong move to below-knee amputation has resulted in an overall success ratio of below-knee to above-knee amputations of nearly 70% compared with 30% in previous years in this Unit with similar patients (Ham et al, 1987). It is expected that use of adjuvant oxygen therapy will further increase this success rate.

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## The value of revision surgery after initial amputation of an upper or lower limb

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### Abstract

The value of revision surgery when carried out more than six weeks after initial amputation of the upper or lower limb was assessed. When performed for stump and/or phantom limb pain alone, only 33/95 (35%) obtained satisfactory results after one revision; 25/95 (26%) of the patients required four or more surgical procedures without relief of pain. However, when carried out for local specific pathology, the results of surgical revision were 100% successful, even if the procedure had to be repeated once in 15% (28/189) of this group of patients. Transcutaneous nerve stimulation appeared to offer no long lasting relief of pain following amputation surgery.

### Introduction

Revision surgery after initial amputation of an upper or lower limb is often necessary. The revision rate at the authors' Amputee Clinic is 25% for all levels of upper and lower limb amputees. Fifty per cent were revised at the same level and 50% to higher levels. Indications for such a procedure include:

1. Stump pain and/or phantom limb pain.
2. Late infection of the stump.
3. Symptomatic bone spurs.
4. Revision of a skin graft used primarily to conserve stump length.
5. Improvement of the stump for prosthetic fitting.

It is the purpose of this review to assess the results of revision surgery performed for the above indications at least six weeks after the

initial amputation of an upper or lower limb (excluding partial hand and partial foot amputations, which have previously been reported from this clinic. Harris and Silverstein, 1964; Harris and Houston, 1967; Lily, 1974).

### Patients and methods

The case histories of patients who had revision surgery performed at least six weeks after the initial amputation were reviewed from the files of the Amputee Clinic of the Workers' Compensation Board of Ontario. The timing of six weeks was chosen to exclude minor debridement and stump closure as surgical "revision" procedures.

All patients with peripheral vascular disease (either pre-existing or developing after accident) were excluded from this study.

Revision surgery for pain in the absence of local tissue pathology included excision of neuromata (56%) or proximal amputation (44%). Either of these two procedures was often combined with proximal neurectomy and the nerve was buried into adjacent muscle or soft tissue away from the suture line.

When carried out for local specific pathology, surgical treatment included management of late infection, removal of bone spurs, adjustment of skin and soft tissues after skin grafts or provision of a better stump for prosthetic fitting.

After chart review, postal questionnaire, telephone interview and where necessary, personal examination, there was sufficient information to include 284 patients in the study.

The average age of the patients at the time of accident was 38 years with a range of 17 to 64 years. The period of follow-up after surgical treatment varied from 1-21 years with a mean of 8 years.

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## Results

Success after revision surgery was defined as the relief of the postoperative problem. Failure was defined as persistence of the preoperative problem often requiring one or more further surgical procedures on the stump.

The results (Table 1) indicate that when revision surgery was carried out for pain alone, in the absence of local specific pathology, only 33/95 (35%) of patients obtained satisfactory relief of pain after the first revision operation. In this group with chronic pain, revision surgery included excision of the neuroma, proximal neurectomy and/or proximal amputation. Often during the prolonged treatment, all of these procedures had been attempted on one or more occasions.

A total of 239 procedures had been carried out on 95 patients for stump and/or phantom limb pain alone at the time of review and 25 of these patients had four or more revision procedures with little ultimate benefit.

However, when revision surgery was carried out for the treatment of chronic infection, removal of bone spurs, revision of skin grafts or to provide a better stump for prosthetic fitting, the results were successful in 161/189 (85%) of patients after the first revision and 100% successful after a second revision procedure.

Regarding the site of amputation and revisions,  $\frac{2}{3}$  of patients had lower limb amputations and  $\frac{1}{3}$  had upper limb amputations. There appeared to be no difference between reasons for revisions or results of revisions in these two groups.

Approximately three of four amputees were limb wearers, but there were problems with recurrent skin breakdowns and problems of pain. There were more problems in lower limb amputations than upper limb because of weight-

bearing and this prevented full use of a prosthesis. (Millstein et al, 1985).

## Discussion

In this series, local revision surgery was unsuccessful in relieving stump and/or phantom limb pain in the absence of local specific pathology.

Other authors have also found stump revision for pain to be unsuccessful. Leriche (1939) emphatically states reamputation must be avoided, even if the stump is not very satisfactory. Mitchell (1965) stated that he did not reamputate any of his patients, but that he certainly was aware of other people who had reamputated because of pain and had not been rewarded in their efforts. Sherman et al (1980) found non-surgical treatment methods were more successful than surgical treatment. Sherman et al (1984) reported that 52% of 27 amputees had only minor temporary improvement following stump revision.

Following loss of a limb, most amputees will suffer stump and/or phantom limb pain for a varying period of time. At this Amputee Clinic, 68% of amputees reported stump and phantom limb pain with a 14 year follow-up. Millstein et al (1985) and Sherman et al (1984) found phantom limb pain was as high as 78% and correlated with stump pain.

The treatment of pain following loss of a limb is difficult to assess, because there are many aetiological factors (Table 2) and there is no reliable way to measure precisely the intensity of pain.

In the authors' Amputee Clinic the standard measures are employed, such as analgesics, biofeedback, acupuncture, and on occasion nerve blocks and neurosurgical procedures to treat the established pain syndrome following amputation.

Table 1. Number of revisions performed on 284 patients

Number of revisions	Pain	Chronic infection	Bone spurs	Revisions of skin graft	Poor stump modified for prosthesis
1	33	58	13	50	40
2	18	18		7	3
3	19				
4	15				
>5	10				
Number of patients Total=284	95	76	13	57	43



Table 2. Causes of pain following loss of limb

Painful phantom limb  
 Reflex sympathetic dystrophy (causalgia)  
 Referred pain, e.g. neck, back.  
 Psychogenic pain

*Intrinsic stump problems*

Bone spur or fracture  
 Ischaemia  
 Infection  
 Bursitis  
 Neuroma  
 Skin problems  
 Recurrent tumour

*Extrinsic prosthetic problems*

Volume changes of stump  
 Malalignment  
 Inlet impingement of prosthesis

In retrospect, many of these patients exhibit features suggestive of a chronic pain syndrome (Table 3). Psychological assessment prior to surgery cannot be over-emphasized, but it should be stressed that this particular group of patients often deny psychosocial factors and are resistant to standard psychotherapy.

The development of a neuroma is a natural response to section of a nerve; it is not surprising that excision of the neuroma, proximal neurectomy or proximal amputation would only be successful in relieving pain in one of three patients when no local specific pathology was identified (Table 1). Leriche (1939) stated nerves were not meant to be divided and the effectiveness of neurosurgical techniques for phantom limb pain have been disappointing (Sunderland and Kelly, 1948).

The fact that 25/95 (26%) of patients required four or more revision procedures would indicate a degree of "Mania Operativa" (Hunter and Kennard, 1982) as a result of chronic pain syndrome.

Since all these patients sustained their amputation as a result of a work related accident, they were covered by the Ontario Workers' Compensation Board. Under the Workers' Compensation Board Act, patients currently receive benefits for medical expenses and loss of wages (75% to 90% of their earnings up to a maximum of \$32,100.00). Upon completion of treatment, and when the patient is ready to return to work, patients are awarded a permanent disability pension based on their level of amputation and their earnings. Under the Act, patients who accept W.C.B. compensation benefits relinquish the right to litigation and the majority of patients do not

Table 3. Features of chronic pain syndrome

(Spengler et al, 1980)

1. Symptoms lasting longer than six months and which affect the patient's life style.
2. Few if any objective findings.
3. Addiction to medication or alcohol.
4. Insomnia.
5. Depression and hostility.
6. Manipulative behaviour.
7. Suffering inappropriate to somatic problems.
8. Failure of standard medical and surgical methods to relieve pain.
9. Denial of psychosocial factors.
10. Minimally productive with no realistic plan for future.
11. Possible secondary gain factors.

pursue litigation except under unusual circumstances.

Repeated surgery may be due to a simple desire not to work, coupled with secondary gain, as patients generally receive benefits almost equal to their salaries while on medical treatment (Hunter and Kennard, 1982). It should be noted, however, that permanent disability pensions are relatively small by today's standards, even for proximal limb amputation and there is no doubt that the patient would be better off financially returning to the work force.

It is difficult to understand why operations were performed without any specific reason in the stump. Often the reason for revision was not evident and difficult to determine in a retrospective study. Baumgartner and Riniker (1981) reported operating on stumps which externally presented a normal aspect and found deep scars and thus suggested the amputee has a chance for relief from his pain by operative revision, even if an exact diagnosis cannot be established preoperatively.

The authors' have found that revision surgery for pain when no specific stump pathology can be determined, is usually unsuccessful in relieving the amputee's pain problem.

The results were successful when objective findings necessitated revision surgery, even if the operation had to be repeated once in 28/189 (15%) patients (Table 1).

Should non-operative treatment be resorted to in the hope of relieving pain following amputation? In a separate review, a group of 35 patients, who had not responded to standard methods of treatment for stump and/or phantom limb pain were given a transcutaneous nerve stimulator (T.N.S. Neuromod) if preliminary

tests indicated relief of symptoms. Most patients adjusted the use of their machine to suit individual requirements.

At one year follow-up, 15/35 (43%) reported improvement in symptoms, but only six months later, only 4/35 (11%) continued to have relief of pain. These results are compatible with other T.N.S. studies that indicate an initial success of 60%, but with a marked tendency to decrease with time to about 30% or less. (Erikson et al, 1979; Myerson, 1983).

Eleven out of 35 (31%) patients were found to have a significant psychological handicap, but there did not appear to be any correlation between the result of the psychological testing (including the Minnesota Multiphasic Personality Inventory) and the success or failure of T.N.S.

Although the effectiveness of T.N.S. is not impressive, it is a non-invasive treatment, easy to use and has no side effects and may help some patients (Miles and Lipton, 1978; Gessler and Struppler, 1981; Winnem and Amundsen, 1982). The reduction of pain from T.N.S. appears to be temporary at best. Any treatment technique that ignores the multifactorial influences on chronic pain is unlikely to lead to a satisfactory result. Sherman et al (1984) when assessing the effectiveness of treatment for chronic phantom and stump pain found that only 1% reported lasting benefits from any of a multitude of treatments attempted.

Until the mechanism of pain following amputation is better understood, the authors strongly advise against repeated local revision surgery in the hope of relieving stump and/or phantom limb pain.

When local specific pathological findings were present, however, surgical treatment was successful in relieving the patients' problems and should allow early prosthetic fitting and rehabilitation.

#### Acknowledgements

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## A versatile hand splint

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### Abstract

Splintage plays a major part in the management and rehabilitation of the hand following injury, infection and operation. It is essential to have a simple, comfortable, and firm but flexible splint. This should be available "off the shelf", but be acceptable to the patient and to the treating clinician.

This paper will describe a splint which not only has these qualities, but is cheap and is re-usable after washing.

The splint is made of high density Plastazote and is available in two sizes for each hand. It is moulded into the shape of the functional position of the hand and can easily be trimmed with bandage scissors to give a precise fitting. The splint has been evaluated following surgery on fifty hands. Its fabrication, use and simplicity are discussed.

### Introduction

Leading authorities in hand rehabilitation including Bunnell, Rank, Wackfield, Heuston, Wynn Parry and others have emphasized the importance of correct splintage for the recovery of hand function following operation, injury or infection.

Choosing a splint is very difficult. Clinicians have their likes and dislikes with regard to the varying characteristics of splints, but most will agree on the following criteria.

The splint should—

1. Maintain the hand in the position of comfort or the "position of function".
2. Allow the fingers as much mobility as is permissible in accordance with the disease or the operation.
3. Be strong enough to support the hand and forearm without losing its integrity.

4. Be firm but flexible.
5. Be lightweight and durable.
6. Be cost-effective.
7. Be available off the shelf.
8. Be easily modified according to the needs of the individual.

### *Position of comfort/position of function*

Positioning of the hand in a splint is very important. There have been very few studies on this aspect. In most of these (Bateman, 1946; Bunnell, 1946; Capener, 1946) the emphasis has been on the status of the collateral ligaments of MP, PIP and DIP joints of the fingers. It is generally accepted that these joints should be placed in a position where the ligaments are in the taut position; i.e. that the MP joint is in 35° to 40° of flexion whereas the IP joints are almost in extension.

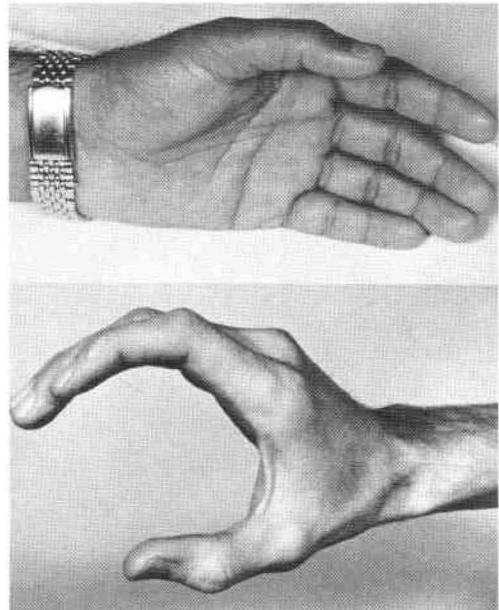


Fig. 1. Top, position of comfort/position at rest. Bottom, position of function.

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Observation of peoples' hands when they are walking, sleeping or at leisure shows a certain posture of wrist, hand and fingers—the attitude of comfort or rest (Fig. 1, top). This position is that of maximum relaxation with a corresponding decrease of energy consumption and increase in comfort. This position of physiological rest suggested by Capener closely resembles the prescribed position of function with the addition that the wrist is in slight dorsi-flexion with ulnar deviation and the thumb in opposition (Pryce, 1980) (Fig. 1, bottom).

The ideal splint, while maintaining this position, should also allow some movements within prescribed limits and approximately satisfy the criteria already listed.

High density Plastazote appeared to fit the material property criteria most closely being light weight, firm but flexible, durable, re-usable and inexpensive.

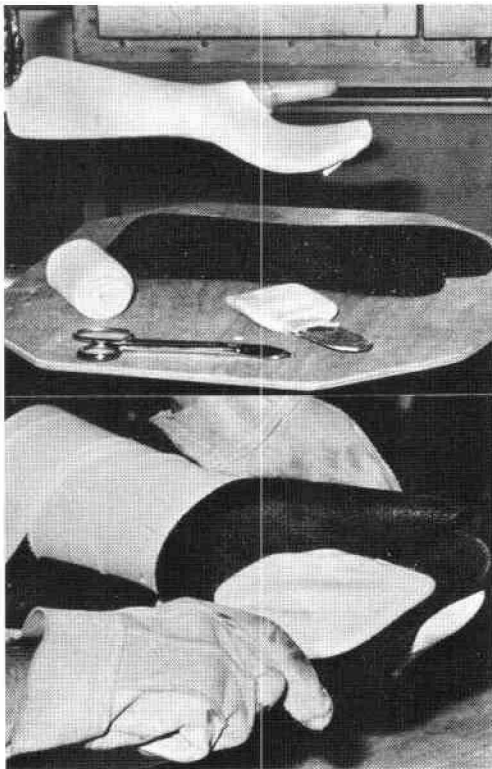


Fig. 2. Top, items required for splint fabrication—oven; pre-cut Plastazote sheet; spatula; crepe bandage; scissors; mounted cast. Bottom, use of spatula to contour the thenar eminence.

#### Fabrication of splint (Fig. 2, top)

A rough-shaped portion is cut from  $\frac{1}{4}$ " high density Plastazote sheet, heated in an oven at  $200^{\circ}\text{C}$  for 3 minutes, and then wrapped on the master cast. (A pair of heat resistant gloves should be used to handle the material). A

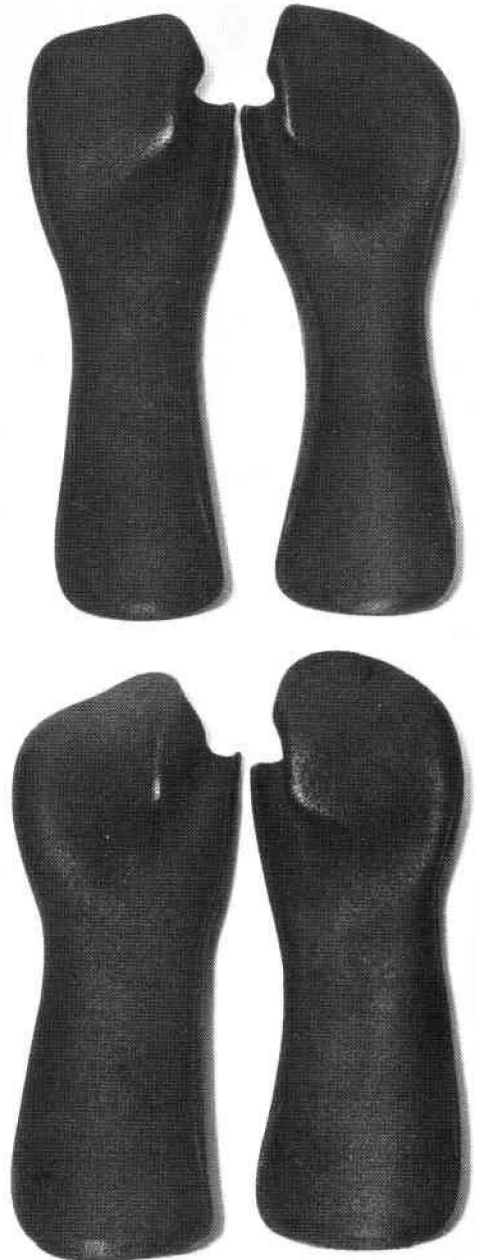


Fig. 3. Two sizes for each hand—large and small.

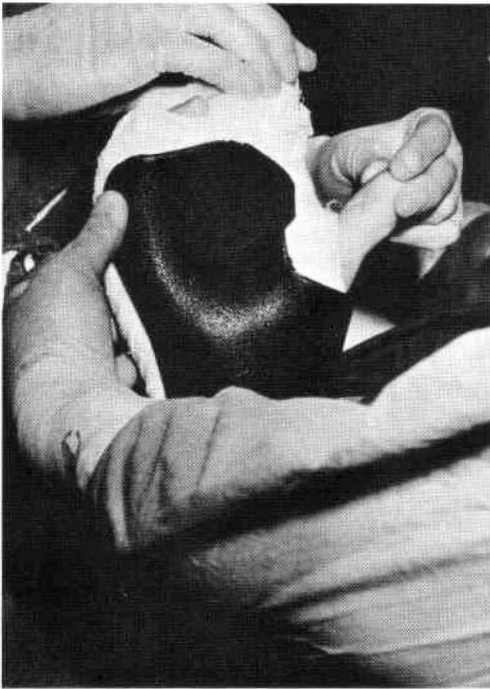


Fig. 4. Individually trimmed splint being applied.

spatula is used for contouring the thenar eminence (Fig. 2, bottom). A crepe bandage is used to wrap the splint round the master cast.

After proper pressure the bandage is removed. The final trimming of the splint is carried out simply by using bandage scissors.

Two standard sizes of splints for right and left hands are stocked and are then readily available, off the shelf (Fig. 3). The use of the splint in many patients with varying clinical conditions has suggested that two sizes meet the needs of most adult patients. This is due to the flexibility and malleability of the splint.

The larger size is sufficient to cater for all hands having bulky dressings i.e. post-operative patients and traumatic hands with bandages etc. The smaller size is used for splinting of hands where there is no bandage or minimal dressing. The contour of the splint can be adjusted by squeezing or stretching to fit the patient's forearm. Further individual trimming is easily performed at the time of application (Fig. 4).

#### Evaluation of splint

This splint has been evaluated on fifty hands (47 patients) following operation for Dupuytren's contracture. Forty-four were males

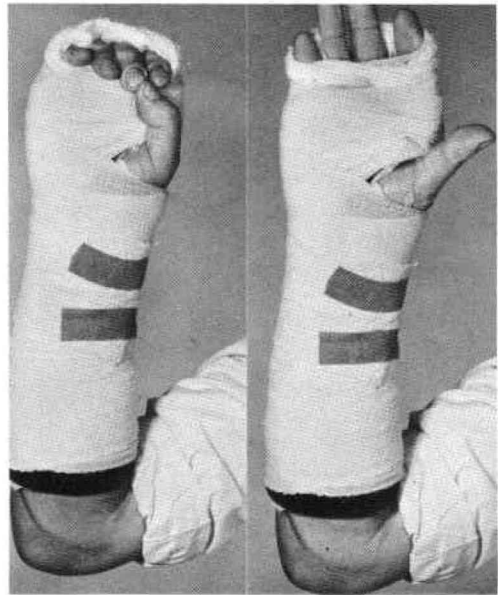


Fig. 5. Free movement of fingers and thumb with splint in position.

and only three were females. All the patients were operated on by open McCash technique and were splinted for two weeks.

At two weeks a subjective evaluation of the patients' impressions was carried out.

They were asked to comment on—

1. Pain—increase in pain after first day.
2. Movements of fingers and thumb (Fig. 5).
3. Weight of splint.
4. Acceptability of splint.
5. Any other comment.

None of the patients complained of any increase in pain after the day of operation. This was confirmed by the prescription of analgesics. All the patients required simple oral analgesics after twenty-four hours of surgery. All the patients but one were discharged home within forty-eight hours of surgery. Unfortunately one developed pneumothorax following brachial block regional anaesthesia. This was treated by chest drain, but he did not need any injectable analgesics. Most patients took a mild analgesic occasionally at home after discharge. All the patients were able to move the fingers and thumb freely and all agreed it was very light. None rejected the splint.

Six patients complained of the smell of the splint. It seemed that sweating and bleeding within the bandage caused an odour which was

unpleasant, but not serious enough to warrant rejection. This problem can easily be solved by using carbon impregnated dressings; carbon particles absorb odours.

At follow-up all the splints were examined for any breakage. Except for one or two creases in a few splints nothing abnormal was noted. All of the splints could be re-used twice with some being used three times.

Since the survey of patients operated on for Dupuytren's contracture the splint is also being used in the following conditions—

1. Post-operative patients following—
  - a—correction of flexion contracture of fingers.
  - b—repair of extensor tendons.
  - c—surgery for rheumatoid arthritis.
2. Infected hands.
3. Metacarpal fractures.
4. Neuro-muscular problems.

### Discussion

Splintage is generally accepted as being necessary in the recovery of the hand following trauma, infection and operation, but positioning of the hand within the splint has always been a matter for discussion. The views of Capener, Bunnel and Bateman have been followed for years. Recently, biomechanical studies by Smidt et al (1975) and Pryce (1979) have confirmed that to gain maximum grip power the wrist should be placed in 30° of dorsiflexion with ulnar deviation. It is known that mobilization of the fingers with forceful grip will help in reducing swelling, thus relieving pain. This in turn helps

the patient to increase his active mobilization.

Reduction of swelling, relief of pain and active mobilization are the keys for the successful outcome for the hand under treatment.

Heavy density Plastazote is an excellent material. It has all the required characteristics, provides easy fabrication in the desired hand position and can be contoured according to the shape of the forearm. It has the added advantage of off the shelf fitting by trimming using simple bandage scissors.

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## **Evaluation of introducing the team approach to the care of the amputee: the Dulwich study**

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### **Abstract**

The effects of introducing the Team Approach to the management of the lower limb amputee has been assessed in a consecutive series of 233 patients over a five year period.

During the first year, baseline data was collected and during the subsequent yearly phases the effects of introducing a physiotherapist co-ordinator, visiting prosthetist and medical officer from the local Artificial Limb and Appliance Centre (ALAC), and finally trained surgeons were studied. During the final phases of the study, the effects of changing team staff were monitored.

The results have shown that only when the full Team Approach is adopted are the best results achieved, but that, once this approach is established, staff changes can be made without serious reductions in effectiveness. The study has shown that the team can reduce in-patient stay by 20 days; reduce the need for post-discharge physiotherapy by 94%; increase the proportion of patients discharged with a prosthesis more than fivefold and increase the effectiveness of long term rehabilitation threefold.

### **Introduction**

In spite of advances in vascular surgery over the last decade, patients with advanced arteriosclerosis are still coming to major amputation when vascular reconstruction and radiological procedures are of no help. At the end of 1984 there were more than 51,000 lower limb amputees in England and Wales (McColl,

1986). Of these, 88% were civilian (rather than war pensioners) and 68% were over 60 years of age.

Many authors (Murdoch, 1984; Little, 1975) have stressed the need for good surgical techniques, ward management, and intense, co-ordinated rehabilitation so that these patients can quickly and successfully return to the community. Rehabilitation of the amputee is not complete however, unless every patient has had the opportunity to be assessed and try an artificial leg. In the majority of the United Kingdom, amputations are carried out at District General Hospitals (DGH) in which typically only 5-10 are carried out annually. The surgery is performed by junior surgeons who have little experience in amputations and generally less knowledge of prosthetic prescription (McColl, 1986). The patients can wait up to 60 days to visit their local ALAC and this is often a distance of 60 miles, involving a 2-3 hour ambulance journey (Hutton and Rothnie, 1977). It is only at the few specialist centres such as Roehampton, London and Dundee, Scotland that staff are knowledgeable about correct surgical management, the team approach to rehabilitation and modern prosthetics. These centres are in close contact and proximity to an ALAC which makes prosthetic supply, alteration and repair a quicker process than it is for the rest of the country (McColl, 1986).

The authors' centre is a busy vascular unit without an ALAC on site (and therefore typical of many DGH's). In 1981, a general dissatisfaction with the services provided to the hospital by the local ALAC prompted moves to improve the management of patients. These moves have included improving both the patient

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assessment and preparation, the surgery and the rehabilitation, as well as introducing the team approach and the visiting services of the ALAC to the hospital. The changes in management which were introduced in distinct phases and the subsequent results of their introduction are reported here.

### Patients and methods

Patients with peripheral vascular disease who are referred to the Camberwell Health District in London are dealt with either at King's College or at Dulwich Hospital. Of the patients requiring amputation, the majority (81%) come from this health district and 95% are from the lower social classes. Over the five year period 1981-86, 233 patients have undergone lower limb amputation for vascular insufficiency in this district, the greater majority on the Dulwich site. All the patients were managed throughout their entire stay on acute general surgical wards at either site.

The five year period was divided into annual phases so that the specific changes in management could be evaluated (Table 1). During *Phase I* (1981-82) base line data were collected from the two sites. Patients were managed by either the general or vascular consultant surgeon under whom they were referred and the amputation was performed under a general anaesthetic by a surgical registrar in training. Following surgery, a crepe bandage was used to cover the wound and the stump was often immobilized by sand bags or sheets to prevent flexion contractures

developing. There was no routine antibiotic or analgesia cover and the post-operative management varied with each consultant. Physiotherapy sessions generally lasted half an hour and were given either by a junior or student physiotherapist. Early mobility walking aids were not used routinely and consultants were often actively opposed to their use. Patients were referred to the ALAC using a standard Department of Health and Social Security (DHSS) form (AOF3) and they generally attended for their first appointment while they were still in-patients. Once the patients were medically stable, they were discharged either on crutches or using a wheelchair. In a few cases only had a home visit been carried out by the occupational therapist. Patients received their prostheses as out-patients and then reattended the physiotherapy department until they were either walking independently or had discarded their prostheses totally.

During *Phase II*, changes were implemented on both sites. At Dulwich a full-time senior physiotherapist was appointed to co-ordinate the amputee rehabilitation. The amount of physiotherapy the patients received increased and they were treated together as a group. The physiotherapist co-ordinated the post-operative management, communicated with the other staff members and started a weekly multidisciplinary team meeting. The physiotherapy on the King's site remained unchanged. Also in *Phase II*, the visiting services of an ALAC Medical Officer (MO) and a prosthetist from Vessa Ltd. was started on a weekly basis to both the hospitals.

Table 1.

Phase	Hospital	Protocol
1 (1981-1982)	KCH	— Base line data of standard treatment collected.
	DH	— Base line data of standard treatment collected.
2 (1982-1983)	KCH	— Addition of the ALAC Medical Officer & Prosthetist.
	DH	— Addition of the ALAC Medical Officer & Prosthetist & Senior Physiotherapist/Co-ordinator.
3 (1983-1984)	KCH	— As phase 2.
	DH	— As Phase 2 plus surgical involvement, use of TcpO <sub>2</sub> for level selection & increase in staff education and teaching.
4 (1984-1985)	KCH	— Change in Surgeon & ALAC Medical Officer. Co-ordination by Physiotherapy Department began.
	DH	— Changes in Surgeon, ALAC Medical Officer & Physiotherapist/Co-ordinator.
5 (1985-1986)	KCH	— Patients transferred to DH either pre- or post-operatively.
	DH	— Change in Surgeon & appointment of Physiotherapist/Co-ordinator.



The MO and prosthetist assessed the patients, measured and delivered the prostheses to the patients while they were still in hospital. Patients on the Dulwich site were not discharged until they were fully rehabilitated, either on a prosthesis or from a wheelchair.

During *Phase III*, and on the Dulwich site only, the involvement of the surgeons completed the team approach. Senior registrars (surgeons in the final stages or training) who had an interest in amputee rehabilitation visited Roehampton and gained up to date knowledge regarding surgical techniques and modern prosthetic needs (McColl, 1986). In addition, improvements were made in the diagnostic tests provided by the Vascular Laboratory for the assessment of amputation level. Particular emphasis was placed on the use of transcutaneous oxygen (TcPO<sub>2</sub>) measurements (Butler, 1986). The amount of day to day teaching and education by the physiotherapist and surgeon on the modern management of these patients also increased during this phase. The service on the King's site remained unchanged from *Phase II*.

During *Phase IV*, there were changes in staff on both sites. At King's there was a change in the surgical registrar and a physiotherapist began to act as co-ordinator for the amputees on that site. At Dulwich there were three staff changes. The surgical registrar in training rotated to another surgical firm; the physiotherapist co-ordinator left for another department and as a consequence there was a four month interval preceding the appointment of a new physiotherapist co-ordinator (which occurred at the start of *Phase V*) during which time the team was co-ordinated by a junior physiotherapist as part of her normal workload; lastly there was a change in the ALAC MO.

During *Phase V*, patients were transferred wherever possible from King's to Dulwich pre-operatively so that they could benefit from the full-time physiotherapist and the team approach to rehabilitation. Due to these transfers, *Phase V* results are reported for the Dulwich site only. At Dulwich during this phase a new full time physiotherapist co-ordinator was appointed and there was the annual change of surgical registrar.

Table 2.

Phases	1981-82 I	1982-83 II	1983-84 III	1984-85 IV	1985-86 V
<i>King's College Hospital</i>					
Total patients	19	8	16	13	—
Total rehabilitated	10	7	13	10	—
Average age	67	70	70	65	—
Hospital mortality	3(16%)	1(12%)	2(12%)	2(15%)	—
Final proportion at AK level	74%	87%	69%	23%	—
Patients suitable for prosthesis	10	7	11	10	—
Days from operation to measurement	32.0	28.0	30.0	23.0	—
Days from measurement to delivery	14.0	7.0	7.0	7.0	—
% of suitable patients discharged with a prosthesis	10%	100%	100%	100%	—
Hospital stay (days)	60.0	96.0	74.0	60.0	—
Outpatient physiotherapy	47.0	24.5	3.5	6.3	—
% using prosthesis at 1 year	29%	50%	80%	60%	—
<i>Dulwich Hospital</i>					
Total patients	25	32	43	36	41
Total rehabilitated	17	21	35	23	30
Average age	71	72	68	71	69
Hospital mortality	5(25%)	8(25%)	7(16%)	11(31%)	11(32%)
Final proportion at AK level	88%	62%	39%	44%	33%
Patients suitable for prosthesis	12	15	27	16	27
Days from operation to measurement	65.0	21.0	13.5	17.5	22.2
Days from measurement to delivery	29.6	7.5	7.0	8.6	7.0
% of suitable patients discharged with a prosthesis	17%	93%	89%	94%	100%
Hospital stay (days)	71.5	63.3	51.0	51.0	50.8
Outpatient physiotherapy	29.8	1.8	0.8	4.1	1.7*
% using prosthesis at 1 year	36%	91%	85%	79%	94%*

\* These figures are for 10 months only.

## Results

To evaluate the introduction of the team approach, the base line data (*Phase I*) from King's and Dulwich is compared with *Phase II* and then *Phase III*. To evaluate the effects of staff changes comparison should be made between the results in *Phases IV and V* and the earlier phases (Table 2).

In *Phase I*, all the patients were of a similar age, 73% suffering from arteriosclerosis and 20% diabetes. The majority of amputations (74% at Kings and 88% at Dulwich) were at the above-knee level and the hospital stay was 60 and 72 days respectively. Only three patients (one at Kings and two at Dulwich) received a prosthesis while they were in-patients. The patients re-attended for out-patient physiotherapy following prosthetic delivery an average of 47 times/patient at Kings and 29.8 times/patient at Dulwich. The percentage of patients using their prostheses functionally at one year was 29% and 36% respectively (these figures are affected by the deaths which occurred following discharge, three for the King's group and one for the Dulwich group).

In *Phase II* on the King's site, with the addition of the visiting services of the ALAC MO and prosthetist to the hospital, the results show that there was an increase in the number of patients discharged with a prosthesis (100%). There was also an increase in the hospital stay (from 60 to 96 days) and in the percentage using their prosthesis functionally at one year (29% to 50%)—(these figures take into account one death in the 12 months following discharge). There was also a decrease in outpatient physiotherapy reattendance (from 47 to 24.5 visits/patients).

In *Phase II*, at the Dulwich site (with the addition of the visiting ALAC and the physiotherapist co-ordinator) there was a similar increase in patients discharged with prostheses (17% to 93%) in its subsequent functional use (36% to 91%) (again these figures take into account the 4 deaths which occurred following discharge). There was also a decrease in the hospital stay (63.3 from 71.5 days) and outpatient re-attendance (1.8 from 29.8 visits/patient).

The percentage of above-knee amputations on both sites remained high but the days to prosthetic assessment and delivery began to decrease.

In *Phase III* on the King's site, the services remained unchanged from *Phase II* and the results were similar. On the Dulwich site, as the surgical involvement completed the team, the percentage of amputations at the above-knee level decreased to 39% and the hospital stay and out-patient re-attendance were reduced further. Prosthetic measurement and delivery times from operation were also further reduced, especially on the Dulwich site with both the improved surgery and with the more careful co-ordination of the treatment of the patients. Functional use of the prosthesis in the team approach situation at Dulwich continued to increase as the patients were fully rehabilitated at discharge. This figure remained low at King's.

In *Phase IV* at King's, with the greater level of education in the District and a change in surgical staff, there was a dramatic reduction in the final percentage of above-knee amputations (23%). A physiotherapist acted as a part-time co-ordinator for these patients during this phase and there was a further reduction in hospital stay, days from operation to prosthetic delivery and functional use of the prostheses. Out-patient re-attendance increased. The ALAC MO increased the prescription of P.T.B. rather than AK/BK prostheses with a subsequent increase in days from operation to measurement at the Dulwich site. At Dulwich there was also a change in surgical staff and this may account for the increase in hospital mortality and increase in amputations at the above-knee level. The physiotherapist co-ordinator also changed during this phase and the team was co-ordinated by a junior physio. This could account for the increase in outpatient re-attendance and decrease in functional use of the prostheses.

During *Phase V* at Dulwich, a new senior physiotherapist co-ordinator was appointed and the surgeon in training also rotated. The hospital mortality remained high and the number of days between operation and measurement increased by almost five days. These results could be a reflection on both the surgeon and the prosthetic prescription by the MO. As the in-patient stay remained constant the number of days available for prosthetic training fell to 28.6 days from 37.5 days (a reduction of 8.9 days), a level at which it has been in *Phase III* with experienced team members.

Delivery times of the prostheses have remained almost constant (around one week)

during the four phases that the prosthetist has been visiting the hospital.

### Discussion

The results show the value of the multidisciplinary groups that are so often mentioned in the make-up of the team approach (Murdoch, 1977).

Amputees who are not rehabilitated while in hospital have to await long periods of time to receive their prostheses (McCull, 1986). Once they take delivery of the artificial limb, many outpatient physiotherapy sessions are required and few gain good functional use of their prostheses (*Phase I*). When the cost of the hospital stay and the outpatient reattendance are added together, "rehabilitation" for these patients is very expensive.

Providing the patients with an artificial limb while they are inpatients, but without adequate physiotherapy is again of little benefit either functionally or as a cost saving exercise (King's *Phase II*). Providing patients with prostheses, the appropriate physiotherapy and co-ordinating their rehabilitation, reduces the hospital stay and out-patient re-attendance, increases the functional use of the prosthesis and is a cost saving exercise for the Health District.

When surgical involvement is added (Dulwich *Phase III*), patients benefit as both their knees and subsequent expenditure during walking energy are saved (Finch et al, 1980; Romano et al, 1971; Robinson, 1972). As the stumps are also technically better, the ALAC staff can supply the prostheses sooner, which also helps to reduce the hospital stay. The percentage of amputations at the below-knee level increased during this study though the patient type remained unchanged. With the reduction in the energy required for walking which this produces (Waters et al, 1976), more patients were able to continue to use their prosthesis functionally.

The present study clearly shows that even with the inevitable staff changes in a National Health Service, which uses staff-in-training to help run the service, these positive results can be maintained and continued (*Phase IV & V Dulwich*) as long as there is at least one experienced person who has the energy and enthusiasm to continue organizing the team, and the ability to continue the staff training and education programmes.

### Conclusion

For a long time, the amputee had been sadly neglected in this Health District as in many others throughout the United Kingdom (D.H.S.S., 1972). The morale, interest and knowledge of the staff dealing with these patients was low as was the morale of the patients themselves.

The team approach to the management of these patients and to other disabilities alike, has been well documented since the second World War. Up to now it has only been practised in a few specialist centres in this country. Implementing the team approach in phases has shown both the value of each team member and how the results alter as each professional interacts in amputee rehabilitation. For its successful adoption and implementation however, it must have the support of the consultant in charge of vascular surgery. There are some benefits with improved physiotherapy and intensive, co-ordinated rehabilitation, some with the improved surgery and improved medical management. The introduction of the visiting services of the ALAC MO and prosthetist to the hospital site to assess, measure and deliver the prostheses also had some benefits, but it is only when all these disciplines work together that the maximum is achieved for the patient and staff alike (Hutton and Rothnie, 1977).

Continuous education and training programmes are essential and must be the responsibility of every teaching hospital where medical, physiotherapy and nursing students are trained for the benefit of the rest of the country. Perhaps the most important point to emerge from this study is the fact that the team approach can and does work in a hospital that is not a specialist amputee centre and should be possible and feasible in every Health District carrying out more than 20 amputations annually.

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## Abnormal extension of the big toe as a cause of ulceration in diabetic feet

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### Abstract

Relief from external pressure and repetitive stress is a main concept in treating diabetic neuropathic ulcers. Ulcers on the tip of the big toe may be caused by abnormal extension of the big toe, which can be diagnosed only by observing the patient during barefoot walking. A flexor pad underneath the big toe eliminates the phenomenon, but in case of rigidity of the toe, extremely roomy toe boxes must be prescribed. Out of a series of 272 diabetic patients with skin lesions on the feet 18 suffered this phenomenon, in one case with bilateral ulcerations. Fifteen ulcers healed and below the knee amputation had to be carried out in 4 legs due to ischaemia.

### Introduction

The degree and duration of the extension of the toes during walking is, like the walking pattern itself, highly individual (Saunders et al, 1953). The authors have observed that problems from the big toe may be ascribed to excessive and constant extension during walking found in some patients. The phenomenon stresses the tip of the toe as it repeatedly bumps against the upper of the shoe. In patients with peripheral neuropathy, e.g. diabetics, there is a high risk of ulceration. In case of occlusive arterial disease, gangrene of the toe may be initiated (Fig. 1, top). A callosity on the tip of the toe or under the rim of the nail indicates the occurrence of stress and will precede ulceration or necrosis of the skin.

The phenomenon of abnormal extension can be diagnosed only by observing the patient during barefoot walking. A normal pattern of walking implies that the big toe is slightly extended during swingphase and at heelstrike.

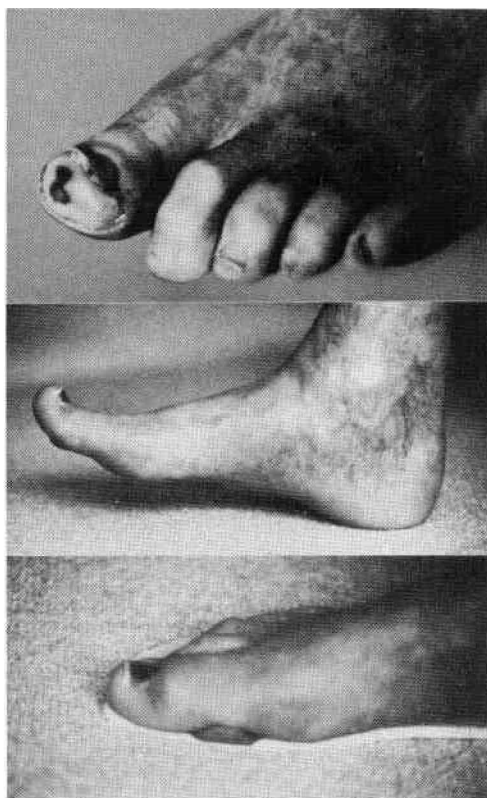


Fig. 1. Top, skin necrosis of the tip of the big toe. Centre, abnormal extension of the big toe at heel strike. Bottom, flexor pad placed underneath the big toe causing flexion of the interphalangeal joint.

Abnormal extension is easily recognized as the big toe is markedly extended during the whole walking cycle. (Fig. 1, centre). The phenomenon is usually bilateral and connected with cavus foot deformity.

Compensation for the abnormality can be provided by hand made shoes with extremely roomy toe-boxes. Another solution is a "flexor-pad" which consists of a soft bar, about 5 to 6 mm in height placed under the first phalanx of

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the big toe and transversely to its longitudinal axis (Fig. 1, bottom). This bar will cause the big toe to be slightly flexed during heel rise and push-off. It is a condition for employing a flexor pad that the flexor hallucis longus muscle and the joints of the hallux are mobile.

#### Patients and methods

During a 3 years period (01.12.79 to 30.11.82) 272 diabetic patients with skin lesions on the feet were treated. The clinical examination included an evaluation of the foot as regards function of the joints and muscles; the pattern of walking; peripheral neuropathy and arterial supply as well as an examination of the shoes with special attention to the roominess of the toe caps. Eighteen patients (7%) had ulcers on the tip of the big toe, in one case on both feet, caused by abnormal functional extension. The patients were supplied with insoles made from soft materials using functional imprints (Holstein et al, 1976; Larsen et al, 1982). In 13 patients flexor pads were placed underneath the big toes. In three cases hand-made shoes with extremely roomy toe-boxes were prescribed. This treatment was chosen because of hallux rigidus in two of the patients and because of paralysis of the flexor hallucis muscle in the third patient. In the last two patients no local treatment was given because the lesions developed into frank gangrene.

#### Results

The duration of the treatment period averaged 3 months (range 1 to 10 months) and 15 out of the 19 ulcers healed. In the four other legs a below-knee amputation became necessary. In these cases the systolic ankle and toe pressures demonstrated severe ischaemia. The legs in which the big toe lesions healed were followed up for on average 30 months (range 6 to 47 months). None of the skin lesions on the tip of the big toes recurred. Four patients died and three legs were amputated. The cause of amputation was progressive occlusive arterial disease resulting in heel necrosis in one leg and heel necrosis in combination with gangrene of more than one toe in the other two legs.

#### Discussion

Abnormal extension of the big toe during walking as a cause of ulceration of the tip of the big toe is not described in current text-books. Reumert (1976) has described abnormal extension as a cause of unguis incarnatus in

non-diabetic patients, and has recommended treatment with a flexor pad as a supplement to nail braces.

In diabetic patients the extension phenomenon is probably related to the presence of peripheral neuropathy. It is well known that weakness of the intrinsic musculature of the foot predisposes to claw-toe deformity (Wagner, 1981). In patients with big toe extension the clinical examination suggests weakness of the peroneal muscles compensated during walking by dorsiflexion of the foot by means of the long extensor muscles, especially the extensor hallucis longus muscle. The subsequent extension of the big toe is then a risk due to the neuropathic sensory loss. The phenomenon is easily overlooked unless observation of barefoot walking is included in the clinical examination. Treatment with the flexor pad, or in case of rigidity with extremely roomy toe caps has proved successful in cases where the blood supply is adequate for healing. In theory there is a risk of pressure ulcer underneath the big toe due to the flexor pad but the authors have not so far encountered such cases.

In the four legs which had to be amputated primarily the pressure lesions developed into gangrene. This demonstrates the risk of the abnormal extension especially in case of ischaemia. The presence of a skin lesion on a diabetic foot always requires a careful analysis of the pathomechanism. Correction for abnormal extension of the big toe must be part of the armamentarium in the relief of intolerable local external pressure and stress to the neuropathic foot.

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## **Foot loading characteristics of amputees and normal subjects**

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### **Abstract**

The foot loading characteristics of 100 consecutively attending amputees wearing their definitive prostheses were studied during their routine visits to the Artificial Limb and Appliance Centre. Results were compared with observations on 100 age and sex matched controls who were free from any locomotor disability. The parameters measured were the percentage of body weight borne on each foot, the positions of the centres of pressure under each foot and the position of the overall centre of foot pressure. The results demonstrate the range of variability of these parameters in normal subjects of different ages and provide preliminary indications of the patterns associated with different types of prostheses and different levels of amputation. The information was collected using the Double Video Forceplate (DVF) a tool developed for the rapid assessment of stance, at University College London Bioengineering Centre. It is proposed that the DVF may be useful in assisting prosthetic alignment, in clinical teaching of prosthetists, physiotherapists and doctors and in monitoring of patients with lower limb amputation.

### **Introduction**

To attain good function, the lower limb amputee must strive to achieve a pattern of standing and walking that approaches normality (Murdoch, 1969). His success in this will depend upon effective and pain free transference of body weight through the stump to the socket, as well as upon optimum alignment of the prosthetic limb. Achieving an even distribution

of body weight between the limbs during standing is especially important for the elderly vascular amputee to prevent the deleterious effects of excessive load upon the remaining limb. When interpreting the foot loading pattern of an amputee it is necessary to bear in mind the range of variation in weight distribution between the feet in subjects free from locomotor disorders. This has been determined for a group of predominantly young males (Murray et al, 1975) but not for more elderly subjects.

The positions of the centres of pressure under each individual foot are important determinants of stance. These are henceforth referred to as the individual centres of foot pressure (ICFP). In the "ideal" symmetrical subject the left and right ICFP should be in identical positions within the respective foot outline. The patterns of these individual central foot pressures has not been systematically studied in normal subjects although preliminary data indicates that the ideal situation is true on average (Lord and Smith, 1984). When asymmetry is caused by amputation or deformity the position of the centres of pressure of the feet will be altered with respect to one another according to the type of deformity or the alignment of the prosthesis (Lord and Smith, 1984). The forward shift of one ICFP will then cause a corresponding backward shift of the contralateral ICFP. A straight line joining the two ICFPs will pass through the overall centre of foot pressure (CFP) which bears a close relationship to the vertical projection of the body centre of gravity. The exact location of the CFP along the line is determined by the relative weight distribution between the feet. The present study was undertaken to delineate the characteristic foot pressure patterns associated with different levels of amputation and compare them with foot

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pressure patterns of a control population of similar age and sex free from locomotor disorders.

### Methods

Measurements were carried out using the double video forceplate (DVF), an instrument that was developed at the University College London Bioengineering Centre (Lord and Smith, 1984). The DVF consists of a low platform with separate force plates for each foot, a BBC microcomputer, a video display and a printer. The patients were asked to stand 'normally' on the forceplates with hands by the side and facing forwards for 15 seconds without using any support after which a time-averaged display of foot loading was produced. The video monitor showed the foot outlines and the percentage of body weight borne on either foot. A (+) within each foot outline denoted the ICFPs and a (+) between the foot outlines the CFP. The screen display was printed out to form a permanent record.

### Patients

One hundred consecutively attending patients were studied during their routine visits to the Artificial Limb and Appliance Centre. All patients were wearing their definitive prostheses. Only patients with temporary prostheses and those unable to stand unsupported for 15 seconds were excluded from the study. There were 80 male and 20 female amputees. The mean age of the population was 57 years, with an age range of 10-83 years. More than half the subjects were over the age of 60 years. Fifty-one patients had amputation of the right leg, 44 of the left leg and five both legs. There were 29 above-knee amputees, 56 below-knee amputees (including four bilateral), four through-knee amputees, four Gritti-Stokes amputees, three through-hip amputees and four Symes amputees (including one bilateral). In the above knee groups 10 patients wore endoskeletal limbs and 19 metal limbs. Types of

socket, knee mechanism and prosthetic ankle are shown in Tables 1 and 2. Thirty-three unilateral below-knee amputees and three bilateral below-knee amputees wore patellar tendon bearing prostheses, whilst 19 unilateral below-knee amputees and one bilateral below-knee amputee wore metal limbs with a thigh corset. Three Gritti-Stokes patients and two through-knee amputees wore endoskeletal limbs and the others in these groups wore metal limbs. All three through-hip patients wore endoskeletal type tilting table prostheses. The Symes amputees wore end-bearing prostheses.

Table 2. Types of prosthetic foot and ankle joints in above and below-knee prostheses

	Uniaxial	Multiaxial	Sach
AK	26	2	1
BK (PTB)	29*	6	1
BK (metal)	20**	—	—

\* includes 3 bilateral amputees

\*\* includes 1 bilateral amputee

### Controls

One hundred age and sex matched individuals free from any locomotor disability were selected randomly from members of staff, local clubs and community centres. None of the subjects used any walking aids. The mean age of the control subjects was 56 years. Twelve control subjects stated they were left handed and 88 that they were right handed.

### Analysis

The position of the ICFP within each foot outline was expressed as a percentage of foot length and width (Fig. 1). To make valid comparisons between individuals, data on the anteroposterior locations of the ICFPs were expressed as a percentage of foot length anterior or posterior to the CFP. When the ICFP was anterior to the CFP it was arbitrarily assigned a positive value. A negative value denoted an ICFP posterior to the CFP.

Table 1. Types of socket and knee joint mechanism in above-knee amputees

		Quadrilateral	H	Conventional	Suction TSB	Total
Free knee	Stabilized knee	1	—	—	3	4
	Other	2	7	5	2	16
Locked knee		2	5	2	0	9
Total		5	12	7	5	29



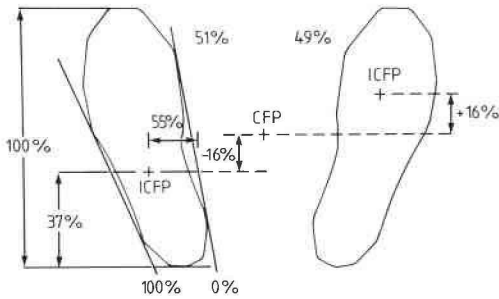


Fig. 1. Calculation of the position of the ICFP within the foot outline and with respect to the CFP.

## Results

### 1. Weight distribution between the feet

For control subjects the average foot loading on the left side was 49% body weight and on the right side 51% body weight. There was no difference in males and females in this respect and no significant difference between right and left handed persons. The average difference in the percentage of body weight borne by the two feet was  $7.5\% \pm 5.8\%$  for the whole group. Females showed a greater range of variation in weight distribution between the feet with a mean difference of 10% of body weight compared with 7% of body weight for male subjects.

For amputee subjects the mean percentage of body weight transmitted through the prosthetic limb was 39.5% for above-knee amputees, 46% for below-knee amputees wearing limbs with thigh corsets, and 45% for PTB prosthesis wearers. Preliminary data on smaller groups of patients with other types of amputations show corresponding values of 40% of body weight for through-hip patients, 46% for through-knee or Gritti-Stokes and 51% for Symes amputees. Four double below-knee amputees bore an average of 43% of body weight on the left leg and 57% on the right leg, and one bilateral Symes amputee had 45% of body weight on the left foot and 55% on the right foot. The ranges of weight distribution under the prosthetic foot are shown in Figure 2 and are compared with that under the left and right feet in normal subjects. For none of the amputee groups was any relationship found between prosthetic weight-bearing and age, sex or time since amputation. Using the students' t-test there was a significant difference ( $p < 0.01$ ) in weight bearing between the above-knee group and the through-knee/Gritti-Stokes group.

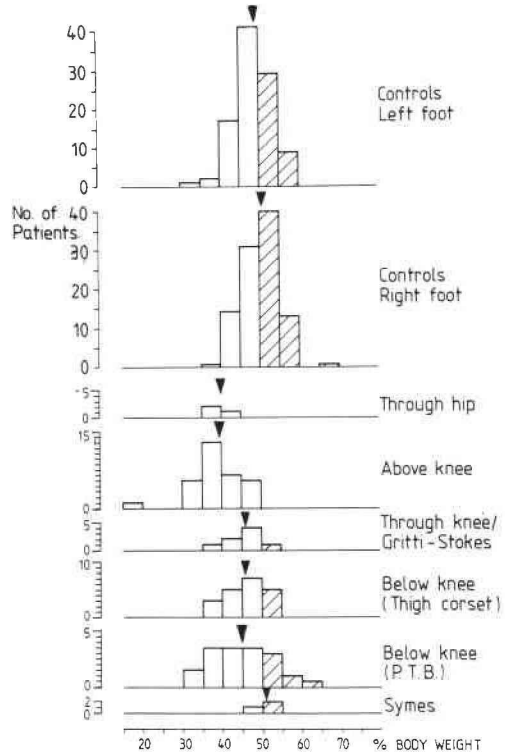


Fig. 2. Percentages of body weight borne on left and right feet in normal subjects and on the prosthetic foot in amputees. Arrows show the mean values.

### 2. Foot pressure patterns

The mean foot pressure pattern for normal subjects is shown in Figure 3 and the antero-posterior distributions of the left and right ICFPs with respect to the CFP in Figure 4. The right ICFP was on average slightly anteriorly placed

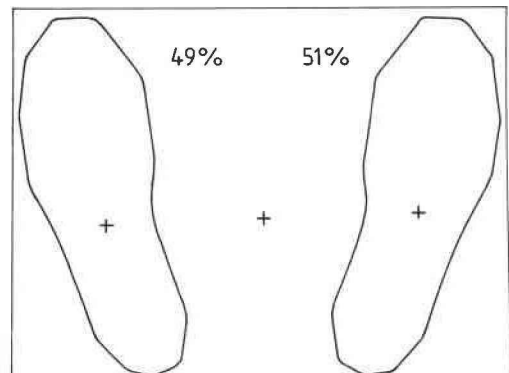


Fig. 3. Mean foot pressure pattern and weight distribution in 100 normal controls (20 female and 80 male).

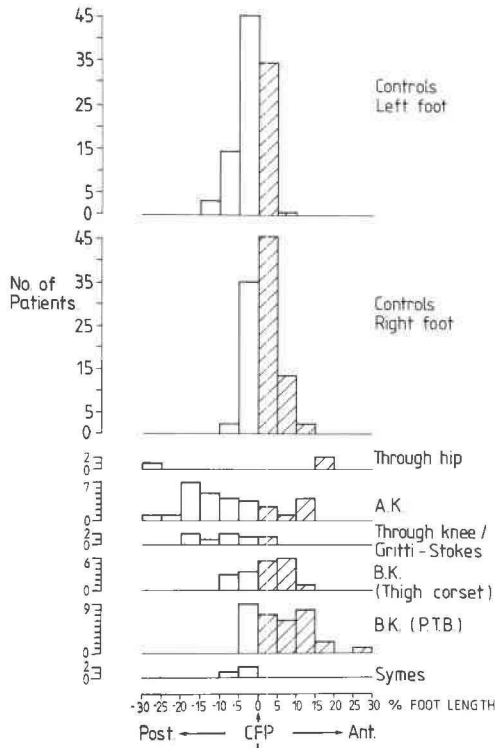


Fig. 4. The anteroposterior distribution of ICFPs in normal subjects and amputees expressed as a percentage of foot length with respect to the CFP position. Anteriorly placed ICFPs are assigned a positive value.

and this tendency was more marked in female subjects. In 80% of subjects a difference in the antero-posterior locations of the ICFPs compared to the CFP was less than or equal to 5% of foot length. The number of left handed persons was too small to detect a significant effect of dominance although left handed subjects appeared more likely to have anterior left ICFPs than right handed persons (56% of subjects versus 33% of subjects respectively). In normal subjects the centres of foot pressure were centrally placed within the foot outline.

The antero-posterior distributions of foot pressure placements in amputee subjects is shown in Figure 4 and the mean positions in Figure 5. In above-knee amputees two types of foot pressure patterns were found. Twenty-one patients had anterior placement of the prosthetic ICFP compared to CFP whilst in seven patients the prosthetic ICFP was posterior. In one patient all the pressures were at the same antero-posterior location. All four patients who

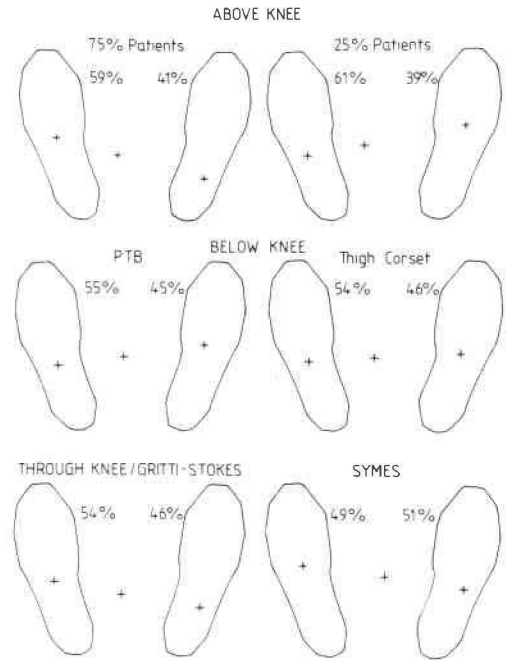


Fig. 5. Mean weight distributions and foot pressure patterns in amputees. For the purpose of illustration the amputee side is shown as the right side.

possessed a stabilized knee had anterior placements of their prosthetic ICFPs. There was no obvious difference in foot pressure patterns between those who walked with free or rigid knee. On average patients with quadrilateral or H sockets produced prosthetic ICFPs that were markedly posterior to the CFP (-12% and -12.4% of foot length respectively). Patients with conventional sockets and total surface bearing suction sockets had an average prosthetic ICFP only slightly posterior to the CFP (-3% and -2% of foot length respectively). Three of the five patients with TSB suction sockets also had stabilized knees. Patients were not formally examined for hip flexion deformities since they were attending a busy outpatient department. However two patients recently recorded as having flexion deformities of 15° had posteriorly placed prosthetic ICFPs whilst one patient with a 5° hip flexion deformity had an anteriorly placed prosthetic ICFP. Of four further patients who were said not to have hip flexion deformities, three had posteriorly placed and one an anteriorly placed ICFP.

The lateral placement of the ICFP within the

foot outline differs between those above-knee amputees who carried their weight predominantly on the anterior part of the foot and those who carried their weight predominantly on the posterior part of the foot. The anteriorly placed prosthetic ICFPs tended to be central within the foot outline and the ICFP on the normal side was then shifted laterally (Fig. 5). When the prosthetic ICFP was posterior it tended to be laterally placed within the foot outline and the corresponding ICFP on the normal side was centrally placed (Fig. 5).

In below-knee amputees wearing PTB limbs the prosthetic ICFP was anterior to the CFP (24 patients) or only slightly posterior (nine patients). The prosthetic ICFP is also more medial within the foot outline than the average position for normal controls (Fig. 5). The foot pressure pattern in below-knee amputees wearing limbs with thigh corsets was more variable. Prosthetic ICFPs were anterior to the CFP in 12 patients, posterior in six and neutral in one. Compared to normal controls the ICFP of the unaffected foot was rather laterally placed within the foot outline (Fig. 5). The type of prosthetic ankle joint did not appear to have an influence on the foot loading pattern. The only consistent abnormality for double below-knee amputees was that all four patients tended to lean forward with a mean CFP of 49% of foot length.

The foot pressure patterns of through-knee and Gritti-Stokes amputees resembled those of the majority of above-knee amputees with six prosthetic ICFPs that were posterior to the CFP, one neutral and one anterior. The prosthetic ICFP tended to be shifted laterally and posteriorly within the foot outline (Fig. 5).

Two of the three through-hip amputees had prosthetic ICFPs that were markedly anterior to the CFP while in the other patient the prosthetic ICFP was markedly posterior.

Each of the three unilateral Symes amputees had prosthetic ICFPs that were shifted slightly posteriorly and laterally compared with normal controls.

### Discussion

This study has indicated the limb loading characteristics of normal subjects and provided the preliminary data on the abnormalities shown by amputees.

For normal controls the variability in weight

distribution between the feet is very similar to that described by Murray and Peterson (1973). The average difference in the percentage of body weight borne by the feet was 7% for men which compares well with Murray's figure of 7.3% for her groups of 21 younger men. It is of interest that women show a greater variability in weight bearing between the feet with an average difference of 10% of body weight. Foot loading was assessed in this study in a clinical setting with a rapid 15 second analysis on the DVF. In the study of Murray and Peterson (1973) subjects underwent a more complicated testing procedure of four separate one minute assessments on a forceplate, with analysis being limited to the last 15 seconds of each test period. The fact that the results of this study compare well with those obtained under more rigorous laboratory conditions tends to confirm the usefulness of the DVF as a clinical tool. Murray and Peterson (1973) also noted no significant differences in the distribution of weights for tests repeated on the same day or on consecutive days. Lord and Smith (1984) have shown that repeated testing of 14 healthy subjects on the DVF produced measurements that varied less than 7%. The authors' repeat tests on a few normal subjects and amputees showed similar reproducibility.

Some reduction in weight bearing on the prosthetic side is to be expected since the weight of the prosthesis is lower than the weight of the amputated limb. Using anthropomorphic data Arsenault and Valiquette (1981) were able to calculate the likely weights of the amputated limbs in ten above-knee and ten below-knee amputees. Using their data, the theoretical foot pressure under the prosthesis during symmetrical standing should amount to 48% of body weight for above-knee amputees and 49% for below-knee amputees. These values would be approximately 1% body weight lower for patients wearing the lighter type of prostheses. A similar calculation reveals a value of between 44% and 46% of body weight for the "ideal" prosthetic foot pressure of a through-hip amputee wearing a light endoskeletal prosthesis. It is clear from this study that the majority of amputees, particularly those with above-knee prostheses do not achieve ideal weight bearing. Lack of confidence in the limb, poor balance and discomfort in the stump might well lead to reduced weight bearing on the prosthetic side. It

has been noted that weight bearing by below-knee amputees on the prosthetic limb increases from 20% of body weight to 50% of body weight during walking training (Stolov et al, 1971). It appears from analysis of the data that age, sex and time since amputation did not influence the percentage of weight carried on the prosthetic limb. None of the patients had had their amputation less than six months before this study and only 9% had their amputations less than one year before the study. It seems likely that weight bearing on the prosthetic limb does not change significantly after the first six months although a prospective study would be needed to confirm this. The average weight bearing by patients with Gritti-Stokes or through-knee amputations was significantly higher than that of above-knee amputees and this is probably accounted for by the partial end-bearing capabilities of these longer stumps.

One of the most immediately apparent features of the foot pressure patterns is the antero-posterior distribution of the ICFPs with respect to each other and with respect to the resultant CFP. Figures 4 and 5 show the considerable overlap of the anterior-posterior distribution of foot pressures between amputees and normal subjects. Only 30% of above-knee amputee patients, 5% of below-knee, 25% of through-knee or Gritti-Stokes and all the through-hip amputations could be recognised as definitely abnormal on the basis of their foot pressure patterns alone. The above-knee amputees appeared to fall into two groups—those with prosthetic ICFPs which were anterior to the CFP (25% of patients) and those whose prosthetic ICFPs were posterior to the CFP (75% of patients). Anteriorly placed ICFPs representing the ground reaction force predominantly under the front of the foot tended to be associated with stabilized knee joints and total surface bearing or conventional sockets. Quadrilateral and H sockets were more often associated with markedly posterior prosthetic ICFPs. All above-knee prostheses are ischially seated although this may be relatively less important in patients with total surface bearing or conventional sockets. The presence or absence of flexion deformities at the hip did not appear to influence the foot pressure pattern, although this was not formally studied. It seems likely that many above-knee amputees would have at least minor degrees of hip flexion

deformity, although this may well be compensated for by the socket alignment and thus not be obvious in the foot pressure pattern.

The type of knee joint may have a major influence on the foot pressure pattern. All patients in this study with stabilized knees had anteriorly placed foot pressures on their prosthetic side reflecting the fact that these types of knee joints are aligned in several degrees of flexion. It was a little surprising that patients who walked with a free knee did not have more anteriorly placed foot pressures than those patients who walked with rigid knees in view of the necessity for maintaining a load-line anterior to the prosthetic knee to achieve stability during standing. It is likely however that the degree of plantar flexion of the prosthetic foot is important and it is possible that a relatively large degree of plantar flexion was responsible for some of the anterior foot pressures in both free and rigid knee walkers.

Below-knee amputees wearing PTB sockets has prosthetic ICFPs that were anterior or only slightly posterior to the CFP reflecting the anterior placement of load at the knee and the setting of the PTB socket in flexion. The distribution of foot pressures in patients wearing limbs with thigh corsets was more variable with a significant proportion of posteriorly placed ICFPs. This is probably because this type of prosthesis allows full extension of the knee in the stance phase.

The pattern of foot pressures for through-knee and Gritti-Stokes amputees resembled that of above-knee amputees with predominantly posterior ICFPs on the prosthetic side reflecting the ischial seating of the limbs. All patients with the Symes prosthesis had the expected posteriorly placed ICFPs on the prosthetic side.

The divergent foot pressure patterns produced by three patients with hip disarticulation prostheses cannot be accurately interpreted, although it is likely that the alignment of the prosthetic limb has a major influence on the prosthetic ICFP position.

The authors feel that rapid analysis of weight distribution between the feet and foot pressure patterns using the DVF may be useful in the clinical situation. Preliminary observations concerning the influence of socket type, knee mechanism and type of prosthetic ankle joint on foot pressure patterns need to be confirmed by a larger study. Having identified the average

patterns for different levels of amputation and different types of prosthesis such measurements may help in the analysis of alignment problems and allow rapid documentation of the effects of alteration or adjustments to the limbs. It appears that the lateral placement of the ICFP within the foot outline is a particularly sensitive indicator of malalignment.

During walking training in the early post-operative phase, serial assessment of the amputees' foot pressure patterns can provide an objective measure of improvement and may well act as a source of encouragement for the patient (unpublished data).

The DVF is also a live interactive device and the patient can monitor his weight bearing and foot pressure patterns by watching the screen. This form of external proprioception or biofeedback may be used by patient and therapist during rehabilitation to enable the patient to achieve symmetrical standing and increase confidence in putting weight through the prosthetic limb in a controlled fashion.

The DVF may also have a role in the clinical teaching of doctors, therapists and prosthetists enabling them to gain an understanding of prosthetic design, alignment and fitting by visualisation of the ground reaction force.

#### Acknowledgements

The authors would like to thank Dr. M. Lord and Mr. D. M. Smith, UCL Bioengineering

Centre for their help and advice regarding the double video forceplate. They are grateful to Mr. D. Deacon, Manager of Vessa Limited and Mr. A. Butcher, Manager of Hanger Ltd at the Oxford Artificial Limb and Appliance Centre for their kind co-operation throughout this study.

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## Technical note

# A multipurpose orthosis for paralysed children

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### Abstract

A severely paralysed child whose trunk as well as both lower limbs is affected needs an aid for the basic needs of sitting, standing and other activities of daily living. Often a number of aids such as standing table, adapted chairs, commode etc., is required to meet basic needs. Special equipment has been designed for this multipurpose use, which does not occupy much space in a house and is portable. This equipment enables the parents to manage the handicapped child at home.

### Introduction

The child who has both lower limbs paralysed undergoes intensive rehabilitation training for his potential sitting, standing, ambulation and other activities. Children with spinal cord injuries, progressive conditions such as myopathy etc. are being given rehabilitation training and treatment in specialized centres, where equipment such as standing tables, special chairs, walkers, inclined tables etc. are available. As soon as the child leaves the rehabilitation centre, the parents often find it very difficult to have this equipment at home to continue the management of their child.

Often either the parents are not able to continue the rehabilitation training of their child in the specialized centre due to socio-economic factors, or the rehabilitation centres may not be able to keep the patient for long due to the demand for places.

Whatever the situation, the rehabilitation process should be completed. In such circumstances the multipurpose orthosis described here provides an answer.

### Salient features

The device can be easily operated by a family member. One can make the child comfortable in

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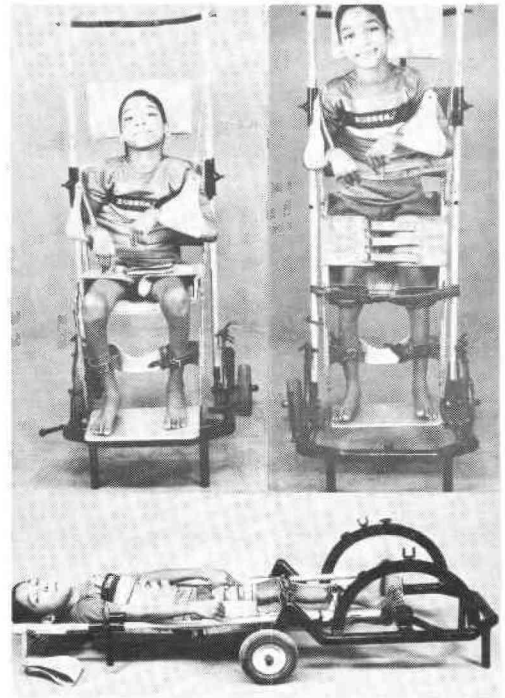


Fig. 1. The multipurpose orthosis is easily adjusted for any desired position.

the desired position such as sitting (Fig. 1, top left), standing (Fig. 1, top right), or lying supine (Fig. 1, bottom), without shifting or lifting the child. Provision has also been made for toilet activities.

### The multipurpose orthosis

The device has two wheels, so that the attendant can easily move the equipment with the patient. The over-head sling is provided to support the paralysed deltoid, to facilitate upper arm exercises and activities. The lap board (detachable) can be fixed to undertake writing, reading or any other work which has to be done at the level of the chest (Fig. 2, left).

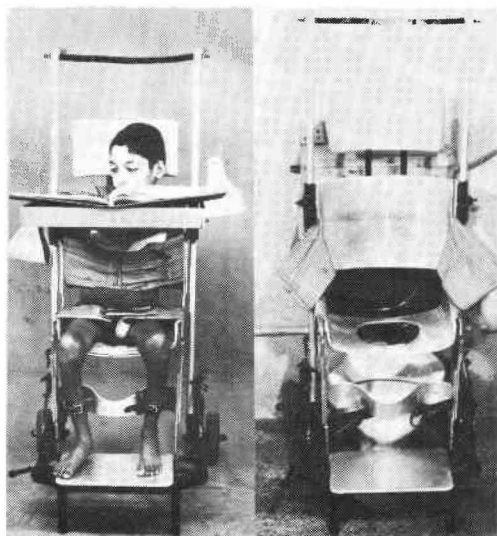


Fig. 2. Left, the detachable lap board. Right, fitted commode.

Appropriate straps are provided to support the trunk and lower extremities, and an adjustable head support is also provided at the back. If one needs to have graded, inclined sitting/standing positions in the early stages of bringing the patient to the standing position, this can be done without extra effort.

#### Design details

The base which is "U" shaped is made of 45 mm diameter G.I. tube and has two 150 mm diameter castor wheels at the back. The centre width of the base can accommodate a pedestal type commode (Fig. 2, right).

A moveable 20 mm diameter G. I. tube frame (length 1500 mm, width 380 mm) is fitted on the middle arm of the "U" base. Two semicircular 40 mm width 6 mm thick mild steel plates are welded either side of the base to guide the frame. Locking clamps are also welded on the semicircular flat.

Adjustable monobar orthoses made of high strength aluminium alloy with joint units at ankle, knee and hip are inter connected by 12 mm width 3 mm thick mild steel flat bars; 3 mm thick aluminium sheet is placed to serve as a backrest and a seat. The seat is perforated with an oval shaped hole at the centre for toilet activities.

The frame is fitted with two 25 mm diameter, 125 mm G. I. tubes having handles at both sides which are moveable in both upward and downward directions to the stopper provided at the sitting position. These are inserted on both sides of the frame. Locking stoppers for stability are provided to lock the frame in the standing position so that the child with involuntary body movements can also safely use it. A single piece curved calf band and resting stirrups are provided at the foot region of the frame, along with a leg shifting lever.

Appropriately positioned straps are provided to support the trunk and the lower extremities. For the weight and height of the patients for which this multipurpose orthosis is designed the centre of gravity will fall within the base for all possible positions of the patient. For patients of greater weight and height the base can be modified by providing a telescopic arrangement in the base tubes.

#### Durability and maintenance

The frame has been designed to withstand static and dynamic loads of 80 kg. The frame has to be painted once a year to resist corrosion. Periodic lubrication must be applied to the moveable parts. This frame is in use in the National Institute of Rehabilitation Training and Research. The doctors, engineers, prosthetists, physiotherapists and occupational therapists of the Institution consider this equipment to be an excellent indigenous adapted device for the handicapped. The frame is an improved design based on an earlier version designed and described by Balakrishnan (1978).

#### Acknowledgements

The author is thankful to Shri. A. Balakrishnan, Director NIRTAR for his encouragement and suggestions. Shri. M. M. Sangoi Asst. Professor for his assistance in preparing this paper and to Shri. Gangasagar Chaudhary, Prosthetic and Orthotic Technician ALIMCO-Kanpur and Shri. Sahadev Moharana who fabricated this device.

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## Technical note

### New splinting materials

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#### Abstract

Plaster of Paris (P.o.P.) bandage has been the pre-eminent external splinting material for over 150 years and from time to time synthetic alternatives have been tried. So far none has seriously challenged the dominance of P.o.P. as a primary or secondary material in the management of fractures. The recent introduction of Polyurethane coated fibreglass bandage appears to offer a more serious challenge than previous contenders. This technical note reviews bandage type splinting materials and explains some of the properties of the PU materials.

#### Background

Over the past few years, there has been an increase in the number of splinting materials available. Plaster of Paris (P.o.P.) which is still the most popular splinting material, has a long history stretching back to early times in India and Arabia. It was first used in the form of an impregnated cotton bandage by Mathijsen in 1854. P.o.P. combines ease of application and conformability with rapid setting time. It is also very cheap.

In spite of its popularity P.o.P. bandage is not the ideal splinting material. It has a poor strength-to-weight ratio, and a rapid loss of strength when brought into contact with water. Owing to its capacity to absorb and scatter X-rays, P.o.P. can adversely affect the definition of radiographs. It is messy in application and a mobile patient will have to use crutches for two days until the cast is cured before it can be fully

weight bearing. Despite this, the cast may break down when subjected to full weight bearing.

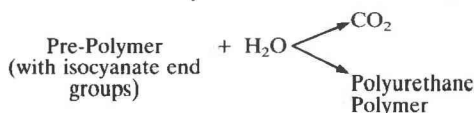
To overcome the obvious disadvantages of P.o.P. bandages, numerous attempts have been made to impregnate various fabric bandages with polymeric solutions. Combination casts have been tried using an outer layer of a rapidly curing synthetic bandage, for example, \*Crystona or Deltacast around P.o.P. cast. The philosophy of this approach is to combine the unrivalled moulding properties of P.o.P. with the stronger, faster curing, more water resistant, resin coated bandages. This should mean a saving on the more expensive resin coated bandages. The authors' experience with the P.o.P./Crystona combination is that it offers no advantage in terms of durability for weight bearing casts. Furthermore it does not allow earlier weight bearing than for P.o.P. alone, because body weight forces are transmitted through the single layer of Crystona to the uncured P.o.P., resulting in breakdown of the P.o.P.

#### Polyurethane coated bandages

##### (a) Description

There is currently available a range of knitted fabrics (cotton, polyester, or more commonly fibreglass) coated with a moisture curing polyurethane pre-polymer which hardens after immersion in water. When correctly wrapped they produce a strong, durable cast that is weight bearing within thirty minutes.

The basic chemistry is:



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\*Trade names



The isocyanate end groups may react with any molecule containing an active hydrogen.

These polyurethane (PU) coated bandages derive a large proportion of their strength from the fibreglass substrates. Typical proportions of fibreglass to resin would be 55% fibreglass and 45% PU resin. The fibreglass substrate typically has a mesh size of forty five openings per square centimetre and a thickness of 0.75mm (Fig. 1).

(b) *Cast application and removal*

The technique of applying PU coated fabric bandages is similar to P.O.P. bandages. However the manufacturers instructions should be closely adhered to in all circumstances.

Casts can be removed using plaster shears or a plaster saw. Bivalving is usually necessary.

(c) *Mechanical properties*

In general PU coated fabrics are much stronger and tougher than plaster based materials. They are more hard wearing and have a greater fatigue strength. Their strength-to-

weight ratio is higher than plaster based materials and the incidence of cast breakdown is greatly reduced. PU coated bandages regain most of their strength after immersion in water.

This will mean that casts should need replacement for clinical reasons only, for example, remanipulation or reduction of swelling, and therefore minimize the potential risk associated with frequent cast changes.

(d) *Radiolucency*

Plaster of Paris absorbs and scatters X-rays due to its crystalline structure and the thickness of the cast. This means that the fine detail of bone structure is obscured. The current range of PU coated bandages are radiolucent due to their lower density and amorphous structure. Furthermore, fewer layers are required in cast construction. This results in sharper definition of the bony structures. Some of the fibreglass weaves may provide a distracting pattern when viewing the films closely.

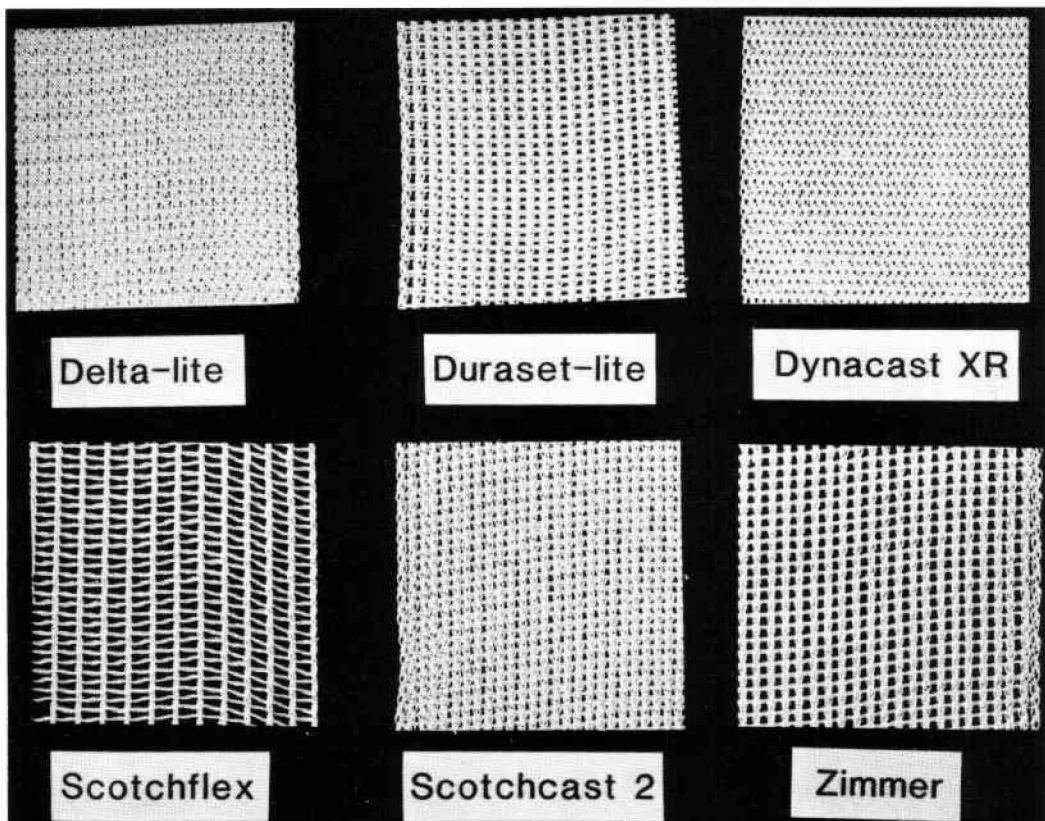


Fig. 1. Examples of polyurethane impregnated fibreglass bandages.

(e) *Potential hazards*

Some of the potential hazards associated with the current range of PU coated bandages are listed below:

(i) *Chemical*

The Polyurethane resin coated bandages described in this article are made from methylene bisphenyl di-isocyanate (MDI). This substance might present an inhalation toxicity hazard before it is exposed to moisture. Upon exposure to moisture the MDI is converted to a non-toxic, non-volatile polymeric urea substance. Free isocyanates, however, represent a small proportion of the pre-polymer element of the uncured bandage and are unlikely to be a skin or inhalation hazard to the patient or the applicator. The applicator is advised to use gloves or barrier creams to prevent the resin sticking to the hands.

(ii) *Flammability*

All polyurethane resins burn easily. When coated on a fibreglass bandage and wrapped to form a cast the ability of the bandage to burn may be modified by one or more of the following factors:

- (a) Uneven distribution of resin on the fabric.
- (b) Number of layers of bandage in the cast.
- (c) Rucking of the bandage in the cast.
- (d) "Heat sink" effect of the fibreglass substrate resulting in a reduced local temperature.
- (e) The angle of the incident flame to the cast.

In practice the rate of heat transfer through the cast is such that the patient would be aware of the raised temperature before the cast had ignited.

(iii) *Toxic gas emission*

During the partial combustion of

Table 1. Comparison of currently available bandages for splinting

Below-knee casts				
Type of bandage	Product name	No. of rolls (10cm. wide)	Average weight of cast (g)	Average cost of cast
100% Knitted fibreglass impregnated with polyurethane resin	Dynacast XR Scotchcast 2 Deltalite Dureset-lite Zimmer Scotchflex	3	580	£17.85
Knitted polyester impregnated with polyurethane resin	Dynacast	3	735	£20.10
Knitted cotton impregnated with polyurethane resin	Deltacast (Baycast)	6-8	338-434	£12.00-£16.00
Cotton mesh impregnated with a thermoplastic polyester	Hexcelite	3	515	£12.60
Aluminosilicate glass and polyacrylic acid polymer on a cotton bandage	Crystona	6	1124	£16.74
Plaster of Paris on Leno weave cotton bandage	Gypsona	8	1183	£2.32

polyurethane resins, hydrogen cyanide, carbon monoxide and oxides of isocyanates may be produced. The quantity of the gases released from a PU coated bandage when ignited is likely to be insignificant and would only prove to be a hazard if released in an unventilated, confined space. Under these circumstances carbon monoxide is likely to present the most serious problem.

(iv) *Dust generation*

Entrapment of airborne dusts in the lungs could represent a respiratory hazard leading to fibrosis. Particles of up to  $5\mu$  may be deposited in the alveolar passages (respirable dust) while larger particles retained in the mucous membranes of the respiratory tract are eliminated by means of the lung clearance mechanism.

Airborne dust generation during cast removal with a power saw could represent a respiratory hazard if the concentration of total dust exceeds a threshold limit value (TLV) of  $10\text{mg}/\text{m}^3$  or if the respirable fraction exceeds a TLV of  $5\text{mg}/\text{m}^3$ .

Plaster of Paris is classified as a nuisance dust by the Health and Safety Executive, however, it is anticipated that dust generation from knitted fibreglass fabric coated with PU resin would be less severe.

The majority of particles are larger than P.O.P. since they contain bandage and resin combined and are, therefore, less mobile. A particle size of less than five microns ( $5\mu$ ) could cause respiratory problems.

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## Letters to the Editor

Dear Sir,

Re: Angliss V.E. "Holte revisited — a review of the quality of prosthetic treatment"  
Prosthetics and Orthotics International, Vol 10, No 1, April 1986

The Australian Orthotic Prosthetic Association whilst agreeing in principle to the thrust and recommendations of the article, consider that some inaccuracies need to be addressed.

Primarily our association expresses concern that the article was published with no reference to the date of writing nor the date of the survey upon which the article was based. To our knowledge the survey was conducted in early 1983. The results as published are therefore over 3 years out of date.

The AOPA believes that given the progressive development in many aspects of Prosthetics and Orthotics in Australia the article is quite out of context.

More specifically our association holds in contention comment made in Method and Results, Section 3, Paragraph 2:—

*"Largely due to employment of inexperienced staff and lack of adequate monitoring this evaluation has not been completed . . ."*

This appears to be an unsubstantiated personal comment. In actual fact both of the pilot Prosthetic and Orthotic units to which the author is referring, were reviewed, evaluated and favourably reported upon to the Health Commission within 18 to 24 months of each units establishment. The staff of these pilot units constantly worked towards 'Holte type' goals and their results reported on several occasions (1) (3) (4).

Further corrections in section 3 of Methods and Results should be noted. The author reports 20 Prosthetic and Orthotic diplomates being employed. To our knowledge 27 were employed in 1985 (2) and currently in 1986 there are some 35 graduates employed in Victoria which is in line with Holte recommendations, although not all are employed in clinical or production settings (e.g. some are involved with education, administration and research.)

Here in 1986 several hospitals and most private facilities employ technicians. A Prosthetic and Orthotic technicians course is currently under consideration in Victoria. The establishment of further Prosthetic and Orthotic units (at least three to date), employment of more graduates and use of technicians are not reported in the article.

This quiet revolution in Prosthetics and Orthotics over the last few years has, however, evolved on an ad-hoc within individual hospital basis, often without health commission financial support. The AOPA agree with the author that government commitment with policy and guidelines and also a community education programme in regard to Prosthetic and Orthotic needs to be implemented.

(1) Hurley Dr. J., Bauer D. Queen Elizabeth Geriatric Centre Ballarat — What is the value of a Prosthetist/Orthotist to a hospital based rehabilitation team?

Community Needs in Prosthetics and Orthotics: Notes abstracts and short papers from a National Seminar held on August 24 and 25 1984. (Lincoln Institute.)

(2) Radford D. Where have all the Graduates gone? AOPA Magazine Vol. 1 No. 1 February 1986.

(3) Twist Dr. E. Caulfield Hospital — What is the value of a Prosthetist/Orthotist to a hospital based rehabilitation team?

Community Needs in Prosthetics and Orthotics: Lincoln Institute, Notes, abstracts and short papers from a National Seminar held on August 24 and 25 1984.

(4) Woolley D. Role of the Prosthetist and Orthotist in Australia.

AOPA Magazine Vol. 1 No. 1 February 1986.

Yours sincerely,

Damian P. Wooley.  
Australian Orthotic Prosthetic Association,  
P.O. Box 2305V, Melbourne,  
Victoria 3001, Australia.

**Editor's Note:** *The above paper was submitted for publication in March, 1985.*

Sirs,

Following the issue of *Prosthetics and Orthotics International* Vol. 10 No. 1, April, 1986, in which my article appeared, I was approached by members of the Australian Orthotic Prosthetic Association (AOPA) who criticized points made regarding the quality of Prosthetic-Orthotic services in the State of Victoria.

In reply I suggested that an appropriate setting for discussion would be in *Prosthetics and Orthotics International*. I explained that the article emanated from a paper delivered at the 4th ISPO World Congress in 1983, at which time the information was valid.

Facts and figures were supplied by the Health Commission in each State and from personnel in Prosthetics Pilot studies in a rural and urban hospital in the State of Victoria.

Although P/O practice in Australia has developed since the time of presenting the paper (1983), it would be of interest if the Honorary Secretary of AOPA would provide specific comment on the progress made in overcoming any differences (facts) recorded in this article.

It is considered that such discussion through the Journal would provide a stimulus to the Prosthetic/orthotic service generally.

Yours sincerely,

Valma Angliss  
Therapist, Central Development Unit  
Prosthetics and Orthotics  
Yarra Boulevard,  
Kew, 3101, Victoria,  
Australia

Dear Sir,

World Orthopaedic Concern (UK) is hoping to produce a small handbook on varieties of simple appropriate techniques which can be used in the Third World, based on the experience and financial confines of those working in these restricted health services. It is felt that there must be a number of simple orthopaedic procedures and instrument improvisations which have proved useful in these conditions, but which may be unknown to others working elsewhere in the Third World. WOC hope to be able to collate these into a small paper-back and is looking for suitable material. Anyone who has experience in the Third World and has an orthopaedic, prosthetic or orthotic "wrinkle" which they feel could be used in such a book, please send it to me at the address below.

Yours faithfully

J. N. Wilson, ChM FRCS  
World Orthopaedic Concern  
The Chequers  
Waterdell  
Nr Watford  
Herts WD2 7LP

## Book Review

### **Physical Therapy Management of Lower Extremity Amputations.**

**Gertrude Mensch and Patricia Ellis.**

**Published by Aspen Publications Inc.**

**375pp, \$35.**

Amputee care and rehabilitation form a relatively small part of modern medical treatment. However it is a major problem for those unfortunate enough to require it. It is for this reason that a publication regarding the subject is more than welcome. Gertrude Mensch and Patricia Ellis have recognised a need and produced a publication of considerable value. The fact that they have set themselves this task is refreshing.

The presentation is unique, the editing excellent and the illustrations apt. Much research has gone into the publication and although bibliographic quotes are extensive, personal views are expressed on all subject matter.

The authors do not hesitate to comment on related professional activities and this must indicate a closely integrated caring team, the essence of good amputee care. Further, this makes the volume very acceptable to all professionals involved and the views of physical therapists must be considered and related to one's personal views regardless of discipline.

The publication is an excellent addition to those already in print and forms a very firm basis for continuing education in amputee care, particularly in the field of physical therapy.

It is hoped that not only therapists but doctors, nurses, prosthetists and engineers involved in amputee care, read and refer to this publication. In my view they will expand their personal knowledge and improve the integration of their own professional activities within the caring team to the benefit of our common interest, the patient.

I. M. Troup,  
Dundee.

### **For Immediate Release**

"Manual Wheelchairs — a guide" is the title of a guide recently issued by the ICTA Information Centre. It is the result of a project carried out by the ICTA Information Centre with different specialists involved.

The guide is mainly intended for wheelchair users and relatives and friends of people using manually propelled wheelchairs.

It describes various types of manual wheelchairs — with rearwheel versus frontwheel drive, fixed versus folding frame, wheelchairs for children as well as accessories. A chapter on wheelchair practice gives examples of how to transfer to and from the wheelchair, how to drive a wheelchair including examples of how to manage obstacles like thresholds, kerbs and stairs.

Useful advice is given on the maintenance of different parts of the wheelchair. Another chapter explains how high-quality functional wheelchairs can be produced in any country — not only in industrialized countries but also in countries in the Third World where resources are scarce and wheelchairs must be of a sturdy construction in order to withstand the stress of being manoeuvred over rough terrain.

Advice is given on what to think of when starting up a Third World wheelchair business. It also gives hints on how to adapt a home to make it more accessible for wheelchair users.

The guide contains 44 pages and the text is richly illustrated with drawings, photos and tables.

The guide is available at the price of SEK 45 from:

**ICTA Information Centre, Box 303  
S-161 26 BROMMA, Sweden**

*P.S. ICTA members will receive one copy of the publication free of charge upon written request to the ICTA Information Centre.*

## Calendar of events

### **3-5 June, 1987**

3rd Canadian Congress on Rehabilitation, Quebec, Canada.

Information: Secretariat, Canadian Rehabilitation Council for the Disabled, One Yonge Street, Suite 2110, Toronto, Ontario M5E 1E5, Canada.

### **4-6 June, 1987**

Annual Meeting of the Association of Children's Prosthetic Orthotic Clinics, Vancouver, British Columbia.

Information: Sidney Fishman M.D., c/o NYU PGMS, 317 E.34th St., New York, New York 10016, U.S.A.

### **5-7 June, 1987**

4th International Independent Living and Polio Conference, St Louis, Missouri.

Information: Rehabilitation International, 432 Park Avenue South, New York, New York 10016, U.S.A.

### **9-12 June, 1987**

13th Canadian Medical and Biological Engineering Conference, Nova Scotia, Canada.

Information: CMBEC-13-CCGB Secretariat, c/o The Nova Scotia Association of Health Organisations, 5614 Fenwick Street, Halifax, Nova Scotia B3H 9Z9, Canada.

### **9-13 June, 1987**

Canadian Physiotherapy Association Congress, New Brunswick, Canada.

Information: Nora Scanlon, Canadian Physiotherapy Association, 44 Eglinton Avenue West, Suite 201, Toronto, Ontario M4R 1A1, Canada.

### **12-14 June, 1987**

Rehabilitation International Assembly Meeting, Helsinki, Finland.

Information: Rehabilitation International, 432 Park Avenue South, New York, New York 10016, U.S.A.

### **12-14 June, 1987**

4th International Conference on Biomedical Engineering, Singapore.

Information: 4th Biomed., Faculty of Engineering, National University of Singapore, Kent Ridge, Singapore 0511, Republic of Singapore.

### **14-17 June, 1987**

Biomechanics symposium, Cincinnati, Ohio.

Information: Dr. David Butler, Dept. of Aeronautic Engineering and Engineering Mechanics, University of Cincinnati, Cincinnati, Ohio 45221-070, U.S.A.

### **14-17 June, 1987**

2nd International Congress on Back Pain, Hong Kong.

Information: Congress Team International, 30 Deane Way, Ruislip, Middlesex HA4 8SX, England.

### **14-20 June, 1987**

11th Congress of European League against Rheumatism, Athens, Greece.

Information: Prof. G. Fostiropoulos, 57 Ipsilanti St., 11521 Athinai, Greece.

**19–23 June, 1987**

10th Annual Conference on Rehabilitation Technology, San Jose, California.

Information: RESNA, Suite 700, 1101 Connecticut Avenue NW, Washington, DC 20036, U.S.A.

**20–24 June, 1987**

6th World Symposia of International Federation of Adapted Physical Activity, Brisbane, Australia.

Information: Jean Claude de Potter Ph.D., Secretary General, Universite Libre de Bruxelles, Institut Superier d'Education Physique, Avenue Paul Heger 28, 1050 Brussels, Belgium.

**24–27 June, 1987**

10th Interbor World Congress, Barcelona, Spain.

Information: BRP—Barcelona Relaciones Públicas, C/. Pau Clarís, n.º 138, 7.º 4.ª, 08009 Barcelona, Spain.

**25–28 June, 1987**

North American Spine Society Annual Meeting, Banff, Canada.

Information: A. H. White, NASS Program Chairman, 2225 Prospect, Suite 127, Park Ridge, Illinois 60068, U.S.A.

**28 June–2 July, 1987**

American Physical Therapy Association Annual Meeting, San Antonio, Texas.

Information: American Physical Therapy Association, 1111 N. Fairfax Street, Alexandria, VA 22314, U.S.A.

**29 June–3 July, 1987**

11th International Congress of Biomechanics, Amsterdam, Netherlands.

Information: Congress Secretariat, 11th International Congress of Biomechanics, Interfaculty of Physical Education, Free University, PO Box 7161, 1007 MC Amsterdam, The Netherlands.

**5–8 July, 1987**

3rd International Consultation on Counselling Disabled People and their Families, Vienna, Austria.

Information: Allgerneine Unfallversicherungsanstalt, Kongressburo, Adalbert—Stifter—Strasse 65, A-1200 Vienna, Austria.

**26–31 July, 1987**

International Symposium on Disability Education, Jerusalem, Israel.

Information: Secretariat—Disability Education, Peltours Ltd.—Conventions, P.O. Box 394, Tel. Aviv 61003, Israel.

**2–7 August, 1987**

5th World Congress on Pain, Hamburg, FRG.

Information: 5th World Congress on Pain, c/o Hamburg Messe und Congress GmbH Congress Organization, Postfach 30 24 80, 2000 Hamburg 36, FRG.

**7–13 August, 1987**

15th International Conference on Medical and Biological Engineering and 8th International Conference on Medical Physics, San Antonio, Texas.

Information: Mr J. A. Hopps, IFMBE Secretariat, c/o National Research Council of Canada, Room 164 Building M50, Ottawa, Ontario K1A 0R8, Canada.



**16-21 August, 1987**

SICOT '87, Munich, West Germany.

Information: SICOT-Secretariat, Frau Renate Berger, Postfach 60, D-8501 Schwarzenbruck, Nürnberg, West Germany.

**31 August-1 September, 1987**

Inaugural Meeting of the International Society for Fracture Repair, Helsinki, Finland.

Information: International Society of Fracture Repair Meeting 1987, c/o Kreab Congrex AB., Box 5619, S-11486 Stockholm, Sweden.

**6-10 September, 1987**

International Seminar on Prosthetics and Orthotics, Herzliya, Israel.

Information: Secretariat ISPO 1987, PO Box 50006, Tel Aviv 61500, Israel.

**9-11 September, 1987**

6th Annual Advance Course in Lower Extremity Amputation and Prosthetics, New York, U.S.A.

Information: Daniel Shapiro M.D., Nassau County Medical Center, East Meadow, New York 11554, U.S.A.

**16-17 September, 1987**

Biomechanics in Sport, Leeds, England.

Information: Paul Wright, Conference Dept. C3409, The Institute of Mechanical Engineers, 1 Birdcage Walk, Westminster, London SW1H 9JJ, England.

**16-18 September, 1987**

11th American Society of Biomechanics Annual Meeting, Davis, California.

Information: R. Bruce Martin, Secretary/Treasurer, University of California, Davis, CA 95616, U.S.A.

**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, U.S.A.

**1-3 October, 1987**

Multidisciplinary International Meeting on Care of Babies Hips, Belgrade, Yugoslavia.

Information: Meeting on Care of Babies Hips, SAVA Centre, PO Box 1, 11070 Belgrade, Yugoslavia.

**3-8 October, 1987**

Western Orthopaedic Association, Colorado Springs, CO.

Information: 2975 Treat Blva,-E5, Concord 94518, U.S.A.

**7-9 October, 1987**

International Meeting of Rehabilitation Centres for the Physically Handicapped, Madrid, Spain.

Information: Secretariat, Fundacion Mapbre, International Meeting of Rehabilitation Centres for the Physically Handicapped, Apartado de Correos 36.237, Madrid, Spain.

**7-9 October, 1987**

3rd International Symposium on Biomedical Engineering, Madrid, Spain.

Information: 3rd International Symposium on Biomedical Engineering, Lab. de Bioingeniería, Clínica Puerta de Hierro, c/ San Martín de Porres 4, 28035 Madrid, Spain.

**7-10 October, 1987**

American Academy of Cerebral Palsy and Development Medicine Annual Meeting, Boston, U.S.A.  
Information: AACPDM, PO Box 11083, Richmond, VA 23230, U.S.A.

**28-30 October, 1987**

2nd Protech International Congress, Groningen, Netherlands.  
Information: Dept. of Rehabilitation, University Hospital, Oostersingel 59, 9713 E Z Groningen, Netherlands.

**1988****4-9 February, 1988**

American Academy of Orthopaedic Surgeons Annual Meeting, Atlanta, Georgia.  
Information: AAOS, 222 South Prospect, Park Ridge, IL 60068, U.S.A.

**18-20 April, 1988**

ISPO UK Scientific Meeting, Bath, England.  
Information: Dr R. G. S. Platts, Institute of Orthopaedics, Brockley Hill, Stanmore, Middlesex HA7 4LP, England.

**May, 1988**

Quadrennial Congress of the International Federation of Physical Medicine and Rehabilitation, Toronto, Canada.  
Information: Dr John M. Melvin, 1000 N 92 St., Milwaukee, Wisconsin 53226, U.S.A.

**5-8 May, 1988**

Pediatric Orthopaedic Society of North America, Colorado Springs, Colorado.  
Information: AAOS, 222 South Prospect, Park Ridge, IL 60068, U.S.A.

**June, 1988**

Congress of the World Federation of Occupational Therapists, Australia.  
Information: Ms. S. Degilio, Plaistow Hospital, Samson St., London E13, U.K.

**June, 1988**

3rd European Conference on Research in Rehabilitation, Rotterdam, The Netherlands.  
Information: Office for Post Graduate Medical Education, Erasmus University Rotterdam, PO Box 1738, 3000 DR Rotterdam, The Netherlands.

**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, Higashi, Ikebukuro, Toshima-ku, Tokyo 170, Japan.

**12-16 September, 1988**

Dundee '88 — International Conference on Wheelchairs and Special Seating, Dundee, Scotland.  
Information: Dundee '88 Secretariat, c/o Dundee Limb Fitting Centre, 133 Queen Street, Broughty Ferry, Dundee DD5 1AG, Scotland.

**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, U.S.A.

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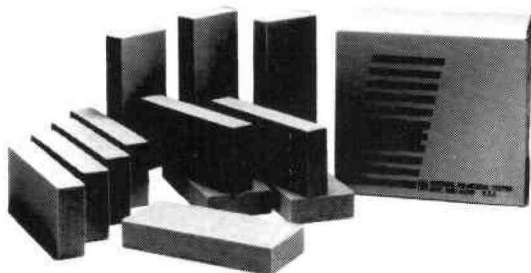
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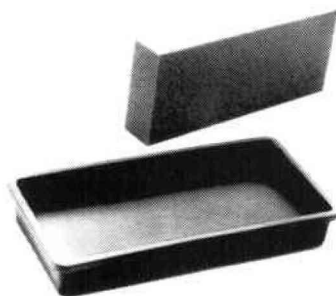
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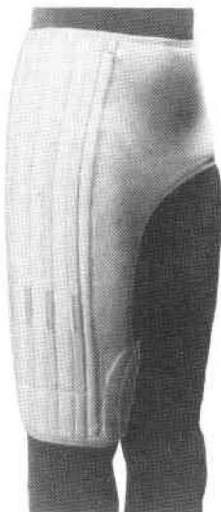
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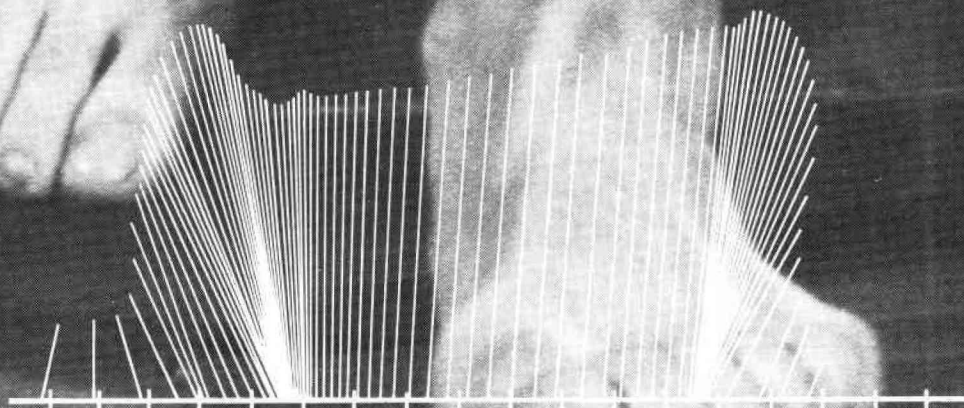
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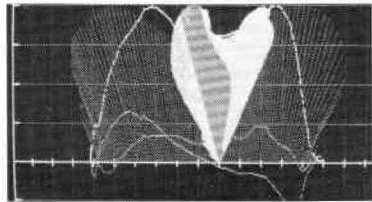
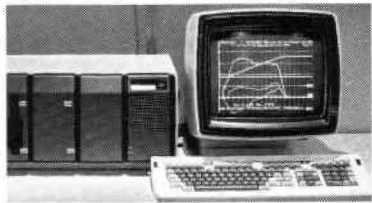
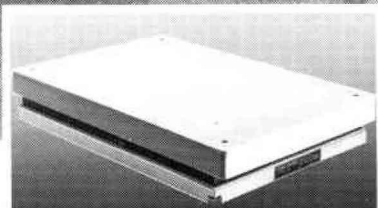
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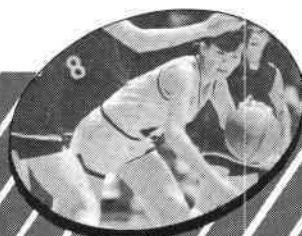
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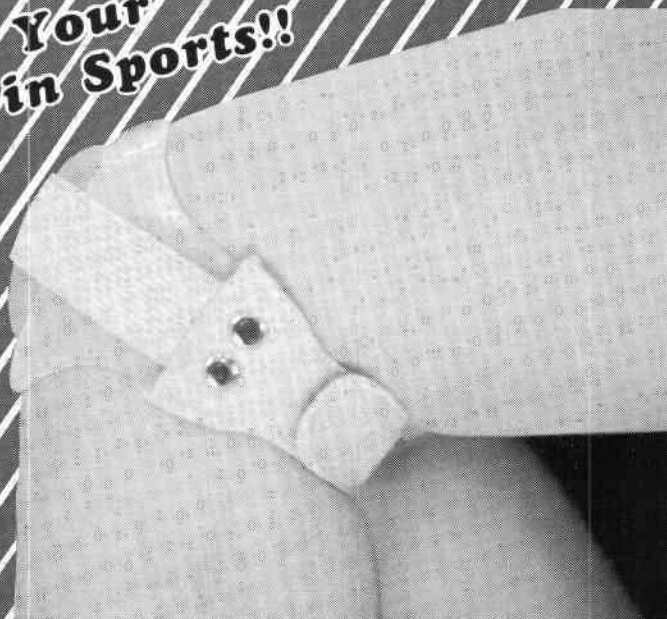
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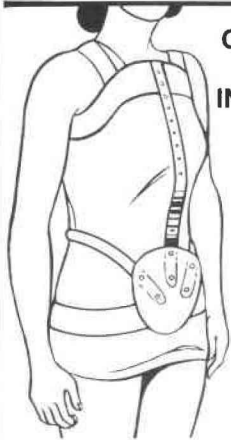
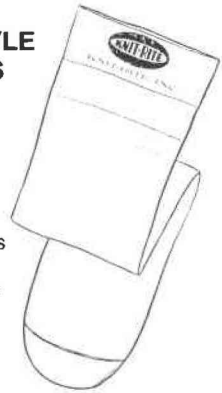


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